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Table of Contents

- 4 Hollywood Culture: Portrayals of Romantic Interactions and Gender Tropes Pre- and Post-Sexual Assault Awareness Movements of the 21st Century
Lydia Guertin
- 22 Analyzing Student Perception of Teacher Quality
Juliet Pridgen
- 34 Sharing is Caring: The Effects of Communication Mediums on Self-Disclosure in Adolescents
Sawsan Haider
- 50 An Assessment of Macroplastic Litter Surrounding Four Freshwater Lakes in Columbus, Georgia
Clara Ray
- 62 The Effect of Creative Computer Science Workshops on the Interest Levels of Female Middle School Students
Ella Hilton
- 84 Chemotaxis of *C. reinhardtii* Towards AHLs
Esha Patel
- 94 A Flawed System of Accessibility: A Mixed-Methods Study of the Shortcomings of Disability Accommodations for Female Undergraduate Students with Autism Spectrum Disorder, Level One
Alyssa Gaylard
- 108 The Effect of Reading Literary Fiction on Theory of Mind
Julia Werner
- 148 Glycovariants of the Novel Immunotherapeutic Drug ManC-lectibody and their Effects on ADCC Activity
Sreevatsa Vemuri
- 164 Seasonality in Equities Traded on the Toronto Stock Exchange Between 1980 and 2019
Nick Woollcombe
- 178 The Effect of Animal-Assisted Therapy on Fine Motor Skill Development
Madeline McWatters
- 188 Influential Factors for Young Entrepreneurial Success: A Delphi Study on High School Entrepreneurs
Nanyi Jiang
- 208 Cus Efflux System and Resistance to Nanoparticles
Pragyat Khanal
- 220 The Assessment of Unpaid Dementia Caregivers by Primary Care Clinicians
Asha Kalapatapu
- 234 Not a Children's Game: Misogyny in the North American Online Gaming Community
Siyu (Elaine) Liu
- 256 Theory of Mind Ability in Opposite-Sex Twin Females: The TTT Hypothesis
Rakshita Kota
- 286 The Effects of Instagram Media Usage Frequency of Females in an Urban Public High School on Perceptions of Body-Image for Teenage Female Athletes and Non-Athletes
Abigail Bohn
- 302 The Experiences of Five Southern Ontario High School Principals in Dealing with Student Mental Health: A Qualitative Study
Alistair Langhorne
- 318 Engineering a Low-Cost, Non-Invasive Corrosion Monitoring System
Demos Negash

Editorial

Curiosity is one of nature's greatest gifts. We strive towards the accumulation of knowledge and data not for reward, or for incentive, rather, for the raw, universal motivator that is curiosity. The ability to learn more about the things that interest you is not only a gratifying experience but is also the essence of what we know today as research. Research not only benefits you, but it also helps countless others who want to enrich their learning and perhaps make their discoveries.

In the age of information, ironically scholarly research falls under threat. In a time with boundless access to accurate information, popular media and communication channels are flooded with misinformation, unsubstantiated claims, and eye-catching headlines that polarize opinions and affirm their readers' existing biases. Now more than ever, it is incumbent upon those who value an informed and intelligent society to monitor the quality of the information one consumes and familiarize oneself with a multitude of perspectives.

The Young Researcher seeks to help you in your quest for truth. The journal features original, peer-reviewed, scholarly research conducted by ambitious secondary-school students from around the globe. We hope to provide a reputable platform for these accomplished students to present their work while also inspiring the scholars of tomorrow to share what they are passionate about.

The Editors

Alistair Langhorne
Wil Lenkov

Callum Manson
Nicholas Woollcombe

Hollywood Culture: Portrayals of Romantic Interactions and Gender Tropes Pre- and Post-Sexual Assault Awareness Movements of the 21st Century

Lydia Guertin

Since the 2017 allegations of sexual assault against director Harvey Weinstein and the subsequent trending hashtag “#MeToo”, sexual assault awareness has become a leading edge of fourth-wave feminism. This study explores the impacts of sexual assault awareness movements on Hollywood film by examining 18 films from 1999-2001, 2009-2011, and 2016-2018 and analyzing categorical data gathered to generate trend lines for various aspects of the portrayal of romantic interactions and gender tropes from 1999-2018. These trend lines and correlation coefficients show drastic changes aligned with the goals of fourth-wave feminism, particularly in camera angles, sexual interactions, heteroromantic relationships, and trope portrayal and, in some cases, show shifts directly aligned with the timing of Hollywood sexual assault scandals. These findings demonstrate the influence of American activism, specifically “#MeToo” and sexual assault awareness movements, on cultural markers, in this case, Hollywood film portrayals, and encourage further research on the implications of public activism on cultural and societal norms.

Keywords: film analysis, sexual assault awareness, feminist film theory, gender in film

Introduction

According to the United States (US) National Victim’s Center, the incidence rate of sexual assault, defined as “sexual contact or behavior that occurs without explicit consent of the victim,”¹ is growing at a faster rate than any other violent crime in the United States². Sexual assault can include gender-based harassment, pressured sexual contact, blackmail, and rape, making the identification of “assault” subjective and difficult for people who have not experienced sexual assault firsthand. Over the past 20 years, the rise of sexual assault awareness movements has ignited a widespread American cultural shift through advocacy

for knowledge of the types of unacceptable behaviors as well as the ubiquity of these movements across ethnicities, ages, and genders. From the “#MeToo” movement in 2017 that aimed to spread awareness of the range of victims and the “Time’s Up” movement in 2018 advocating to remove offenders in positions of power to the publication of *She Said* by Jodi Kantor and Megan Twohey, a frontline nonfiction account of the news break that ignited allegations against Harvey Weinstein in 2019³, women have increasingly advocated for awareness of the reality of workplace sexual harassment and Hollywood sexual coercion through positions of power. Likewise, an increasing number of sexual assault documentaries have been released

1 “Sexual Assault”, *RAINN*, accessed January 20, 2020. www.rainn.org/articles/sexual-assault.

2 Jennifer Finnegan, “Sexual Assault Awareness Month: A New Focus to Stop Rapes”, *Off Our Backs*, vol. 27, no. 4 (1997): 3

3 Jodi Kantor and Megan Twohey, *She Said*, Penguin Press, 2019.

HOLLYWOOD CULTURE: ROMANTIC INTERACTIONS AND GENDER TROPES

since 2000. Some examples include *The Invisible War* (2011), which uncovered sexual assault in the US military, *Twist of Faith* (2004), which reported on sexual abuse and misconduct in the Catholic church, and *The Hunting Ground* (2015), which explored widespread college campus rape culture⁴. Since the Committee on the Elimination of Discrimination against Women issued a recommendation in 2017 that widespread violence against women be seen as a human rights violation⁵, changes in social and legal categorization of the severity of sexual assault crimes will likely be seen in future years. Some examples of shifts in social norms have already been seen through the conviction of rapists and the increased concern and support given to victims who have come forward in recent years, as exhibited by the Kavanaugh confirmation of 2018, where Justice Kavanaugh was held accountable to the testimony of a woman claiming he had raped her. Although some cultural shifts in the perception of sexual assault can already be seen, this study aims to assess whether there are perceptible shifts in Hollywood film direction choices from time periods before, during, and after these sexual assault awareness movements. This study targets Hollywood film portrayals because of their ability to change gender stereotypes and acceptable social interactions through film's vast influence and coverage in mainstream media⁶.

Traditional romantic roles between characters are demonstrated well in 20th century movies like *Pretty in Pink* (1986), where the female, subtly-beautiful outcast ends up dating her quirky best friend rather than the popular "hottie," but non-traditional romantic roles have been increasingly visible due to a number of films involving gender expression and identity, especially in young adult movies like *She's the Man* (2006), where the female protagonist cross-dresses to play soccer on the boys' team and attracts the popular boys instead of chasing them. Since Hollywood

film set in America is likely intended to portray the American lifestyle through its depictions of partying, romance, sexual interactions, and everyday relationships, this study will draw comparisons between how actors and directors have chosen to portray romantic interactions and the consequent impressions given about American values and attitudes towards romantic and platonic interactions. Romantic interactions are here defined as male-female interactions, for the purpose of a clearly-defined history of gender roles between males and females, that are either overtly sexual or suggestive in tone and/or display romantic dynamics or interest, such as touching or one-on-one time. The results of this study may predict how society will react to future awareness movements, allowing a better understanding of current American ideals and their basis, and aim to understand in more depth how American society and culture has already responded to instances of sexual assault in politics and Hollywood. This study is grounded in feminist film theory and Laura Mulvey's "male gaze," a concept defined by University of Puget Sound Gender Studies Professor Ann Putnam, who asserts that the "male gaze" is a combination of film effects that "[highlight] a woman's 'to-be-looked-at-ness,' a system which is always 'cut to the measure of [male] desire'"⁷. Viewing Hollywood film and culture through this lens allows traditional gender stereotypes and andro-centric thinking of the 20th century to be seen more easily, and thus allows shifts in said concepts to be visible in changes in cinematography and direction choices.

Literature Review

Much of the inspiration for this study came from film studies covering aspects of romantic films, specifically a study titled "The End of Romance: The

4 Gary Crowdus et al, "Transforming Trauma into Political Activism: An Interview with Kirby Dick and Amy Ziering", *Cinéaste*, vol. 40, no. 3 (2015): 44. www.jstor.org/stable/43655496.

5 Rachel Hall-Clifford, "Where There Is No Hashtag: Considering Gender-Based Violence in Global Health Fieldwork in the Time of #MeToo", *Health and Human Rights*, vol. 21, no. 1 (2019): 132. www.jstor.org/stable/26727077.

6 James Dowd and Nicole Pallotta, "The End of Romance: The Demystification of Love in the Postmodern Age", *Sociological Perspectives*, vol. 43, no. 4 (2000): 554. www.jstor.org/stable/1389548.

7 Ann Putnam, "The Bearer of the Gaze in Ridley Scott's 'Thelma and Louise'", *Western American Literature*, vol. 27, no. 4 (1993): 291. www.jstor.org/stable/43021037.

Demystification of Love in the Postmodern Age” by James Dowd and Nicole Pallotta. That study aimed to assess a perceptible shift in attitudes towards and approaches to long-term romantic relationships in Hollywood films from 1930 to 1999. Dowd and Pallotta took a simple random sample of all films from 1930 to 1999, except those on videocassettes, from specific genres of romance, and chose to analyze specifically English-language Hollywood films because “the romance [in Hollywood films] is a clearly defined genre that has a sufficiently long history to cover the period of interest”⁸ This rich history of film is one of the reasons the study below centers around Hollywood film. Dowd and Pallotta conducted a well-controlled experiment where the genres, ages of film, and romantic plot points were viewed as objectively as possible under the constraints of film creativity and general diversity to decrease variation and bias in the analysis. The researchers concluded, through extensive analysis of romance’s portrayal and the depiction of marriage and its motivations, that the decline of romantic drama and traditional marriage ideologies is due mainly to an increased sense of realism in young couples that has taken away from the utopian romantic ideal of the past. Though Dowd and Palotta effectively conduct the same type of experiment as the one below, there are significant differences between the content of “The End of Romance” and the study of this paper, as this study is largely recent films—since 2000—and covers a much smaller sample of films due to the specific cultural change being observed and its recent nature. There is a gap in current film studies in assessing the modern effects of “fourth-wave feminism”⁹, or the post-2000 wave of feminism associated with cyberactivism and female empowerment, and sexual assault awareness movements due to how recently these movements have begun. This study aimed to ad-

dress and fill that gap through analysis of several recent films from before and after feminist movements, such as “#MeToo,” to determine if there has been a perceptible shift in the portrayal of romantic interactions and gender stereotypes in the wake of increased awareness of the commonness of sexual assault. Likewise, inspiration was drawn from related studies covering similar concepts in the genre of romance, such as “Wealth and/or Love: Class and Gender in the Cross-class Romance Films of the Great Depression” by Stephen Sharot, “Women Stripped Bare: Rape in the Films of Hong Sang-Soo” by Marc Raymond, and “The Bearer of the Gaze in Ridley Scott’s ‘Thelma and Louise’” by Ann Putnam. Each of these presents an example of a well-designed film study, so they were used as models when designing the following methodology, especially in the aspects of identifying the “male gaze” in cinematography¹⁰, exploring motivations and intended effects of including sexual harassment in film¹¹, and collecting common female gender tropes in film¹². As referenced above, Ann Putnam’s survey gave this study a lens through which to analyze the cinematography of the films chosen by describing different aspects of the “male gaze” and how this bias can be displayed, which eventually factored into how notes were taken during film evaluation. The constraints of the gap this study intends to fill were refined through examples in “Men, Women, and Chain Saws [sic]: Gender in the Modern Horror Film” by Carol Clover, where she identifies a conjunction of psychology theory and film theory¹³, and “Masculinity in the Contemporary Romantic Comedy: Gender as Genre” by John Alberti, where Alberti asserts that his gap was defined by the lack of connection and review of the intersection between humor and gender studies¹⁴. These examples helped me understand more clearly how the lack of knowledge of post-sexual-assault-awareness

8 Dowd and Palotta, “The End of Romance”, 554.

9 Marc Raymond, “WOMEN STRIPPED BARE: RAPE IN THE FILMS OF HONG SANG-SOO”, *Revue Canadienne D’Études Cinématographiques / Canadian Journal of Film Studies*, vol. 26, no. 1 (2017): 46. www.jstor.org/stable/26532120.

10 Putnam, “The Bearer of the Gaze”, 292.

11 Raymond, “Women Stripped Bare”, 47-48.

12 Stephen Sharot, “Wealth and/or Love: Class and Gender in the Cross-Class Romance Films of the Great Depression”, *Journal of American Studies*, vol. 47, no. 1 (2013): 89-90. www.jstor.org/stable/23352508.

13 Carol Clover, *Men, Women, and Chainsaws: Gender in the Modern Horror Film* (Princeton University Press, 2015), 68.

14 John Alberti, *Masculinity in the Contemporary Romantic Comedy: Gender as Genre* (Tim Miles, 2013), 120.

Hollywood, combined with an already lacking database of romantic film studies, could culminate in the study described below.

Methodology

The sample of films used in this study were first determined by narrowing the genres from which to choose. Finding enough films of appropriate genre proved challenging because a standard of production quality and direction was set by using only films that were nominated for Oscar awards in the categories “Best Picture”, “Best Original Screenplay”, “Best Story”, “Best Story and Screenplay”, “Best Dramatic Picture Direction”, and “Best Cinematography”, which already narrowed the pool of available films. Oscar nominations are, in American culture, meant to represent the best work that the film industry has to offer, hence why Oscar nominees were chosen. Only films that had male-female interactions, for the sake of a well-defined cultural expectation and shift over time, were utilized. Likewise, only films set in the general time period of the years of production were eligible, as films attempting to accurately portray gender tropes and romantic interactions from prior decades would not be suitable for the study. This ruled out any film adaptations of plays or novels set or written in a different time period than the 21st century. The only accepted films were English language-based and American, as that narrows the scope of the investigation to shifts in American culture. Only films meant to portray real life, excluding the supernatural or the fantastic, were taken into account.

Now that parameters had been set, the selection of films began. Two films were randomly chosen using a random number generator from the pool of Oscar-nominated films for each year in the following significant set of years: 2000-2002, 2010-2012, and 2017-2019, spanning a total of 19 years and 18 films. These groupings are significant for their places in time relative to sexual assault awareness movements and fourth-wave feminist movements. The first group, 2000-2002, provides a baseline for the film industry entering the 21st century; the second group, 2010-2012, provides a closer example of how 21st century

feminism has impacted film; the third group, 2017-2019, looks at films that were produced or written after the beginning of large-scale sexual assault awareness movements, such as the “#MeToo” movement starting in 2017. Then, the order of viewing was randomized based on access to the films: the films were grouped into five categories: Free on Amazon Prime, Rent on Amazon Prime, Amazon Prime STARZ Subscription, Amazon Prime Cinemax Subscription, and HBO Subscription. Then, the films within each group were randomized, which resulted in the final order of films. This ensured that I only had to pay for one month’s subscription to each service, as every film available from a service was watched in succession. 2020 Oscar nominees would have been taken into account, but the nomination list was accessible only after data selection had begun, so adding films would have compromised the randomized design of this experiment. The year of release, year of Oscar nomination, category/ies of selection, whether awarded an Oscar were recorded; likewise, genre and ratings according to Rotten Tomatoes were noted. To analyze the impact of director bias, the gender, age, and nationality of directors and screenplay writers were all recorded after the selection of each film. Cultural factors in American society and individual gender and experience play a role in the perception and identification of sexual harassment and assault, which is why the gender, age, and nationality of directors, screenplay writers, and the researcher will be taken into account to differentiate from researcher bias and identify points of view. The genre and ratings were recorded in order to differentiate intended audiences, possible perspective shifts, and the implications of budget on cinematography.

I watched each film twice: once without note-taking to understand the plot and determine the location of relevant scenes, and a second time in which I took notes on specific criteria. Aspects of the “male gaze” were discerned through answering the following questions, as inspired by Ann Putnam’s study concerning the 1991 film *Thelma and Louise*: “[Is] the camera still or always moving? Does the camera remain fixed or does it seem to survey the female form? Does it seem to travel over the female body? Whose point of view is privileged? Through whose eyes do we see the story? Who is doing the beholding and who is

beheld?”¹⁵. Since the most common form of sexual assault is arguably gender bias and harassment¹⁶ (Deen 38), this study took into account gender slurs, such as “sweetheart” for females and “dumb jock” for males, to account for different aspects of power and gender relationships. Notes were taken on the following criteria for both males and females: relative heights of characters interacting, camera angles of different characters (to determine the “male gaze”¹⁷), relative aptitudes toward being violent (to discern stereotypes about relative male-female tempers and manners), symbolism in the form of closed versus open spaces¹⁸, if sexual interactions were portrayed as specifically romantic in nature or not (measured based on romanticism, or expressed sentiment, feeling, and closeness, to determine if intercourse has been desexualized and painted as more sensual over time), and whether or not prominent female characters fit specific literary tropes (i.e. the “fallen woman”, “virtuous heroine”, “amoral social climber”¹⁹, or helpless victim²⁰). For this study, the difference between tropes and stereotypes is defined as the overall pattern and aspects of a character versus a single aspect of a character. The symbolism of open versus closed spaces was used alongside female tropes to determine if female characters have been limited to only plot devices (for example: female characters used to further the development of male characters or introduced to move plot along without being given a background or significant role in the film) or if there is an increasing number of female characters who do not follow set patterns and roles in plot.

Each of these categories was written on a sheet of paper for each film, and individualized notes on specifics of each film were taken. These notes were then compiled into a spreadsheet. An analysis of possible

sources of bias for directors and screenplay writers as well as an understanding of the bias the researcher brings as a young American caucasian female were coupled with the notes from each film to form the data and analysis below. The notes taken for *In The Bedroom*, to serve as an example of the notes taken for each film, are recorded in the appendix of this paper.

Findings

In order to present the data collected in an organized fashion, I constructed scaled graphs of the notes on the 15 following divisions: development of male-female relationships (romantic and platonic) as seen in Figure 1, equal height camera angles (see Figure 3), portrayal of awareness of tropes on men and women (see Figure 2), broken stereotypes and tropes of men and women (see Figure 4), portrayal of dominant versus submissive female sexual interactions (see Figure 5), freedom imagery for women and men (see Figure 6), portrayal of male alcoholism (see Figure 7), prevalence of “male gaze” camera angles²¹ (see Figure 8), prevalence of tropes on men and women (see Figure 9), prevalence of stereotypes on men and women (see Figure 10), portrayal of physical and sexual assault on men and women (see Figure 11), prevalence of gender slurs against men and women (see Figure 12), portrayal of male aptitudes towards violence (see Figure 13), prevalence of sexual interactions before developed relationships (see Figure 14), and prevalence of “seductress” and “fallen woman” tropes (see Figure 15). Each of these categories was ranked on a 1-5 scale, described beneath the graphs.

15 Putnam, “The Bearer of the Gaze”, 292.

16 Lango Deen, “#Metoo”, *Women of Color Magazine*, vol. 17, no. 1 (2018): 38. www.jstor.org/stable/26580517.

17 Putnam, “The Bearer of the Gaze”, 292.

18 Putnam, “The Bearer of the Gaze”, 294.

19 Sharot, “Wealth and/or Love”, 89-90.

20 Clover, *Men, Women, and Chain Saws*, 67.

21 Putnam, “The Bearer of the Gaze”, 292.

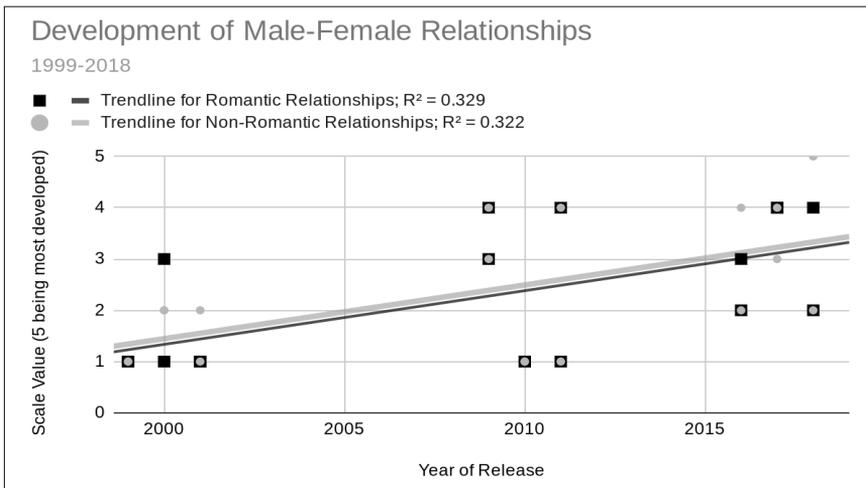


Figure 1. The scale for the development of male-female relationships is a 1-5 linear numeric scale, where 1 designates no developed relationships, 2 designates few, 3 designates a moderate number, 4 designates many, and 5 designates that all male-female relationships in the film were well-developed. Over the course of the past 20 years, there has been an increase in the depiction and prevalence of well-developed relationships between male and female characters, both romantically and platonically.

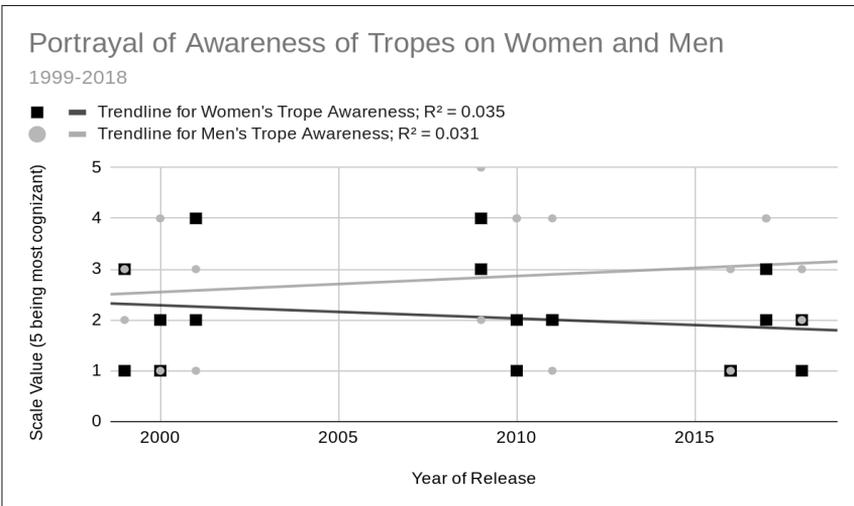


Figure 2. The scale set for the portrayal of awareness of tropes on women and men is a similar linear numeric scale, with 1 being oblivious and accepting of tropes and 5 being fully cognizant and not accepting. The only film meriting a 5 on this scale is *Up in the Air*, where a female character has a conversation with a male and a female and says, “sometimes it feels like, no matter how much success I have, it’s not gonna matter until I find the right guy”²², acknowledging the societal tropes imposed on her. There is no statistically significant shift in the portrayal of awareness of tropes on either men or women in this study.

22 Jason Reitman, dir. *Up in the Air*. (2009; Los Angeles, CA: Paramount, 2009.) *Amazon Prime Video*.

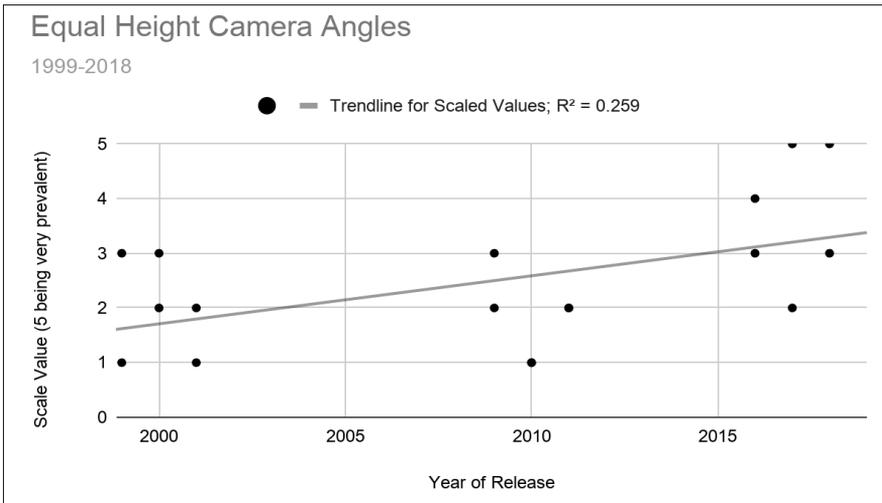


Figure 3. The scale for equal height camera angles is a 5-point frequency scale, with 1 being no male-female equal height camera shots, 2 being few, 3 being a moderate number, 4 being many, and 5 being overwhelmingly equal height shots as opposed to shots showing the relative heights of males and females. Over time, there has been an increase in the prevalence and importance of equal height camera angles in film.

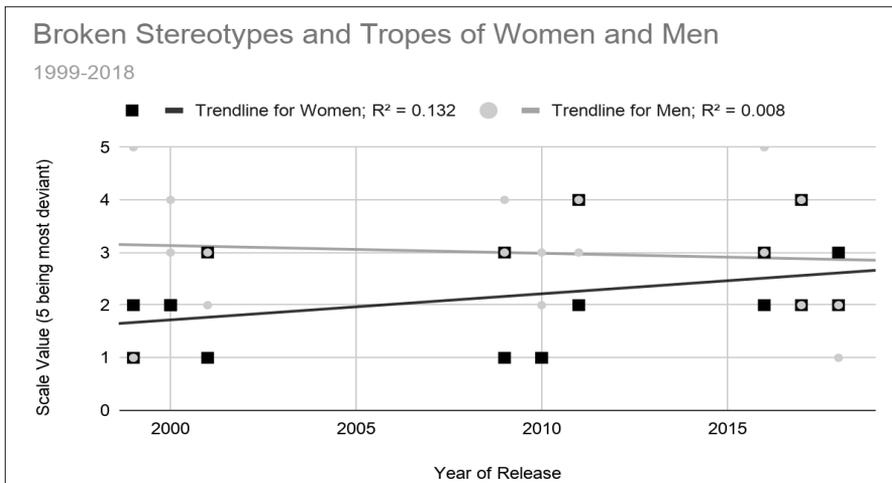


Figure 4. The scale for broken stereotypes of women and men is a similar frequency scale, with 1 being no broken stereotypes and 5 being almost no characters fitting gender stereotypes. *Ladybird* earned a 5 on this scale, as the film follows a young woman's development and attempts to find herself, including trying drugs, being defiant, asserting her dominance, and her tendency to swear and yell.²³ While the trend for broken stereotypes and tropes on men is statistically insignificant, stereotypes and tropes have increasingly been broken in the portrayal of female characters in film over the past two decades.

23 Greta Gerwig, dir. *Ladybird*. (2017; Sacramento, CA: IAC Films, 2017.) *Amazon Prime Video*.

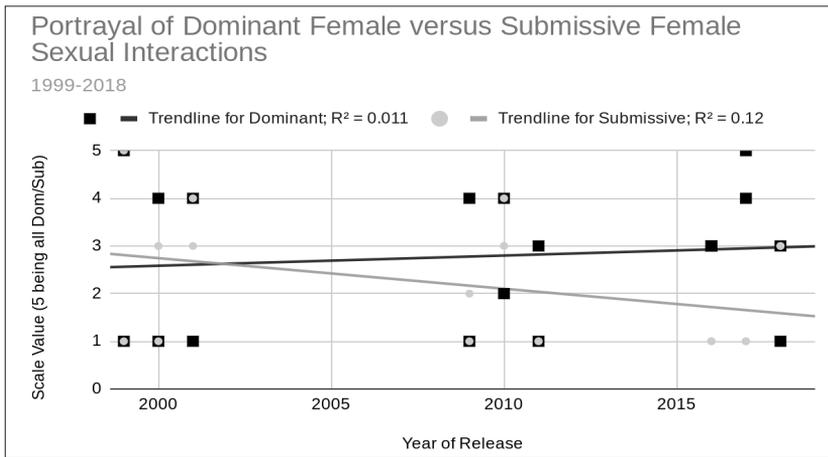


Figure 5. The scale for the portrayal of dominant female versus submissive female sexual interactions is a similar frequency scale, with 1 being completely the opposite of (dominant/submissive) and 5 being completely (dominant/submissive). For example, *Being John Malkovich* earned a 5 on dominant female sexual interactions and a 1 on submissive female sexual interactions because the main female character, the only one engaged in sexual interactions throughout the film, is always the instigator and dominatrix of her sexual encounters²⁴. While female-dominant sexual interactions have neither increased nor decreased substantially, the frequency of female-submissive sexual interactions has decreased.

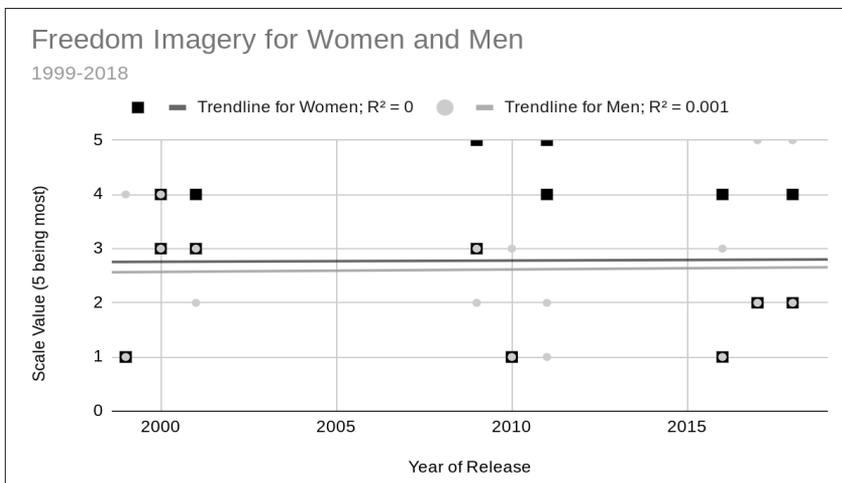


Figure 6. The scale for freedom imagery of men and women is a similar frequency scale, with 1 being no freedom imagery and 5 being vivid and impactful symbolism throughout the film. *Ladybird*, meriting a 5 on female freedom imagery, consistently used open spaces, light, and defiance of the main female character to convey the freedom of a teenage girl²⁵. There was no perceptible shift in the prevalence of freedom imagery for men or women.

24 Spike Jonze, dir. *Being John Malkovich*. (1999: USA Films, 1999.) *Amazon Prime Video*.

25 Greta Gerwig, dir. *Ladybird*. (2017; Sacramento, CA: IAC Films, 2017.) *Amazon Prime Video*.

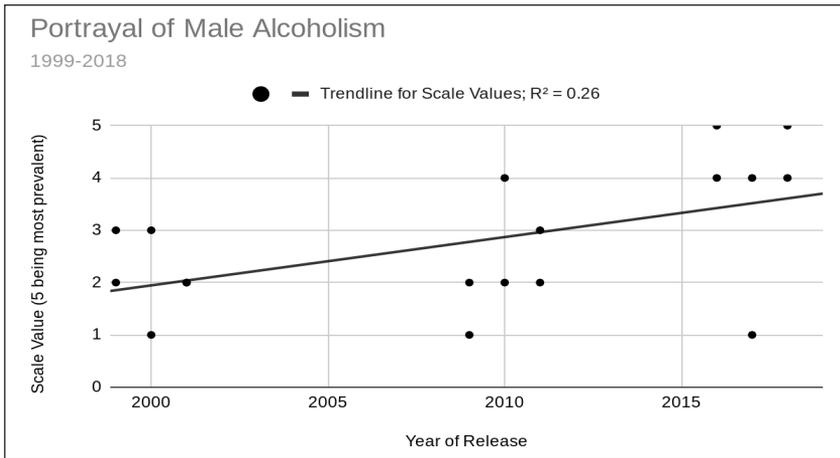


Figure 7. The scale used to determine the trends in the portrayal of male alcoholism is a similar frequency scale, with 1 being no male alcoholism and 5 being alcoholism portrayed as a defining trait in males. Since 1999, there has been a statistically significant increase in the portrayal of alcoholism in male characters.

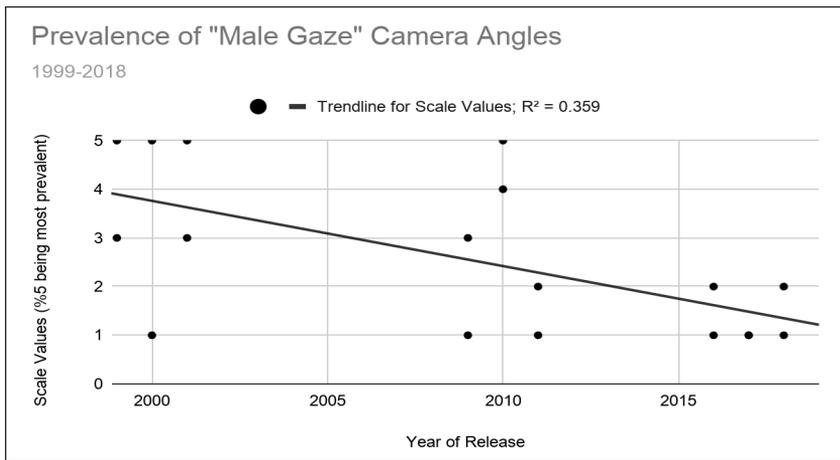


Figure 8. The scale used to show the prevalence of “male gaze” camera angles²⁶ is a similar frequency scale, with 1 being none and 5 being females predominantly shown through the lens of males’ eyes. For example, *Magnolia*, meriting a 5, first showed all women either in lingerie, naked, or raising camera angles that roam their bodies. *Magnolia* also had several shower scenes of only women, sexualized leg shots, and naked women shots throughout.²⁷ Over time, there is a significant decrease in the prevalence and importance of “male gaze” camera angles in Hollywood films.

²⁶ Putnam, “The Bearer of the Gaze”, 292.

²⁷ Paul Thomas Anderson, dir. *Magnolia*. (1999: New Line Cinema, 1999.) *Amazon Prime Video*.

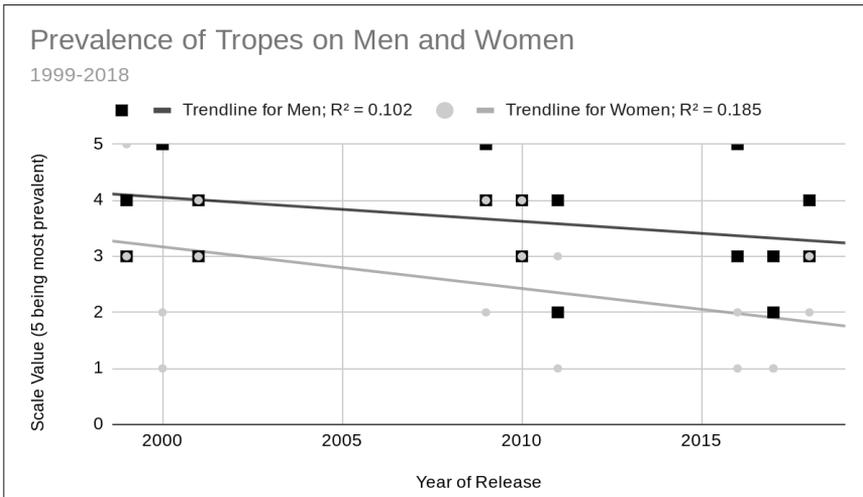


Figure 9. The scale used to show the prevalence of tropes on men versus women is a similar frequency scale, with 1 being almost no characters fitting tropes and 5 being all female/male characters ultimately displaying the traits of a certain trope. *Magnolia*, with its categorization of all men as inherently violent and disloyal and all women as addicts and “fallen women”, earned a 5 on this scale. The prevalence of tropes has decreased for both men and women over the past 20 years.

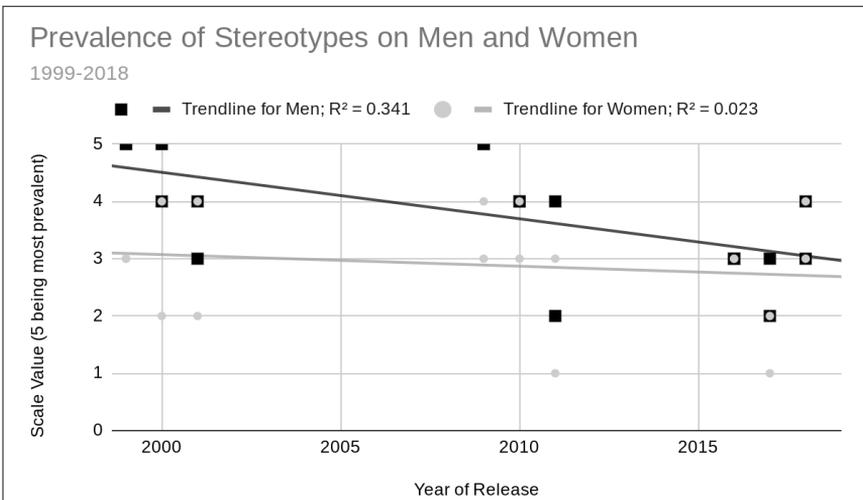


Figure 10. The scale used to show the prevalence of stereotypes on men versus women is a similar frequency scale, with 1 being almost no or very limited use of gender-specific stereotypes and 5 being almost ubiquitous use of and emphasis on gender stereotypes throughout the film, including but not limited to male cursing and violence, female submissiveness, male alcoholism, emotional females, and apathetic males. While the prevalence of stereotypes used on women has not changed significantly, there has been a perceptible decrease in the prevalence of stereotypes on male characters.

28 Paul Thomas Anderson, dir. *Magnolia*. (1999: New Line Cinema, 1999.) Amazon Prime Video.

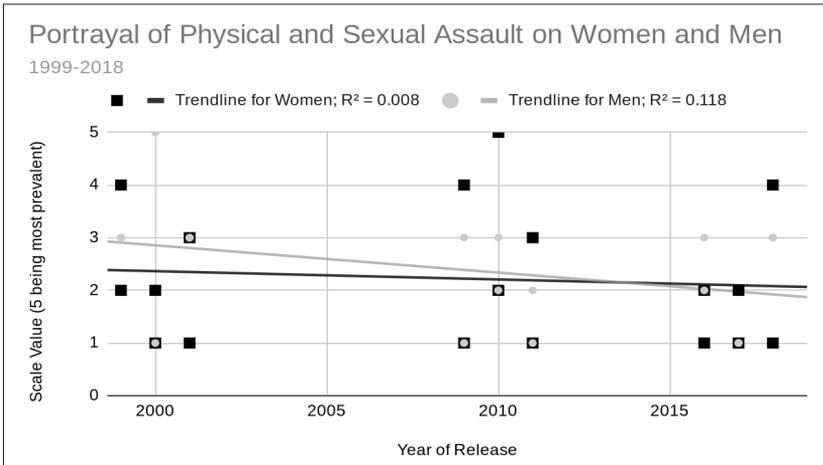


Figure 11. The scale used to describe trends in the portrayal of physical and sexual assault on men and women is a similar frequency scale, with 1 being no portrayal or descriptions of assault and 5 being a central focus on the depiction and description of assault against men/women. *Black Swan*, with its several sexual assault scenes, stabbing of a female, and emphasis on manipulation of women through sex, was the only film to merit a 5 on the scale for assault against females²⁹. Interestingly, the portrayal of physical and sexual assault on women has not changed significantly; however, there has been a decrease in the prevalence of physical and sexual assault against males in film.

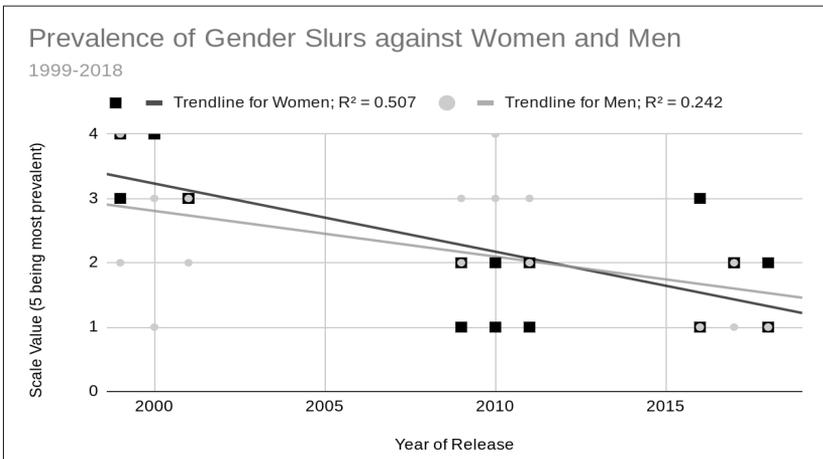


Figure 12. The scale used to show the prevalence of gender slurs, i.e. “slut”, “whore”, “dick”, “bastard”, etc., is a similar frequency scale, with 1 being no gender slurs against men/women and 5 being a constant use of gender slurs throughout male-female interactions. For both genders, there has been a statistically significant decrease in the prevalence of gender slurs over time.

²⁹ Darren Aronofsky, dir. *Black Swan*. (2010; Venice, Italy: Fox Searchlight Pictures, 2010.) *Amazon Prime Video*.

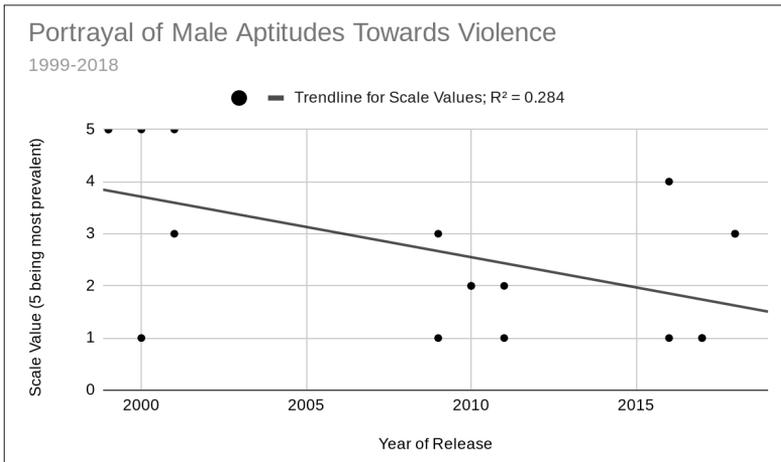


Figure 13. The scale used to describe the prevalence of male aptitudes towards violence is a similar frequency scale, with 1 being almost no male-perpetrated violence, or adamant male stances against violence, and 5 being widespread use of violence, or violent tendencies, by males, whether through one central character or through the tendencies of a cast of male characters. While there is a clear decrease in the portrayal of male aptitudes towards violence over time, there are some higher values from 2017-2019, suggesting the trend over a larger span of time may not be as obviously decreasing.

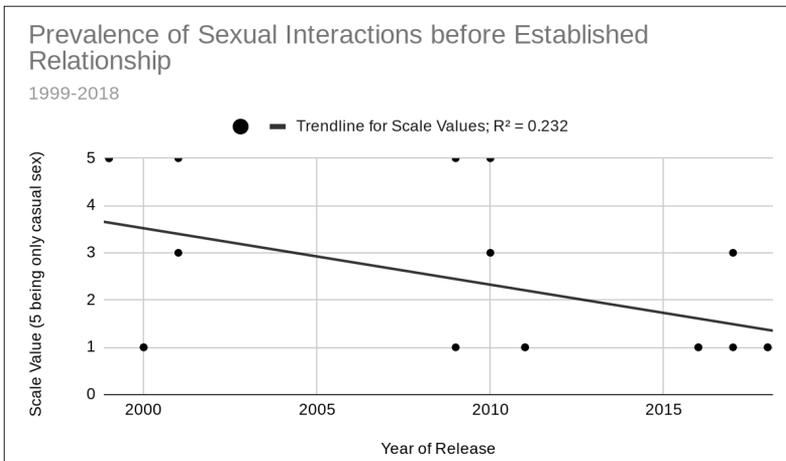


Figure 14. The scale used to show the prevalence of sexual interactions

that occur before the relationship is established is a similar frequency scale, with 1 being no sexual interactions, or well-developed relationships occurring before sexual interactions, and 5 being all casual, non-relational sexual interactions, or no well-developed relationships forming before sexual interactions. *La La Land* earned a 1 on this scale, as even after a plethora of scenes depicting quality bonding time between the main couple and after the relationship is very well developed, there is no sex scene, leading to an emphasis on the relationship emotionally rather than physically. The graph shows a clear decrease over time in the prevalence of sexual interactions before a relationship has developed.

30 Damien Chazelle, dir. *La La Land*. (2016; Venice, Italy: Summit Entertainment, 2016.) Amazon Prime Video.

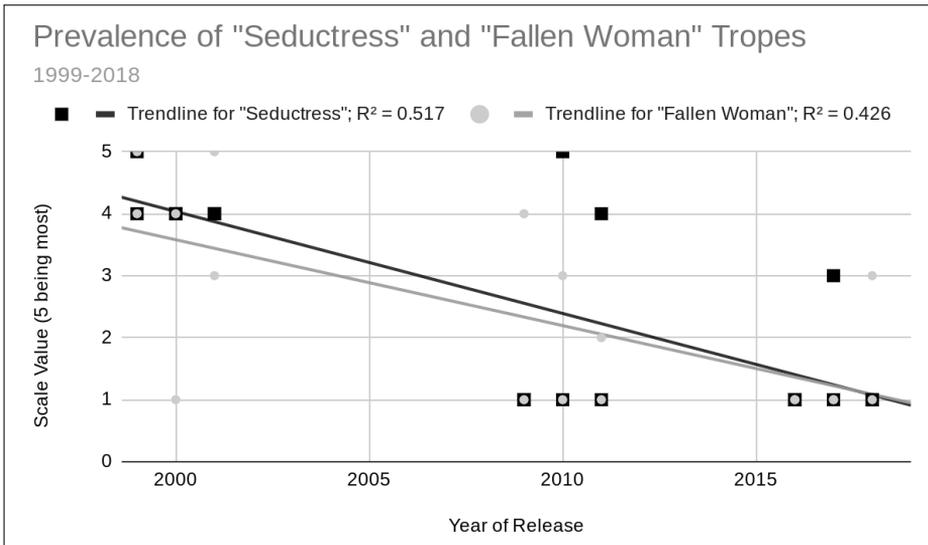


Figure 15. The scale used to show the prevalence of “seductress” and “fallen woman” tropes on female characters is a similar frequency scale, with 1 being neither trope depicted in any female character and 5 being the majority of female characters fitting one or both of the tropes. There are sharp declines noted in the prevalence of both “Seductress” and “Fallen Woman” tropes over time.

Analysis

To analyze changes in the portrayal of gender tropes and romantic interactions in Hollywood film pre- and post-sexual assault awareness movements, the graphs will be viewed first through the overall trend and then from the different time frames of films and their individual trend lines. This analysis will mainly utilize the trend lines plotted and will take special consideration of specific trends, such as camera angles and individual tropes, as the presence of these factors is more objective than the general trends in plot devices and thematic issues because of their clear presence or absence. General trope awareness or stereotype usage can mean different things to different viewers and vary depending on the background of the viewer. Definitions of rankings are as follows: correlation coefficients between 0.00 and 0.25 are considered

“weak” associations, constants between 0.25 and 0.50 are considered “moderate” associations, and constants between 0.50 and 1.00 are considered “strong”. Beginning with camera angles, in Figure 3, there is a clear moderate positive association between equal height camera angles and time, demonstrating an increase in shared power in relationships displayed through equal height shots. There is a similar trend in Figure 8, where there is a moderate decrease in male gaze camera angles over time, showing a general respect for women through decreasing sexualizing camera shots. Figure 5 shows a weak negative trend in submissive female sexual interactions and a weak positive trend in dominant female sexual interactions. These trends were skewed by outliers such as *Being John Malkovich*, a 1999 film in which a female character is blatantly dominant in sexual interactions³¹ and *A Star Is Born*, a 2018 film in which the female character is involved in only one sex scene, but is not dominant during

it³². In Figure 7, there is a moderate positive trend in the portrayal of male alcoholism over time. This is an interesting trend that deserves further study, as it goes against the general historical push for the abolition of gender stereotypes, but could be explained as an attempt to justify male violence, as the movies that scored higher on this scale tended to also score higher on the frequency scale of male violence. Figure 12 displays a strong negative trend for the use of gender slurs against women and a moderate negative trend for the use of gender slurs against men, furthering the previous trends in mutual respect in devices in film. In Figure 13, there is a moderate decrease in the prevalence of male violence and male aptitudes towards violence, a trend that contradicts the trend seen in male alcoholism in Figure 7, emphasizing the need for a more thorough exploration of this particular dynamic of male film depiction. Figure 14 shows a moderate negative trend in sexual interactions before developed relationships, a trend which seems directly related to Hollywood sexual assault scandals and their societal repercussions. This is especially evident by examining the distribution of data points from 1999-2001 to 2009-2011 versus from 2009-2011 to 2016-2018: there is a far larger spread and higher average value between the first group than the second group, and there is a visible decrease in values from 2009-2011 to 2016-2018. Figure 15 shows a similar pattern, with strong negative trends in both the “seductress” trope and the “fallen woman” trope.

Moving on to the more general observations (Figures 1, 2, 4, 9, and 10), and thus more subjective, Figure 1 shows moderate positive trends in the development of heteroromantic relationships and male-female platonic relationships over time. This echoes the pattern of change in specific device trends (Figures 3, 5, 6, 7, 8, 11, 12, 13, 14, and 15) and, when paired with the decreasing portrayal of sexual interactions before established relationships in Figure 14, demonstrates correlation with the fallout from Hollywood sexual assault scandals. Figure 2 shows a weak negative trend for the awareness of tropes on women and a weak positive trend for the awareness of tropes on men,

which seems perplexing until compared with Figure 9, which shows a weak negative trend for the prevalence of male tropes, but a moderate negative trend for the prevalence of female tropes. Thus, although there seems to be a decreasing awareness of tropes on women, it is partially explained by the drop in overall tropes on women, as it is difficult for a film to be aware of its tropes when it employs few to none. Similarly, Figure 4 does not show any trend for the prevalence of broken tropes and stereotypes against men, but shows a weak positive trend for broken tropes and stereotypes against women, demonstrating fewer patterns of trope and stereotype use on female characters over time. Figure 6 displays the first truly null trend lines: freedom imagery for men and women does not appear to have shifted in any way, with an equal spread of data on either side of the center value. Freedom imagery often acts alongside plot, so if there had been a drastic shift in freedom imagery, it would likely correlate to a change in subject matter or broader plot devices, like widespread decreases in tropes and stereotypes, over the past two decades. In Figure 10, there is an interesting twist on the predicted impacts of fourth-wave feminism: while there is a moderate decrease in the portrayal of stereotypes on men, there is a very weak, almost negligible decrease in the portrayal of stereotypes on women. This negates one intended impact of modern feminism, the push to leave gender-based discrimination and assumptions behind, by failing to show a perceptible shift in the prevalence of gender stereotypes against women and, further, only shows a decrease in gender stereotypes towards men. Figure 11 displays a weak negative trend in the prevalence of sexual and physical assault against males but, interestingly, shows a negligible change in the prevalence of assault against females. However, this trend is skewed by outliers such as *Black Swan*, a 2010 film centered on abuse of power in the ballet industry and its impacts on young, impressionable females³³.

The following analysis will focus on Figures 1, 5, 8, 11, and 14, as they most closely relate to sexual assault awareness and its ramifications on the film industry. Beginning with Figure 1, the correlation coefficient

31 Spike Jonze, dir. *Being John Malkovich* (1999: USA Films, 1999), *Amazon Prime Video*.

32 Bradley Cooper, dir. *A Star Is Born* (2018; Venice, Italy: Warner Brothers, 2018), *Amazon Prime Video*.

33 Darren Aronofsky, dir. *Black Swan* (2010; Venice, Italy: Fox Searchlight Pictures, 2010), *Amazon Prime Video*.

from the data points from 1999-2011 for romantic relationship development was calculated to be $r = 0.3796$, which indicates a moderate positive linear association between heteroromantic relationship development and time. The correlation coefficient from the data points from 2009-2018 was calculated to be $r = 0.3102$, indicating a similar moderate positive linear association between heteroromantic relationship development and time. Interestingly, the association from before the beginning of the “#MeToo” movement and corresponding sexual assault movements is greater than the association after these movements, indicating that this shift was more strongly correlated with fourth-wave feminism rather than sexual assault awareness movements. For Figure 5, the correlation coefficient from 1999-2011 for female-submissive sexual interactions was calculated to be $r = -0.2976$, indicating a moderate negative linear association between female-submissive sexual interactions and time. From 2009-2018, the correlation coefficient was calculated to be $r = -0.0869$, indicating a weak negative linear association. This is another interesting calculation, as it would imply that the decrease in the portrayal of female-submissive sexual interactions was influenced less by sexual assault awareness movements and more by fourth-wave feminism, although sexual assault awareness seems to apply more to this topic. In Figure 8, the correlation coefficient from 1999-2011 for the prevalence of male gaze camera angles was calculated to be $r = -0.3243$, indicating a moderate negative linear association between male gaze camera angles and time. The correlation coefficient for the data points from 2009-2018, $r = -0.5209$, indicates a strong negative linear association, which corroborates the correlation with sexual assault awareness movements and Hollywood sexual assault scandals occurring between 2009-2011 and 2016-2018, as there is a more significant negative trend from 2009-2018 than from 1999-2011. Because Hollywood sexual assault scandals have focused mainly on the abuse of women, the only correlation coefficient calculated for Figure 11 was for the association of the portrayal of sexual and physical assault on women. From 1999-2011, this was found to be $r = 0.1495$, indicating a moderate positive linear association, whereas the regression constant for 2009-2018 was calculated to be $r = -0.2810$,

indicating a moderate negative linear association over time. This again corroborates a correlation between the portrayal of assault against women in film and sexual assault awareness movements because of the drastic shift from 1999-2011 to 2009-2018 in correlation coefficients, showing a negative trend from 2009 to 2018, but a positive trend from 1999 to 2011. For Figure 14, the correlation coefficient for sexual interactions before developed relationships from 1999-2011 was calculated to be $r = -0.2342$, whereas the constant from 2009-2018 was found to be $r = -0.4857$. While these are both indicative of moderate negative linear associations over time, the second correlation coefficient from 2009-2018 is stronger than the prior value from 1999-2011, again corroborating correlation between Hollywood sexual assault scandals and awareness movements and the portrayal of romantic interactions in film.

Conclusions

The above analysis exemplifies broad change in several aspects of romantic interactions and gender tropes in Hollywood film over the past two decades. The detailing of trends in specific devices, namely male gaze camera angles, heteroromantic relationship development, female-submissive sexual interactions, portrayal of physical and sexual assault on women, and sexual interactions before development of relationships, shows a distinct reaction and shift in the 21st century corresponding to the development of technological fourth-wave feminism and sexual assault awareness movements. In particular, the shift shown in Figure 11 on the portrayal of assault on women shows a specific movement in the period between 2011 and 2016, when Hollywood sexual assault cases against renowned director Harvey Weinstein began to develop in the *New York Times*³⁴. Likewise, general negative trends in gender tropes and stereotypes exemplify a societal shift correlating with the rise of fourth-wave feminism, as stereotypes across all genders are under more scrutiny in the 21st century, which has impacted the portrayal of genders in film.

More specifically, these broad shifts in thematic elements and trope usage have resulted in perceptible dif-

34 Kantor and Twohey, *She Said*, 47.

ferences in films pre- and post-sexual assault awareness movements. For example, one of the biggest shifts seen between the periods of 1999-2001 and 2017-2019 is the difference in camera angles when introducing female characters. In *Magnolia* (1999), each female character is introduced either nude or with a camera shot that roams her body before settling on her face³⁵. This is also seen in *Being John Malkovich* (1999)³⁶ and *In The Bedroom* (2001)³⁷. However, in later films, female characters are introduced by dialogue, like *The Blind Side* (2009)³⁸, or by headshots, like in *La La Land* (2016)³⁹. The latter camera angles put the emphasis on the introduction of the female character as a human or individual with thoughts and motivations, rather than the introduction of the female character as a body, which suggests the influence of feminist movements.

Another instance of specific change in film over time is the decreasing prevalence of the “Fallen Woman” trope. While films pre-fourth wave feminism and sexual assault awareness movements had more prevalent stereotypes and tropes placed on women, such as the “Fallen Woman” trope, later films tended to break the mold, offering redemption arcs for female characters and situating their responses within the context of their complex lives. This is especially evident in the contrast between *Magnolia* (1999), where the women all fall to drugs, alcohol, and prostitution without hope of redemption or deeper contextualization surrounding their situations⁴⁰, and *A Star Is Born* (2018), where a woman falls to drugs and alcohol, but is followed as she heals and drags herself out of that situation⁴¹. The breaking of tropes imposed on women effectively humanizes their struggles and creates a narrative that is less patterned and predictable, imitating situations in real life and elevating the women’s experiences as real rather than plot-driven.

Although this study produced significant results and demonstrated very perceptible shifts in Holly-

wood film portrayal, it is limited mainly by the novelty of these sexual assault awareness movements and recent activism that may not have yet influenced the face of film. As the Harvey Weinstein scandal and the ensuing “#MeToo” movement began to gain traction only in 2017, the repercussions of these movements are likely still being worked through, meaning broader impacts could be seen from research conducted in the future. Thus, to further this development, research of this nature should be again conducted in the late 2020s, as enough time should have then elapsed to see the wider shift in portrayal of gender tropes and romantic interactions. Likewise, this study is limited by the inherent diversity of films; variables that are almost unable to be accounted for include the age, nationality, and gender of directors, setting, religious affiliation, budget of production, and experience of cinematography crew, as each of these could impact the quality and outcome of a film. With selecting only from the pool of Oscar Academy Award nominees comes a degree of misrepresentation of the vast majority of American film, although it was necessary for this study to ensure a set quality of production. As far as the analysis of the data collected, I recognize the limitations, mainly subjectivity, of ranking scales, which is why the conclusions drawn from the correlations shown between sexual assault awareness movements and the portrayal of sexual and romantic interactions rely mainly on trends in specific devices, such as camera angles and specific gender stereotypes, more objectively measured than general trends in the prevalence of tropes and stereotypes. Similarly, the regression lines and coefficients of correlation are slightly undermined by the low values of the ranking scale and the gaps between sections of years, but are still reliable to show linear association over time. Although this particular study is limited in scope, studies showing the impact of sexual assault awareness

35 Paul Thomas Anderson, dir. *Magnolia* (1999; New Line Cinema, 1999), *Amazon Prime Video*.

36 Spike Jonze, dir. *Being John Malkovich* (1999; USA Films, 1999), *Amazon Prime Video*.

37 Todd Field, dir. *In The Bedroom* (2001; 2001), *Amazon Prime Video*.

38 John Lee Hancock, dir. *The Blind Side* (2009; New York City, NY: Alcon Entertainment, 2009), *Amazon Prime Video*.

39 Damien Chazelle, dir. *La La Land* (2016; Venice, Italy: Summit Entertainment, 2016), *Amazon Prime Video*.

40 Paul Thomas Anderson, dir. *Magnolia* (1999; New Line Cinema, 1999), *Amazon Prime Video*.

41 Bradley Cooper, dir. *A Star Is Born* (2018; Venice, Italy: Warner Brothers, 2018), *Amazon Prime Video*.

movements on cultural markers, such as Hollywood film, are particularly important in this age of activism, as they demonstrate that raising awareness for a cause genuinely makes an impact on cultural expectations. As Hollywood films under the constraints of this study depict American culture, examples of romantic interactions and decreases in gender expectations shown in this study impact the societal norms over time and set a precedent of respect that is perpetuated on screens and in the minds of the next generation.

Appendix: *In The Bedroom* Notes

PRE-VIEWING NOTES:

Todd Field: Director and screenplay writer
 American middle-aged white male
 Robert Festinger: Screenplay writer
 American middle-aged white male
 Released in 2001; nominated for 2002 Best Picture
 Indie Film/Drama; 93%

VIEWING NOTES:

- Opening scene is male chasing female, but only her legs are showing (male is fully visible)
- Cuts to kissing scene where only lips are visible
- Female is older single mother and male is young college student
- She stays home while men go lobster fishing - only men are ever seen fishing
- Lobster analogy - females with eggs are dangerous (children) & the males get stuck in what's called a "bedroom"
- Males are all taller than females
- Older males sexualize female protag - "you could borrow hers [buns]"
- She is always seen wearing short or tight dresses - temptress? (as parents would say)
- Mother has a master's degree; parents seem to be in a loving relationship before it breaks down
- Violent and angry ex-husband - sees wife as an object & beats up boy multiple times
- Open air scenes with woman at first; transitions to inside house scenes after boy dies - trapped by

ex-husband & grief

- Father is very sexual at first - boy and mother caught having sex - boy says relationship isn't serious
- Ex uses intimidation and physicality to scare wife into letting him move back in - she doesn't but he tries
- "Sweetie" said three times: once platonically and twice towards women
- Ex says "bitch" when a woman won't go home with him
- Boy always protects woman, but she is not portrayed as helpless or clueless
- Father has a doctorate
- Father wants son to hit ex, but he never does
- Male crying scenes much more profound than women crying scenes
- "Wonderful girl" repetition
- Tension between father figure and his predatory tendencies

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HOLLYWOOD CULTURE: ROMANTIC INTERACTIONS AND GENDER TROPES

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Analyzing Student Perception of Teacher Quality at Mabank High School

Juliet Pridgen

The current teacher shortage occurring across the United States in public high schools has led to the development of Alternative Certification Programs (ACPs). This study aims to analyze the difference in student perception between traditionally certified teachers and alternatively certified teachers in the state of Texas in terms of teaching practices, teacher preparation, and teaching attributes. In this mixed-method research paper, a 27-item questionnaire on a Likert scale was distributed to students at Mabank High School in the 2018-2019 academic school year. The students had the option to evaluate their second period teacher, fourth period teacher, or both. The results of this paper suggest that alternatively certified teachers are not significantly different in their teaching practices from traditionally trained teachers based off of student perception. However, the student perceptions of alternatively certified teachers were poorer in comparison to student perception of traditionally certified teachers in regard to teacher preparation and teaching attributes.

Keywords: student perception, secondary education, alternative certifications, low-income schools, teacher shortage

Introduction

The current teacher shortage in public high schools across America is creating a wide-spread demand for teachers. As the pressure to staff low-income and small schools increases, administrators have been turning to alternative routes of teaching in order to staff schools across the United States. This demand is apparent given released statistics from the Texas Education Agency (TEA). According to the Employed Teacher Demographics (2013-2017) produced by TEA, Texas employed 358,514 teachers in the 2016-2017 academic school year. In the 2012-2013 school year, Texas employed 332,587 teachers. Since 2012,

there has been a steady increase in teachers hired in the state of Texas (Parker, 2018). This indicates Texas's efforts to hire teachers more quickly, oftentimes through alternative programs, in order to address this shortage. As to whether these teachers are trained to effectively teach students is the overarching topic that will be analyzed. This study explores whether these teachers are trained competently according to the perceptions of students within a public high school.

Multiple studies exist examining the extent and effect of teacher quality on student learning. Oftentimes these studies address other reasons such as the level of college readiness of students in order to analyze school quality. However, minimal research exists that

STUDENT PERCEPTION OF TEACHER QUALITY

pertains to the effectiveness of state certification programs and how they affect student performance from the perspective of a student (Goldhaber & Brewer, 2000).

Review of Literature

In order to look effectively at the American education system in public high schools, we must refer to history to understand this system's origins. During the 1960s, the efficacy of post-secondary schooling was not widely supported as a result of unequal access to education given the racially charged time (Baum, Kurose, & McPherson, 2013). As a result, legislators began to address prevalent issues in the American education system such as limited access to post-secondary education and the United States' poor rank amongst other countries in regard to education. Thus, they realized that reforms to secondary education might enhance success in post-secondary schooling.

In 2001, the No Child Left Behind Act (NCLBA) was enacted under President George W. Bush, which set requirements for public schools (elementary through secondary) to meet state academic standards and to increase academic testing (Every Student Succeeds Act, 2015). The NCLBA created standardized tests that public schools would administer to students in order to measure school quality. Additionally, the NCLBA created qualifications that would deem certain teachers as "highly qualified" (Hanushek & Rivkin, 2010). As stated by the TEA, a "highly qualified" teacher was one who held a bachelor's degree, was wholly certified to teach in Texas and demonstrated competency in their core subject (2007). However, the term "highly qualified" was no longer accepted starting with the 2016-2017 academic school year under the 2015 Every Student Succeeds Act (ESSA). The purpose of this was to remove the requirement of the "highly qualified" status; therefore, this let teachers have fewer qualifications to be staffed in high-need school districts.

Subsequently, the ESSA replaced the NCLBA in 2015 under President Barack Obama. The ESSA is an effort by the federal government to provide equal educational opportunities to traditionally underserved students (State of Washington, 2015). As to whether these policies have been effective in their existence

is subject to debate. Despite these efforts to improve education, Chelsea Chicosky (2015), author of *Reconstructing Modern Education*, concluded that the United States ranked below various countries in multiple areas such as math and reading through statistical analysis in 2015.

Alternative Certifications

When analyzing school quality, teacher qualifications must be examined. Teacher credentials are used because they are potential indicators of student achievement. (Clotfelter, Ladd, & Vigdor, 2010). Different states have various policies that determine what classes teachers are able to teach with the certification(s) they have. (Clotfelter, Ladd, & Vigdor, 2010). In Texas, there are two routes to enter the teaching field in public schools: a traditional certification or an Alternative Certification Program (ACP). Traditional certifications usually indicate that a person attended college specifically to become a teacher and obtained a bachelor's degree in education. In contrast, an alternatively certified teacher is someone who demonstrated an interest in the teaching field and underwent an alternative program. Typically, these teachers are employed in high need areas without any former experience with coursework in education; thus, they enter the classroom and complete their teaching requirements while teaching. Alongside alternative certifications, emergency permits and non-renewable permits can be allotted. Emergency permits can be issued when the individual has only completed 24 semester hours in the subject being taught and the district is unable to hire a certified person (DeVreis, 2017). Similarly, a non-renewable permit can be issued if an individual has not completed the proper examination requirements (DeVreis, 2017).

Students undergoing a traditional certification take education courses towards the end of their sophomore year and throughout their remaining two years in college while completing student training. However, students in ACPs may hold any bachelor's degree and they often take education courses a few months prior to when they would like to teach (Baines, McDowell, & Foulk, 2001). Once hired, they complete multiple education courses throughout the school year while teaching. Some common alternative programs for teaching include Alternative Certification

STUDENT PERCEPTION OF TEACHER QUALITY

for Teachers (ACT) and Education Career Alternative Program (ECAP). These organizations recruit prospective teachers and employ them in high-need areas. A comparative study by Baines et al., (2001) found that the requirements to obtain a traditional teaching certification are drastically more demanding than the requirements to receive an alternative certification. In 2001, researchers discovered that traditional state programs required SAT scores as an entry requirement whereas the ACPs they analyzed did not. Traditional programs also required 500-1000 hours of field experience before teaching alone whereas ACPs required zero hours. ACPs also did not have student-teaching as a requirement whereas traditional programs were required to complete a semester long of full-time teaching. It is important to note that the requirements for certain ACPs are not the same and they differ by program.

In an attempt to study the different views of teachers who experienced a traditional certification compared to teachers who underwent an Emergency Certification Program (ECP), Justice, Greiner, and Anderson (2003) contacted teacher graduates from Texas A&M-Commerce and those who experienced an ECP via telephone. A survey was utilized to measure various qualities such as teacher preparedness and orientation. As a result, researchers found that teachers on emergency permits were more likely to teach in high school (Justice, Greiner, & Anderson, 2003). Given that most teachers on emergency permits seldom have their official certification, the data revealed that non-certified teachers felt less prepared to teach in their first year when compared to certified teachers. Teachers with emergency permits expressed frustration due to four primary reasons: an inadequate amount of knowledge to convey to students, inadequacy of classroom management, lack of teaching methods, and the failure to meet student's needs (Justice, Greiner, & Anderson, 2003).

As a result of less experienced teachers, a bigger problem arises in regard to school children's preparation for post-secondary schooling. Meaning, the initial solution to teacher shortages in high school has woefully increased the problem of children's lack of preparedness when entering college as a result of less qualified and experienced teachers. Oftentimes, fresh and inexperienced teachers start their career at poorly performing schools that are in need of improved

academic standards that can only be given by experienced, highly-qualified teachers. (Justice, Greiner, & Anderson, 2003). The schools that are in dire need of highly qualified teachers are receiving new and unseasoned instructors. Therefore, an endless cycle of insufficient teachers are instructing students who perhaps need the most experienced teachers.

Additionally, a study performed in 2006 found that 168 English teachers graduated from Non-University Certification Programs; whereas, the University of Texas, Austin only graduated 27 traditionally certified teachers (Baines, 2006). This represents the growing popularity ACPs as opposed to traditional certifications that are received at four-year institutions. The expanding prominence of alternative certifications is further supported by the fact that one in four first-year teachers come from alternative programs in Texas (Baines, 2006).

In a qualitative and quantitative study that addressed prospective graduates from an ACP, O'Connor, Malow, and Bisland (2011) analyzed improvements that could potentially be implemented in the Teaching Fellows program for alternative certifications in New York City. Two months prior to graduation from the Teaching Fellows program, 68 participants were contacted. Participants were given a survey containing 52 items including Likert scale questions and free-response questions. The survey pertained to information about the program, suggestions for improvement of the program, and long-term objectives of the prospective teacher. Researchers concluded that most of the students wanted the Teaching Fellows curriculum to address classroom management (O'Connor, Malow, & Bisland, 2011). This notion supports previous research as seen in the study performed by Justice, Greiner, and Anderson (2003) in which those who went through the ECP expressed frustration because they lacked classroom management skills.

Teacher Shortage

Regardless of teacher education, the teaching profession is experiencing a dire shortage, especially in rural and metropolitan areas (Feistritzer & Chester, 2003). Research performed by Rots, Aelterman, and Devos (2014) suggest that there are three main issues that directly correlate with the current teacher short-

STUDENT PERCEPTION OF TEACHER QUALITY

age: a lack of people entering the teaching profession, an abundance of teachers leaving the field after recently entering the field, and a multitude of teachers not entering the teaching profession after recently graduating from a teaching program. Additionally, the Teaching Fellows study (2011) supports one of the biggest reasons as to why a teacher shortage is occurring. Rots, Aelterman, & Devos (2014) claim that a huge contributor to the shortage is due to the fact that a large portion of recent graduates from teaching programs leave the teaching field quickly after entering the teaching profession, creating a high turnover rate. In the Teaching Fellows study, approximately 44% of the students enrolled in the Teaching Fellows program who had completed the program had already decided that they would leave their position after two years of teaching (O'Connor, Malow, & Bisland, 2011).

Staffing Problem

Due to teacher shortages, alternatively certified teachers are more likely to teach low-income students at small, rural or urban institutions (Ness, 2010). According to an extensive study performed by Goldhaber and Brewer, students who had a tenth-grade teacher with a traditional certification consistently had higher math and science test scores than students who had teachers with probationary and emergency permits (1999). Additionally, in a study performed in Dallas, Texas, researchers found that fourth graders who were taught by experienced teachers scored higher in reading and mathematics when compared to students who were taught by less experienced teachers (Seebruck, 2015).

Student Perception

In terms of student perception on teacher quality, researchers Siti Azkiyah and Amirul Mukminin conducted a mixed-method study that analyzed teacher quality of 199 student-teachers of three schools in the English Education Program in Indonesia (EEP) (2017). Researchers used a student questionnaire paired with observational research in the classroom to develop their data and findings. Two observation instruments were used: a high inference observation instrument that measured the frequency of certain tasks performed and a low inference observation

instrument that documented each activity that the teacher performed during the teaching exercise. The student survey contained 34 items in a Likert scale format measuring factors such as instruction and orientation. The students perceived their teachers as "good enough" (a score of 3.24 out of 5) whereas the observer considered the teaching quality to be very low (a score of 1.94 out of 5). As a result, Azkiyah and Mukminin were able to develop solutions and improvements to be made for the EEP program such as refining the teaching curriculum offered by their teacher programs. Therefore, this study proves that student perception is a valuable tool to assess teacher quality. In this instance, gaining student perceptions of student-teachers allows for improvements to be made to the teaching programs themselves.

Additionally, the Measures of Effective Teaching (MET) Project, a research project sponsored by the Bill and Melinda Gates Foundation, found that student feedback positively influences students and teachers (Bill and Melinda Gates Foundation, 2012). Therefore, the MET project study was crucial because it deemed student perception as useful and relevant. Not only is it useful for teachers to receive feedback on their overall teaching methods but it also allows for students to communicate their thoughts about their education. Thus, student perception can be used as an adequate indicator to assess teacher quality.

Additionally, this study is heavily significant due to the fact that most research focuses on the level of preparedness of students for college and fails to address how students feel about their education. Students are ultimately affected as a result of the academic legislation that is passed in Texas. Therefore, student perception should be analyzed as a potential indicator to measure teacher quality which is what will be analyzed in this paper.

Methodology

Participants

The faculty and students at Mabank High School were utilized as participants in the study in the spring of 2019. The student participants ($N=156$) were randomly selected to include students who had different core teachers in their second or fourth period classes.

STUDENT PERCEPTION OF TEACHER QUALITY

Approximately 15.6% of the student body at Mabank High School was surveyed. All students ranged from ninth through twelfth grade and were enrolled at Mabank High School. To be included in the study, an opt-out method was used. Parents were notified of the study and were given the option to have their child opt out of the survey at their request. Participants were classified as freshman (23.7 %), sophomore (23.1%), junior (24.4%), or senior (28.8%). Refer to Appendix A, Appendix B, and Appendix C for more information collected on the student participants in the study

Additionally, 32 teachers were surveyed for their teaching credentials in the state of Texas. The teachers selected for the study consisted of two groups: (a) traditionally trained teachers (13 teachers) and (b) alternatively certified teachers (19 teachers). Only teachers who taught core classes during their second or fourth periods at Mabank High School were surveyed.

Survey Mechanism

To examine student perception of teacher quality, data was collected by permission of administrators at Mabank High School. The survey used was broken into four categories: Teaching Practices (7 items), Teacher Preparation (4 items), Teacher Attributes (8 items), and Student Environment (8 items). Teaching Practices is characteristic of the teaching style of the instructor. Teacher Preparation is characteristic of the preparedness of the teacher upon student entrance into the classroom and the general readiness of the teacher on a daily basis. Teacher Attributes imply the teacher's personality and attitude. The Student Environment category was included to gain more knowledge about the personal student (i.e. their grade, hours spent on homework) and was not statistically analyzed as they were only collected for background knowledge of the respondents in the study. The questionnaire contained 27-items and was provided on a Likert scale with the following choices: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree. Negative and positive questions were used to preserve the consistency of the respondents when answering the questions. The survey was adapted in part from the Colorado Education Initiative Student Perception Survey (SPS).

The Sole Institution: Mabank High School

For the purpose of this research, a case study of Mabank High School was performed. According to the most recent 2017-2018 Texas Academic Performance Report published by the TEA every fall, 51.6% of Mabank graduates in the 2016-2017 school year were classified as Economically Disadvantaged indicating that Mabank High School is a Title 1 school district. Title 1 institutions have large proportions of students that come from low-income families. Also, in the 2017-2018 school year, Mabank High School enrolled 1,033 students, classifying it as a 4A school in Kaufman County. According to the new enrollment alignments for the 2018-2020 school years, a school that is classified as 4A has between 505 to 1149 students; whereas larger schools have between 1150 to 2189 students (5A) and 2190 students and above (6A) (University Interscholastic League, 2017). This is important knowledge given that alternatively certified teachers are more likely to be staffed in low-income, small schools.

Data Collection and Hypothesis

The data collection process was carried out over a period of four weeks. A 27-item questionnaire was utilized to collect qualitative data provided by Mabank High School. The survey measured students' perceptions of two particular teachers in the classroom setting. Students were given the option to complete one survey evaluating their second period teacher, one survey evaluating their fourth period teacher, or both. Classes surveyed were limited to Math, Science, English, and Social Studies courses. Elective courses were not used (i.e. Art, Theater, Choir, Athletics, Physical Education, Band, Foreign Language). The surveys were distributed via cellular device through an online survey engine in the form of a Quick Response (QR) code for students to scan during lunch hours (11:23 am -12:57 pm) for students to complete. QR codes (12 copies) were created and posted in the lunchroom in various locations for students to scan. To increase the response rate, the researcher walked around the lunchroom asking for responses. Based off of experimental research, hypotheses were created and tested:

STUDENT PERCEPTION OF TEACHER QUALITY

H_0 : There will be no difference in student perception between traditionally certified teachers and alternatively certified teachers.

H_1 : Student perception of alternatively certified teachers is lower than student perception of traditionally trained teachers.

Statistical Data

To quantify the qualitative data, the qualitative data was coded using the appropriate numbers and statistical analysis was performed subsequently. The data was organized into students who measured teacher quality of an alternatively or traditionally certified teacher, forming two separate groups of respondents based off of teacher certification. It was determined that 87 students analyzed an alternatively certified teacher and 69 students analyzed a traditionally certified teacher, totaling 156 participants. The data was organized by the total number of students who answered “one”, “two”, “three” and so forth for each question out of the respondents who analyzed alternatively certified teachers. The same method was repeated for organizing the responses of the students who analyzed traditionally certified teachers. The data was analyzed using the statistical software “RStudio.” Pearson’s Chi-squared test was utilized to examine whether observed differences between alternatively certified and traditionally certified teachers based off of student perception were statistically significant at 95% confidence for each individual question. Fisher’s exact test was used to ensure the results from Pearson’s Chi-squared test were accurate due to small sample sizes at 95% confidence. For the purposes of this study, if the p value is less than or equal .05, the null hypothesis is rejected and there is more evidence that the alternative hypothesis is true indicating that students’ perceptions of alternatively certified teachers are lower. In contrast, if the p value is above .05 there is more evidence that the null hypothesis is true meaning there is likely no difference in student perception based off of teacher accreditation. See Appendix D for the final values that were generated from Pearson’s Chi-squared test and Fisher’s exact test.

Findings

The results of this study are presented in two parts. The first section aims to describe the overall difference in student perception. This section is intended to provide a general understanding of the results in its qualitative format. The second section aims to describe the data once it was quantified.

The researcher discovered that the students’ perceptions varied; however, analysis of the qualitative data showed that students view traditionally trained teachers more positively than alternatively certified teachers. In order to address the qualitative data, the researcher relied upon the percent of favorable responses to understand the general attitude of students who had teachers with alternative and traditional certifications. Percent favorable responses are the percent of the responses in the top two categories (Strongly Agree and Agree), indicating a more positive attitude toward the given teacher. If the question was negative (i.e. responses that indicated a poor teacher), then the number of students who answered in the lower two categories (Strongly Disagree and Disagree) was taken instead, indicating that the student disagreed or strongly disagreed that the teacher performed a negative action or acted negatively. The data showed that the percentage of favorable responses for the Teaching Practices category of students who evaluated an alternatively certified teacher was 57.7% whereas the percentage of favorable responses for the students who evaluated a traditionally certified teacher was 63.56%. For Teacher Preparation, the percent of favorable responses for alternatively certified was 68.1% whereas the percent of favorable responses for traditionally certified teachers was 75%. Moreover, Teacher Attributes contained 65.5% of favorable responses for alternatively certified teachers compared to the 70.65% of favorable responses for traditionally certified teachers. The percent of favorable responses indicated more positive student perceptions of traditionally certified teachers when compared to the student’s perceptions of alternatively certified teachers in all categories.

In terms of the quantitative data, students who participated in the study reported different perceptions for the specified teacher. Pearson’s Chi-squared values indicated that significant differences exist in student perception of teacher quality. For example, in the Teaching Practices category, question 2 stated that the

STUDENT PERCEPTION OF TEACHER QUALITY

given teacher was able to “break down difficult concepts and explain them in an easier way” for student understanding. This question was statistically significant, $\chi^2(4, N = 156) = .006098, p = .05$, indicating that alternatively certified teachers have a poorer student perception in terms of Teaching Practices. Moreover, question 3 and 4 indicated the same results under the Teaching Practices category. In terms of the Teaching Preparation category, questions 9, 10, and 12 were significant ($p = .05$), all questions which address the preparedness of the teacher upon entering the classroom from the perspective of the student. Question 9 stated that the “teacher is organized and is prepared to teach when students enter the classroom” with $\chi^2(4, N = 156) = .01074, p = .05$. Question 10 addressed the ability to fix grades by claiming that “The teacher puts in grades in a timely fashion that allows me to address any failing or low grades” with $\chi^2(4, N = 156) = .02553, p = .05$. Question 12 was a general question about teacher preparation for the course saying “The teacher is knowledgeable in the curriculum taught” with $\chi^2(4, N = 156) = .03079, p = .05$. The p-values from questions 9,10, and 12 indicate a more positive student perception of traditionally certified teachers as opposed to alternatively certified teachers. Similarly, questions 13-20 addressed Teacher Attributes. Questions 14,16,17,19, and 20 were significant ($p = .05$). For example, question 19 addressed the overall attitude of the teacher by stating “The teacher responds to my questions enthusiastically and positively” with $\chi^2(4, N = 156) < .001, p = .05$. Question 20 acted in the same manner by claiming “This teacher is committed to the success of his/her students” with $\chi^2(4, N = 156) = .006909, p = .05$. It is important to note that some of the items on the questionnaire were not statistically significant, generally implying that student perception is not different based off of certification status, specifically in terms of teaching practices.

Conclusion and Future Study

The purpose of this study was to investigate if student perception of teacher quality differed based off of different educator preparation programs in Texas. A questionnaire was distributed to students to collect data on teacher quality. Student perception of teacher quality differed. A general conclusion can be

made that there is a difference in student perception of alternatively and traditionally certified teachers. This study generates new findings that students perceive teachers differently when teachers have certifications from non-traditional programs compared to teachers that have undergone traditional programs. This conclusion is not surprising as it relates to the decreased preparedness and classroom management of alternatively certified teachers as addressed in research by O'Connor, Malow, & Bisland (2011). Of the teachers surveyed, a larger proportion were alternatively certified than were traditionally certified. By a simple majority, this supports the argument found in Ness (2010) that claimed that alternatively certified teachers are more likely to be staffed in low-income, small schools. Because results from the Teaching Practices category indicated less of a difference in student perception, this suggests that alternatively certified teachers are not significantly different in regard to their teaching practices (i.e. teaching methods) from the perspective of the student. However, students reported significant differences in Teacher Preparation and Teacher Attributes. The perceptions of students were less positive for alternatively certified teachers than the responses for traditionally certified teachers. This leads to the conclusion that alternatively certified teachers could potentially be less prepared or have poorer attitudes about teaching.

The study performed revealed areas of alternative certification research worth exploring in the future. Future studies could compare how specific alternative certifications such as intern certifications, probationary certifications, non-renewable permits, and emergency permits compare to standard certifications of traditional certifications. This study did not consider the various alternative certifications that the teachers had in this study; therefore, more in-depth analysis with increased specificity of teaching certifications would be more beneficial when measuring instructional effectiveness. Additionally, given that only student perception was taken into account, it would be of interest to explore how teacher perception varies based off of educator preparation programs. Given that there are many ACPs in the state of Texas, it would be interesting to understand the perception of prospective teachers who are undergoing an ACP when compared to the perception of prospective teachers who are undergoing a traditional certifica-

STUDENT PERCEPTION OF TEACHER QUALITY

tion program. It would be intriguing to compare the level of mentorship, in-class instruction, and culture of the different programs. The third area of research could be the attractiveness of the teaching profession in terms of individuals who apply for alternative certifications. Given that there is a high turnover rate for teachers, it would be interesting to understand why individuals desire to enter the teaching profession when many people spend about two or three years teaching before moving on to their next occupation. A follow-up study could be performed measuring how many of those applicants who completed the alternative certification are still teaching in the profession. Finally, this study did not take into account the level of difficulty of the class taught by the given teacher or the years of experience by the teacher. A more in-depth study taking into account outside variables could be performed.

Limitations and Implications

The findings in this study should be considered with some limitations. The small sample size of the study may not have been representative of all of Mabank students' perceptions on teacher quality at Mabank High School; therefore, the generalizability of the findings in this study to other schools should be applied with caution. A much larger sample size would widen the scope of this study. Additionally, the collective assessment of the teacher was fully subjective to the student's opinion on the teacher which could have led to response bias. Whether students have the perspective to measure instructional effectiveness is subject to debate. Also, the survey was completed during lunch hours which has the potential to affect the results as lunch is often a time of social interactions filled with numerous distractions. Moreover, this study solely dealt with perception and did not measure student achievement. Whether students with alternatively certified teachers or traditionally certified teachers perform differently in terms of student achievement in an academic environment was not explored. If so, there would be stronger evidence that alternatively certified teachers are less effective in teaching when compared to traditionally certified teachers as seen in previous work like Goldhaber and Brewer's study in 1999.

In terms of implications, it is crucial to understand that the survey in this study was not used to measure if a student liked or disliked a teacher. It was intended to determine student experience with teachers who underwent different educator preparation programs. Also, because teachers heavily influence student achievement, this study has implications for educational administrators and educational state programs. This study has the ability to change state and district policies via academic administrators given that students do recognize a difference between instruction from an alternatively certified teacher and a traditionally trained teacher.

Another implication of getting feedback from students is that these responses have the ability to transform school culture if the proper steps are taken to act on the feedback from students. Meaning, teachers have the ability to question their own method of teaching and determine how it truly affects student learning. With student feedback, administrators have the ability to understand their school(s) better in a way that can lead to significant changes in multiple areas like curriculum and teacher training.

Additionally, the overall attitudes of the students when analyzing alternatively certified teachers reflects the need to improve state certification programs. Although students reflected positive scores for some categories, in order to increase the percentage of favorable responses, educator preparation programs could use improvement in alternative programs that would emphasize training in teacher preparation and teacher enthusiasm. The profession of teaching is important because it is a job which single-handedly influences all other occupations (Baines, McDowell, & Foulk, 2001). Therefore, it is important that educator preparation programs prepare teachers to influence and instruct their students effectively. Reform efforts could be made to create a more effective licensing system or alternative educator programs could set higher standards in order to produce more qualified and competent teachers. On a local level, principals and academic administrators have the potential to analyze the effectiveness of teachers from different educator preparation program backgrounds especially in low-income, small schools. For Mabank specifically, principals could increase their standards for hiring new applicants in order to create a more productive environment for student learning.

STUDENT PERCEPTION OF TEACHER QUALITY

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Appendix A

Characteristics of Student Participants: Grade Level

Table A1

Participant Characteristics: Grade

<u>Grade</u>	<u>n</u>	<u>%</u>
9th (Freshman)	37	23.7
10th (Sophomore)	36	23.1
11th (Junior)	38	24.4
12th (Senior)	45	28.8

1) Table A1 contains the grade level that students chose on the survey instrument as question 25.

STUDENT PERCEPTION OF TEACHER QUALITY

Appendix B

Characteristics of Student Participants: Lesson Grade

Table B2

Participant Characteristics: Lesson Grade

<u>Lesson Grade</u>	<u>n</u>	<u>%</u>
100-90	70	44.9
90-80	53	34.0
80-70	28	17.9
70-60	2	1.28
60-50	3	1.92

1)Table B2 contains the lesson grade that most aligns with their grades on average that students chose on the survey instrument as question 26.

Appendix C

Characteristics of Student Participants: Average hours spent on homework per night

Table C3

Participant Characteristics: Average hours spent on homework per night

<u>Hours spent on homework</u>	<u>n</u>	<u>%</u>
0-1 hours	114	73.08
2-3 hours	33	21.15
4-5 hours	5	3.21
6-7 hours	4	2.56

1)Table C3 contains the number of hours students spend on homework per night on average that students chose on the survey instrument as question 27.

STUDENT PERCEPTION OF TEACHER QUALITY

Appendix D

Results from Pearson's Chi-squared test and Fisher's exact test

Table D4

Results from Pearson's Chi-squared test and Fisher's exact test

Item number	Pearson's Chi-squared value	Fisher's exact value
Q2	0.006098*	0.005354*
Q3	0.8746	0.8841
Q4	0.00001791*	0.0000139*
Q5	0.03457*	0.03566*
Q6	0.2115	0.2143
Q7	0.06511	0.06152
Q8	0.05662	0.05623
Q9	0.01074*	0.01013*
Q10	0.02553*	0.02046*
Q11	0.344	0.3635
Q12	0.03079*	0.02844*
Q13	0.3329	0.3332
Q14	0.05449*	0.0536*
Q15	0.4245	0.4388
Q16	0.02302*	0.01885*
Q17	0.0486*	0.04533*
Q18	0.2716	0.2827
Q19	0.0004591*	0.0003535*
Q20	0.006909*	0.0052538*
Q21	0.3556	0.3399
Q22	0.4079	0.4162
Q23	0.6359	0.6442
Q24	0.5727	0.5782

1) Table D4 contains the p-values computed from Pearson's Chi-squared test and Fisher's exact value from RStudio software

2) * = $p \leq .05$. Fisher's Exact test was used to ensure accuracy of Pearson's Chi-squared test due to small sample size

Sharing is Caring: The Effects of Communication Mediums on Self-Disclosure in Adolescents

Sawsan Haider

Self-disclosure, the process by which individuals disclose intimate information about themselves, is a psychotherapeutic technique used to decrease tension and build trust between a therapist and their patient. This true experimental study focuses on identifying the communication medium (face-to-face, online chat-room, or virtual reality chat) which induces the highest rates of self-disclosure in adolescents. The study was conducted at a University Preparatory School and used a series of disclosure sessions with 42 students aged 13-18. In each of the three communication mediums, participants were asked to respond to a series of discussion questions. Responses were recorded and analyzed using a computer software to generate quantitative self-disclosure levels. Both face-to-face and virtual reality communication stimulated high levels of self-disclosure and greater usage of vocabularies associated with high-intimacy topics such as death and violence. The study therefore concluded that virtual reality is a promising medium that can be utilized during therapy sessions.

Keywords: Self-disclosure, virtual reality, psychotherapy, communication mediums

1. Introduction

Self-disclosure, the process by which an individual discloses intimate information about themselves, has become ever more significant in Canadian psychotherapy (Farber, 2006, p. 7). Throughout self-disclosure sessions, patients will often disclose problems that are the primary sources of their distress and this act of disclosing would “decrease tension and improve awareness of viewpoints” (Silove, Ventevogel, & Rees, 2017, p. 13). To facilitate psychotherapeutic development, psychologists observe their patients’ psychodynamics and structure their discussions to encourage high levels of self-disclosure (LOSD). Psychologists will also choose to observe the topics of self-disclosure (TOSD) and the cognitive processes (CP) demonstrated by their patient (Maroda, 2010). Similarly, virtual reality therapy is increasingly being used by

therapists to aid with their patients’ well-being. Dr. Giuseppe Riva (2017), Professor of Psychotherapy at the University of Denver, argues that virtual reality can be used as “a potentially effective way to provide general and specialty health care services, and appears poised to enter mainstream psychotherapy delivery” (p. 220). Virtual reality may facilitate greater levels of discourse within a therapy session and is gradually becoming an accessible medium with which individuals can communicate with (Bruss, 2010, p. 134).

This paper aims to examine the influence of selected communication mediums (face-to-face, online chat-rooms, and virtual reality chatrooms) on the LOSD, TOSD, and CP of high school students in a disclosure setting¹. This study’s results may propose methods outside of conventional therapy outlets (such as face-to-face meetings or online support groups) that can generate a greater degree of disclosure for those

¹ An environment where individuals are prompted to disclose personal information about themselves

in need of therapy. Several studies suggest that there exists a correlation between the communication medium of a therapy session and “the degree to which patients experience inclinations to disclose personal information, the subjects’ frequent references to specific disclosure topics, and the subjects’ display of cognitive language” during the disclosure sessions (Brandon, 2016, p.125; Ruppel, 2015; Nguyen, 2012). Through evaluating and considering current literature, it is hypothesized that virtual reality, which is generally associated with both anonymity and immersion, will generate greater cognitive expressions and higher LOSD during disclosure. Alternatively, online chatrooms, which are often associated with anonymity yet a detachment from reality, will induce lesser use of cognitive language and lower LOSD. This research thus hopes to establish a better understanding of the mood-altering characteristics present within differing communication mediums by assessing the medium’s ability to direct self-disclosure.

The aim of this true experimental study is to examine which communication methods may generate greater degrees of disclosure for future patients of mental illness, an increasingly critical problem in Canada (CAMH, 2017). Currently, 34% of Ontario high school students indicate “high levels of psychological distress” and nearly 1 in 3 Canadians will experience mental illness during their lifetime (Center for Addiction and Mental Health, 2017). Those aged 15 to 24 are identified by the Centre for Addiction and Mental Health (CAMH) to be the group that is most vulnerable to mental illness (CAMH, 2017). This paper can be used to classify and explore the use of potential methods that therapists can use to provide adequate service for this growing patient population.

2. Literature Review

Limited research has been conducted on the role that virtual reality can play in psychotherapy and in eliciting self-disclosure. To explore the topic, the differences in the rates of self-disclosure between conventional communication mediums will be considered as well as the theoretical principles that help to explain such differ-

ences. The extent to which virtual reality is currently being used in therapy should also be considered as this can help build a deeper understanding of how best to use virtual reality in therapeutic sessions.

2.1 Existing Views of Differences in Computer-Mediated and Face-to-Face Disclosure

Inconsistent findings have resulted in opposing conclusions concerning the differences in computer-mediated and face-to-face self-disclosure. Dr. Melanie Nguyen (2012), Professor of Psychology and Behaviour and Senior Lecturer in eHealth and Cyberpsychology at the University of Sydney, observed that “discussions of online communication often assume greater self-disclosure in computer-mediated communication than face-to-face” (p. 103). Another review of computer mediated disclosure by Psychology Professor Jinsuk Kim (2011) from the University of Haifa observed that “a rapidly increasing body of experimental and anecdotal evidence suggests that computer-mediated communication (CMC) and general Internet-based behavior can be characterized as containing high levels of self-disclosure” (p. 162). Comparably, Valkenburg and Peter (2009) employed both experimental and survey studies to “repeatedly demonstrate that CMC stimulates self-disclosure” (p. 2). In an experimental study with 690 pre-adolescents and adolescents (p. 10-17), they revealed that medical patients tend to report more symptoms and undesirable behaviors when interviewed by computer rather than when interviewed face-to-face (p. 17). However, while some researchers claim a “robust” (Taddei, 2013, p. 824) and “pervasive” (Suler, 2004, p. 321) difference in self-disclosure between each communication platform, others have observed inconclusive and unconvincing findings regarding such differences (Nguyen, 2012; Ruppel, 2015).

2.2 Theoretical Underpinnings of Self-Disclosure and their Applicability to VR

The role of a communication medium (e.g., face-to-face or computer-mediated) has received extensive

consideration in the literature on self-disclosure, yet it continues to be both a theoretically and empirically contested issue (Nguyen, 2012, p. 103). There have been several psychological theories posited to explain the differences in the rates of self-disclosure between these mediums the most influential and applicable of which are 1) the online disinhibition theory (Suler, 2004), 2) the social exchange process theory (Clair & Giles, 1982), and 3) the media richness theory (Nguyen, 2012). Existing research on the inherent characteristics of virtual reality can be applied to each of these theories to help predict and understand the effectiveness of virtual reality in psychotherapy in relation to other communication mediums. This section will thus explore each of the four aforementioned theories.

2.2.1 Online Disinhibition Effect

The online disinhibition effect, as explained by John Suler, the department specialist in psychotherapy and psychopathology at Rider University, is a phenomenon in which some people, while online, will “self-disclose or act out more frequently or intensely than they would in person” (p. 321). Inspired by Freud’s “archeological model of the mind,” this theory rests on the supposition that one’s personality is formed of layers and that a “core, true self exists behind several layers of defenses” and artificial norms of everyday social interactions (Burgoon, 1993, p. 190). It is on this basis that different modalities of interaction (e.g., computer-mediated, face-to-face, virtual reality) may facilitate diverse expressions of the self and thus, different degrees of self-disclosure. Suler’s research argues that there are three key characteristics of online communication that facilitate this disinhibition²: anonymity, dissociative imagination, and asynchronicity (Suler, 2004, p.321).

The first characteristic is *anonymity*. One of the major theories of the disinhibition effect is that a heightened sense of anonymity, as seen in online communication, allows individuals to dissociate their actions online from their in-person lifestyle and thus, they feel “less vulnerable about self-disclosing and acting out” (Suler, 2004, p. 323). In comparing degrees of self-disclosure between in-

dividuals in visually anonymous (no webcam) and non-anonymous (webcam) communication, Dr. Louis Schmitt and Dr. Paul Brunet, both professors of Psychology at Oregon State University, support the aforementioned claim and conclude that there is a greater degree of disinhibition in anonymous conditions. They argue that it is this ability to detach oneself from what they say online that creates a perception that they do not have to “own” their behavior and thus, are less restrained in sharing (Brunet & Schmidt, 2007, p. 945). Similarly, Dr. Olivia Bruss, Professor of Psychology at Wisconsin Lutheran College provides a unique perspective in supporting this claim. Her paper provides analysis into how disinhibition is directly linked to deindividuation. That is to say that anonymity (and thus, a dissociation from reality) makes it so that individuals are less likely to see others as people and thus, feel as if their disclosures are less prone to producing immediate social consequences (Bruss, 2010, p. 6). However, Dr. Erin Hollenbaugh, professor of psychology at Kent State University, argues, instead, that visual anonymity leads to less disclosiveness in blogs. Results revealed that participants disclosed more information in their blog entries when they had a profile picture or shared photos of themselves and were thus, more visually identifiable (Hollenbaugh, 2013, p. 298).

Suler’s second factor of disinhibition is a phenomenon known as *dissociative imagination*. Suler argues that the dissociative properties of online communication- which allows individuals to effortlessly escape from what happens online- coupled with the ability to create an online persona of oneself (or imaginary character) is thought to magnify the rate of disinhibition and thus, the rate of self-disclosure (Suler, 2004, p. 325). Emily Finch, Professor of Criminal Law at the University of Southern California and researcher specializing in cyberspace identity theft, has similarly argued that “some people see their online life as a kind of game with rules and norms that don’t apply to everyday living” and thus, act or say things that they would not in everyday life. (E. Finch, 2002, p. 36). In a systematic decadal literature review, Dr. Aardema, applies this principle to virtual reality and argues that this phenomenon would be exponentially magnified

2 A lack of restraint in sharing about oneself

as the success of these virtual environments fundamentally relies on their ability to induce dissociative experiences—whether it be through depersonalization³ or derealization⁴.

The final factor is that of *asynchronicity*. A key characteristic of online communication (that is not shared by face-to-face communication or virtual reality) is that individuals do not interact in real time—one can respond in however much time they choose. Two opposing arguments arise from this characteristic. The first is that, according to Suler, asynchronicity can allow people to participate in an “emotional hit and run,” allowing them to put their information out there and then leave it behind, with no obligation to respond (Suler, 2004, p. 322). This lack of obligation is a disclosure incentive. Judee K. Burgoon, Professor of Communication at University of Arizona, contends with this analysis. Instead, Burgoon (1993) argues that a delay in response can allow people to more rationally think through their actions and thus, be more cognizant of social consequences that could arise. This in turn would make asynchronicity an inhibition factor (Burgoon, p. 973). However, since 1993, online methods of communication have become increasingly less asynchronous as individuals can respond almost immediately as if they were having a real time conversation.

2.2.2 Social Exchange Process Theory

According to a report published Dr. Howard Giles and Dr. Robert Clair in the American Journal of Linguistic Society, the social exchange process theory states that “prior to acting, we attempt to assess the rewards and costs of alternate courses of action” and ultimately base decisions off what will bring the greatest benefits and least costs. In respect to self-disclosure, Giles and Clair (1982) argue that individuals will be more likely to share if they are less prone to immediate social consequences (Clair & Giles, 1982, p. 321). Similar to Suler’s online disinhibition effect, they conclude that in computer mediated environments, individuals are more detached from reality (and thus the consequences that come along with it) and therefore, are

more prone to self-disclose (Suler, 2004; Clair & Giles, 1982). However, Professor Adam Joinson, Professor of Information Systems at University of Bath, suggests that the dangerousness and open-access nature of the internet can cause people to be less inclined to share as they believe that their information can spread more easily and, thus, have greater societal consequences. He therefore posits that face-to-face communication elicits a greater degree of self-disclosure (Joinson, 2003, p. 74)

2.2.3 Media Richness Theory

Unlike the other three theories, the Media Richness Theory (MRT) predicts greater degrees of disclosure in face-to-face environments compared to computer-mediated communication. MRT ranks communication channels on a “richness continuum” where a “rich channel” is one that allows for feedback and the use of a range of cues. Under this context, face-to-face communication is inherently a “richer” medium than computer-mediated communication in that it allows for “the use of gestures, verbal and paralinguistic channels” for communicating (Nguyen 2012; Kang 2010). In this respect, virtual reality, a medium often associated with immersivity, can be considered a “rich media” and could help to facilitate greater degrees of disclosure.

2.3 Gap Analysis

Despite the considerable research that exists on the rates of self-disclosure among varying communication mediums, the role of virtual reality in self-disclosure is a relatively new field. This study would be one of the first to analyze the intersection of virtual reality in the discipline of self-disclosure through an experimental lens. In addition, the demographic targeted (youth aged 13-18) and location of the experiment are different than that of any previously conducted experiment of its kind as it focuses in large part, on self-disclosure in adolescents- one of the most vulnerable groups to mental illness (CAMH, 2017).

3 a state in which one’s thoughts and feelings seem unreal or not to belong to oneself

4 a feeling that one’s surroundings or situations are not real

3. Methodology

In reviewing existing literature, it is hypothesized that virtual reality (VR) will induce higher levels of self-disclosure than face-to-face (FTF) and computer-mediated (CM) communication as it leverages both the anonymity of online communication and naturalness/spontaneity of face-to-face communication. In order to analyze the extent to which communication mediums (FTF, CM, VR) can affect the degree and quality of self-disclosure, a series of conversation-based disclosure sessions between two partners will be recorded and analyzed. The following methodology section will explain 1) the design of this study, 2) the data collection methods used, and 3) ethical considerations.

3.1 Design

This study employs a true experimental design: a quantitative approach that “aims to establish a possible cause and effect [C&E] conclusion between... independent and dependent variables” (Creswell, 2014, p. 294). True experiments seek to remove systematic discrepancies between participant traits that are “potential confounding factors” by randomly assigning subjects to experimental groups (which receive treatment) and at least one comparison group, which receives no treatment or other manipulation (Schutt, 2018, p. 38). These different conditions of the independent variable determine deviations in the dependent variables. In this study, the manipulated independent variable is the communication medium (FTF, CM, VR), and the dependent variable are 1) the level of self-disclosure (LOSD) and 2) the perceived level of self-disclosure (PLOS) from the perspective of the participants.

According to Dr. Barry Gibbons, Senior Researcher at the National Center for Research on Evaluations, Standards, and Student Tests, the “strongest quantitative comparisons come from true experimental designs in which subjects are randomly assigned to program and comparison groups” (Gibbons, 1997, p. 4).

It is this use of random assignment that differentiates true experimental designs from other methods such as a quasi-experimental design (Salkind, 2012). While a quasi-experimental research design [non-random assignment] allows for greater control in partnering up subjects, it does not allow for the elimination of confounding variables and thus has “a generally lower internal validity than true experiments” (Salkind, 2012, p.136). Ultimately, because this study aims to establish a C&E relationship between the medium of communication and the degree of self-disclosure, a true experimental design was chosen. This is because true experimental designs will lend “the strongest argument for the existence of a cause-and-effect relationship” as it includes a) the random selection of subjects, b) the random assignment of groups (partnerships), c) the establishing of a control group, and d) the random assignment of treatments (Gibbons, 1997, p. 5). In a study that relies on establishing a C&E relationship, the use of random assignment is necessary in assuring that groups and treatments are truly comparable and observed variations are not simply the outcome of “extraneous factors or pre-existing differences” (Salkind, 2012, p. 135)

3.2 Data Collection Methods:

3.2.1 Stage 1: Participant Recruitment and Grouping

Upon receiving approval by the ethics review board at my institution and at the selected research site, a secondary school/high school located in the Greater Toronto Area, Canada, a series of disclosure sessions were conducted using 42 students aged 13-18 [grades 9 through 12]. Through the use of a random number generator, participants were assigned to one of three conditions: face-to-face, online chat-room⁵ or virtual reality. Participants were also randomly assigned to a partner within their group. Each pair of participants in the face-to-face group disclosed within the same room to control for environmental factors that may influence the users’

⁵ Private online spaces where users communicate with one another through text-based messages.

“mood and productivity, such as architectural design and light exposure” (Ayers & Baum, 1996, p. 926). Participants in both the online chat-bot and virtual reality groups disclosed in separate rooms to preserve anonymity.

3.2.2 Stage 2: Pre-Experimental Questionnaire

Upon arriving at their respective testing room, participants completed a 7-section pre-experimental questionnaire that asked about their gender, ethnicity, and age (see Appendix A). This questionnaire also included the Positive Affect and Negative Affect Schedule (PANAS), which assessed subjects’ pre-disclosure mood differences, and the Self-Concealment Scale (SCS), which evaluated participant’s daily concealment of personal information by asking them to agree or disagree with 10 prompts [1 being strongly disagree and 5 being strongly agree] (Watson, 2017; Larson, 1990). Ultimately, this pre-experimental questionnaire established factors, such as mood and natural self-disclosure tendencies, that may affect the results if uncontrolled. Both the PANAS and SCS are quantitative measurement tools that required participants to answer questions on a Likert scale (Watson, 2017; Larson, 1990).

3.2.3 Stage 3: Self-Disclosure Sessions

Participants were then each provided with a printed sheet containing the disclosure instructions and a series of three discussion questions (see Appendix B) ; each of which designed to encourage self-disclosure. Within the virtual reality group, instructions and discussion prompts were displayed on the participants’ screens. Discussion questions were taken from Aron, Melinat, Vallone, and Bator’s 1997 Closeness-Generating Questions (CGQ) (see Appendix B). Samples from the CGQ include “if you have to move from where you consider home, where would you go, and what would you miss the most about home?” (Aron, Melinat, & Valone, 1997, p. 189). Following the induction and task directions, the experimenter left the room. A timer was placed in the room and participants were informed that they had five minutes to answer each question. The 15-minute oral disclosures of the participants were recorded with a phone. These

recordings will later be analyzed by a computer algorithm to generate quantitative self-disclosure levels.

3.2.4 Stage 4: Post-Experimental Questionnaire

After completing the disclosure session, participants were asked to complete an adapted version of the Revised Self-Disclosure Scale (Wheeless, 1976). This was a 9-item post experimental questionnaire (PEQ) designed to determine participants’ perceived level of self-disclosure (see Appendix C). Questions from the Wheeless Revised Self-Disclosure Scale were adapted to be more applicable to the interactions of this experiment. The PEQ was designed to measure two things; the first of which is the amount and quality of self-disclosure that participants felt they exhibited in the conversation. Sample items from the RSDS include: “In this experience, I often disclosed intimate personal things about myself without hesitation” and “In this experience, I did not often talk about myself” (Wheeless, 1976, p. 2). The PEQ was also measured the amount and quality of self-disclosure that a participant felt their partner exhibited in the conversation. Sample items included: “In this experience, my partner talked about his/ herself for fairly long periods at a time” and “In this experience, my partner did not seem honest in his/ her self-disclosures” (Wheeless, 1976, p. 2). This portion of the PEQ was composed of Likert-Scale based questions. As a control measure, the PEQ included questions concerning i) the extent to which participants felt they knew their partner before this experiment and ii) how often the study had been thought about by the participants. Both the pre-experimental and post-experimental questionnaire are designed to isolate for confounding variables (i.e pre-disclosure moods or tendency to share personal information) and to measure participants’ perceived rates of disclosure (i.e. how much the participant felt like they shared throughout the session).

3.3 Ethical Considerations:

Because this study inherently deals with the sharing of participants’ personal information, several precautions must be taken to safeguard the study’s ethical validity. The first major concern is the pro-

tection of information and personal data shared by participants within the disclosure sessions. On top of requiring a consent form, the experiment was designed in a way such that it would be measuring the degree of self-disclosure in conversations between strangers/random partners and thus, anything that participants share is information that they would be comfortable sharing with people they had just met. More than that however, because the experimenter was not present in the room during any of the disclosure sessions and because all data collected was collected and analyzed via a recording, all disclosed content was only heard by the participants themselves and never seen by the experimenter. The recordings of each conversation were never listened to and were immediately inputted into an online algorithm to generate quantitative self-disclosure levels. This allows for the removal of any conflicts of interests and ensures that all disclosed information within the sessions was only heard by the participant and their partner. This study was approved by my institution's internal ethics review board.

4. Findings

The experiment was carried out with 42 high school students in grades 9-12, between the ages of 13-18, at Appleby College, a suburban high school in Ontario, Canada. For each experimental group, PANAS, pre and post experimental questionnaires (PEQ), and SCS scores were translated into means and standard deviations for comparison according to each dependent variable. Scores on PANAS, the pre-experimental questionnaire, and the SCS were used to establish and compare possible confounding variables. The post-experimental questionnaire was used to compare perceived rates of disclosure throughout each of the three groups. Audio recordings of each of the disclosure sessions were uploaded electronically to Sonix- an audio to textual transcript generator. The transcripts were then entered into the Linguistic Inquiry and Word Count (LIWC) 2015 algorithm where the average word counts for a) specific disclosure content categories [Family, school, friends, violence, and death] and b) verbal cognitive expressions were calculated. The verbal cognitive expression aspect of

the algorithm grouped the individual's vocabulary by whether it revealed insightfulness, tentativeness, or causation. The word count of cognitive vocabulary and disclosed content categories were converted into means and standard deviations. For example, repeated use of the word "suicide" throughout the disclosure session would be flagged in the 'death' content category, thereby increasing the mean word-count value for that category. The means and standard deviations will be used to compare the actual rates of disclosure within each of the three communication mediums.

For each dependent group, a F-test in one-way analysis of variance (ANOVA) was performed. F-tests are statistical tests used to evaluate the validity of the null hypothesis (Watson, 2017). This hypothesis states that there is nothing significantly different between the dependent groups. If the null hypothesis is valid, the F-statistic will yield a value of 1 ± 0.5 . Probability values (p-values) were computed for each F-statistic to determine their significance (see Appendix D). If the p-values are lower than the pre-determined significance level (α) such as 0.1 or 0.05, the findings are significant, and the null hypothesis can be overruled. The null hypothesis cannot be rejected, however, if these values are greater than α and thus not statistically significant.

4.1 Establishing Control Variables

One-way ANOVAs were calculated for pretest positive and negative affect (PANAS) scores, SCS scores, and certain pre-experimental questionnaire scores. For each group, the F-statistic is within the range of . Therefore, the null hypothesis, which postulates that mean values across experimental groups are the same, is true. The significance level was pre-determined to be 0.1. All p-values are larger than α and thus statistically significant. Therefore, the groups were equivalent on all control variables.

4.2 Perceived Rates of Disclosure

A participant's perceived rate of disclosure is the degree to which the participant felt like they self-disclosed throughout the session. This was measured using the post-experimental questionnaire in which participants were asked to rate the extent to which

SELF-DISCLOSURE AND COMMUNICATION MEDIUMS

Table 1: Means, Standard Deviations, and Summary of Analysis of Variance of Control Variables by Group

Variable	Face-to-Face M (SD)	Computer-Mediated M (SD)	Virtual Reality M (SD)	F-Statistic	P-Value
Positive Affect (PANAS)	25.42 (2.04)	26.30 (1.97)	23.65 (2.00)	0.99	0.3656
Negative Affect (PANAS)	11.43 (1.04)	12.31 (1.08)	11.97 (0.99)	1.01	0.34557
Self-Concealment	22.45 (1.13)	21.98 (1.27)	22.31 (0.98)	1.20	0.40948

Note: M=Mean; SD = Standard Deviation. All Ms and SDs are rounded to two decimal places. All degrees of freedom= (3,48). All F's are not significant, $p>=0.1$.

Table 2: Means, Standard Deviations, and Summary of Analysis of Variance of Perceived Disclosure Levels

Variable	Face-to-Face M (SD)	Computer-Mediated M (SD)	Virtual Reality M (SD)	F-Statistic	P-Value
Personal	6.13 (1.10)	4.67 (0.83)	5.05 (0.94)	4.50	0.0234
Emotionally Revealing	6.23 (0.49)	4.57 (0.76)	5.35 (0.99)	4.32	0.0367

Note: M=Mean; SD = Standard Deviation. All Ms and SDs are rounded to two decimal places. All degrees of freedom= (3,48). All F's are significant, $p<0.05$.

they felt the session was personal⁶ and emotionally revealing⁷.

In terms of how personal the participants regarded their disclosure session, the effect of communication mediums was statistically significant. This is because when α is predetermined to be 0.05, the F-statistic for this group is larger than 1 and can be considered statistically significant. In terms of how emotionally revealing participants rated their disclosure session, the data also reveals that the effect of communication medium was significant. The null hypothesis thus can be rejected.

To pinpoint individual disparities between experimental groups, the means of each category were examined. Participants in the face-to-face group rated their session as being drastically more personal and emotional than those in the other two groups.

4.3 Disclosure Content Categories (Actual Rate of Disclosure)

Communication mediums did not significantly affect the mean word counts for the disclosure topics of family, school and friends. The F-statistics for the content categories of violence and death are greater than 1 and thus, statistically significant when α is predetermined to be 0.05. This indicates that communication mediums had a very significant effect on the use of vocabulary related to death and violence. The null hypothesis can be rejected for these two groups.

To pinpoint individual disparities between experimental groups, the means of each category were examined. Participants in the virtual reality group referenced words linked to death and violence considerably more than those in the other two groups.

6 The degree to which the information shared was intimate and concerning their private life

7 The degree to which the disclosure session elicited strong emotional responses in the individual (sadness, anxiety, fear, anger etc.)

SELF-DISCLOSURE AND COMMUNICATION MEDIUMS

Table 3: Means, Standard Deviations, and Summary of Analysis of Variance of Disclosure Content Categories

Variable	Face-to-Face M (SD)	Computer-Mediated M (SD)	Virtual Reality M (SD)	F-Statistic	P-Value
Family	1.18 (0.59)	1.14 (0.78)	1.13 (0.77)	0.35	0.13534
Friends	1.11 (0.76)	1.18 (0.85)	1.15 (0.79)	0.45	0.23985
School	1.10 (0.76)	0.95 (0.79)	0.91 (0.77)	0.03	0.99034
Violence	0.66 (0.70)	0.14 (0.17)	0.97 (0.81)	3.04	0.03458
Death	0.05 (0.10)	0.01 (0.03)	0.16 (0.19)	3.56	0.00348

Note: M=Mean; SD = Standard Deviation. All Ms and SDs are rounded to two decimal places. All degrees of freedom= (3,48). F is are significant, $p<0.05$. F is very significant, $p<0.001$.

4.4 Verbal Cognitive Expression (Actual Rate of Disclosure)

Results from Table 4 suggest that the effect of communication mediums on the cognitive processes of causation and tentativeness were significant. The F-statistics for these categories are larger than 1 and thus, statistically significant when α is predetermined to be 0.05. The null hypothesis can be rejected. The category of insight, however, was not significantly affected by different mediums as seen by an F-statistic smaller than 1.

To pinpoint individual disparities between experimental groups, the means of each category were examined. Participants in the computer-mediated

group referenced considerably more tentative vocabulary than those in the face-to-face and virtual reality groups. Oppositely, both face-to-face and virtual reality environments caused participants to utilize more language linked to causation than the computer-mediated group.

5. Discussion

5.1 Perceived Rates of Disclosure

An analysis of the post-experimental questionnaire ratings reveals a causal relationship between the communication medium and the participant's perceived

Table 4: Means, Standard Deviations, and Summary of Analysis of Verbal Cognitive Expression

Variable	Face-to-Face M (SD)	Computer-Mediated M (SD)	Virtual Reality M (SD)	F-Statistic	P-Value
Insight	2.47 (1.35)	2.50 (1.23)	2.45 (1.34)	0.04	0.98
Tentativeness	3.10 (0.97)	4.08 (1.04)	3.09 (0.93)	3.22	0.03
Causation	1.35 (0.89)	0.67 (0.54)	1.31 (0.78)	3.01	0.04

Note: M=Mean; SD = Standard Deviation. All Ms and SDs are rounded to two decimal places. All degrees of freedom= (3,48). All F's are significant, $p<0.05$.

rates of disclosure, as measured by how personal and emotionally revealing they thought the disclosure session was. Participants in the face-to-face group rated their disclosure material as significantly more personal and emotional than those in the other two groups as denoted by the group's high mean-value.

This conclusion aligns with the claims made by Joseph Forgas and Julie Fitness (2008), social psychologist and professor of psychology at Macquarie University, respectively, who claim that environments, such as face-to-face communication, which allow for "the use of gestures, paralinguistic channels, and social cues" can make individuals feel as if they are sharing more than what they are sharing in actuality. Participants' perceived rates of disclosure in comparison to their actual rates of disclosure is something that must be considered when determining which of the three mediums is the most favourable.

5.2 Disclosure Content Categories (Actual Rate of Disclosure)

The results indicate a causal relationship between communication medium and topics of disclosure. Participants who disclosed in VR referenced language linked to violence and death more than those who disclosed in the other two environments. The F-test determined that the variances within the categories of violence and death are statistically significant, and the experimental nature of the design confirms this C&E relationship between the variables. Communication mediums did not significantly influence the categories of family, friends, and school.

These findings align with the literature review which suggests the virtual reality can induce greater rates of self-disclosure for certain topics because it leverages both the anonymity and dissociative properties of online communication and naturalness/spontaneity of face-to-face communication. The rates of disclosure within the categories of family, school, and friends were not hugely affected by communication mediums ($p > 0.05$). Dr. Carl Pickhardt (2010), psychologist in personal psychotherapy, claims that topics such as university, friendships, and parental relationships may be considered "low intimacy topics". Likewise, Noah D. Forger (2011) recognizes these topics as "low disclosure topics" due to "their lack of association with individualized affects" (p. 453).

Therefore, according to the results, virtual reality can be considered the medium which induces the greatest rates of self-disclosure for high intimacy topics such as violence and death while all three mediums are relatively equal in inducing disclosure for low intimacy topics such as friends, family, and school. Thus, the implication of this finding is that VR environments are favourable for eliciting highly personal and intimate sessions of self-disclosure.

5.3 Verbal Cognitive Expression (Actual Rate of Disclosure)

The results in Table 4 indicate a causal relationship between communication medium and certain cognitive processes. Participants in the computer-mediated group referenced significantly more tentative vocabularies than those in the face-to-face and virtual reality groups. Alternatively, both face-to-face and virtual reality environments caused participants to express more words associated with causation than the computer-mediated group. The F-test determined that the variances within the groups for verbal expressions of tentativeness and causation are statistically significant, and the experimental nature of the design confirms this C&E relationship between the variables.

The aforementioned analyses of disclosure rates revealed that computer-mediated environments induced the lowest levels of disclosure for high-intimacy topics such as violence. This group also had the highest use of tentative vocabulary. The opposite can be true for face-to-face and computer-mediated environments which induce higher levels of disclosure for high-intimacy topics and higher use of language associated with causation. This aligns with the claim of Katayama et al. (1996), who suggests that low intimacy levels may cause increased hesitancy and tentativeness. The implication from this finding is thus that environments which induce lower intimacy and disclosure rates (in this case, computer-mediated environments) are shown to undermine self-confidence, which could increase one's use of vocabulary such as "maybe". FTF and VR environments are thus favourable because they elicit higher rates of disclosure for more intimate topics.

According to a study by Ryo Orita and Masashi Hattori (2019), professors of psychology at Ritsumeikan University, all levels of intimacy can facilitate

insight in dialogue. Consequently, the mean word-counts of insight were not immensely influenced by communication mediums, which induced differing levels of intimacy and emotion throughout the disclosure sessions.

6. Conclusion

For Ontario students aged 13-18, both FTF and VR communication stimulated high levels of self-disclosure and generated higher usage of vocabularies associated with high-intimacy topics such as death and violence. While VR communication had higher levels of self-disclosure, FTF communication generated higher perceived levels of self-disclosure indicating that despite having shared less in these disclosure sessions, subjects felt that these were more emotionally revealing and personal. CM communication had generated lower levels of self-disclosure than the other two environments and higher usage of vocabularies associated with tentativeness and doubtfulness. The incorporation of the studies of emotion, cognition, and self-disclosure as co-disciplines of therapeutic communication methods allows for a better understanding of subject responses. In the future, experts may start to utilize VR technology during therapy sessions for greater functionality, elevated intimacy, and to stimulate recovery discussions on trauma-related topics such as death and violence. Future research trajectories may include exploring how to optimize virtual reality environments to induce greater rates of self-disclosure. Other possible trajectories include observing the long-term effects of self-disclosure on individuals (i.e. measuring the effects of differing communication mediums on individual psyches throughout several months or years).

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SELF-DISCLOSURE AND COMMUNICATION MEDIUMS

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Appendix A: Pre-experimental Questionnaire

This questionnaire contains questions regarding your sex, ethnic background, and mood-altering behaviour. Please check the box that corresponds to your answer and be sure to answer all the following questions to the best of your ability. All results will not be shared outside of this study.

Item 1: What is your biological sex?

Female

Male

Item 2: Which race / ethnicity do you identify with?

Caucasian

Asian

Latino or Hispanic

Black or African American

Indigenous peoples or Native Americans

If it is not listed above, please indicate below:

Item 3: What is the dominant ethnic constituency of your household?

Caucasian

Asian

Latino or Hispanic

Black or African American

Indigenous peoples or Native Americans

If it is not listed above, please indicate below:

Item 4: Have you been consuming any of the following medication in the last four weeks? Please check all the boxes that apply.

Cardiac and high blood pressure medication

Yes No

ADHD medication

Yes No

SELF-DISCLOSURE AND COMMUNICATION MEDIUMS

Other medications that pose side-effects associated with mood alteration

Yes No

If yes, please indicate how the medication affects your mood below:

Item 5: During the past three weeks, have you been:

Bothered by feeling down, depressed, or hopeless?

Yes No

Bothered by little interest or pleasure in doing things?

Yes No

Suffered frequent mood swings and attacks of anxiety?

Yes No

Item 6: Positive and Negative Affect Schedule (PANAS)

This scale consists of a number of words and phrases that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have felt this way during the past week. Use the following scale to record your answers:

1 2 3 4 5
very slightly a little moderately quite a bit extremely
or not at all

_____ Interested _____ Guilty _____ Irritable _____ Determined

_____ Distressed _____ Scared _____ Alert _____ Attentive

_____ Excited _____ Hostile _____ Ashamed _____ Jittery

_____ Upset _____ Enthusiastic _____ Inspired _____ Active

_____ Strong _____ Proud _____ Nervous _____ Afraid

SELF-DISCLOSURE AND COMMUNICATION MEDIUMS

Item 7: Self-Concealment Scale (SCS)

Please read each statement carefully and check the box that you feel is the most accurate.

This scale measures self-concealment, defined here as a tendency to conceal from others personal information that one perceives as distressing or negative. Please check the box, to the right of each of the following 10 statements, that best describes how much you personally agree or disagree with the statement.		1=strongly disagree	2=moderately disagree	3=don't disagree or agree	4=moderately agree	5=strongly agree
1.	I have an important secret that I haven't shared with anyone					
2.	if I shared all my secrets with my friends, they'd like me less					
3.	there are lots of things about me that I keep to myself					
4.	some of my secrets have really tormented me					
5.	when something bad happens to me, I tend to keep it to myself					
6.	I'm often afraid I'll reveal something I don't want to					
7.	telling a secret often backfires and I wish I hadn't told it					
8.	I have a secret that is so private I would lie if anybody asked me about it					
9.	my secrets are too embarrassing to share with others					
10.	I have negative thoughts about myself that I never share with anyone					

Appendix B: Instruction Guide and Prompting Questions

You will now have 15 minutes to engage in a conversation with your partner. Please answer only the following questions in the following order. You will have 5 minutes to answer each question. A timer is located on the desk in front of you to help keep track of time.

Question 1: If you had to move from where you consider home, where would you go, and what would you miss the most about home?

Question 2: Is there something that you've dreamed of doing for a long time? Why haven't you done it?

Question 3: How close and warm is your family? Do you feel your childhood was happier than most other people's?

Appendix C: Post-experimental Questionnaire

This questionnaire contains questions regarding your disclosure session. Please read each question carefully and answer each question to the best of your ability.

Please check the box, to the right of each of the following 9 statements, that best describes how much you personally agree or disagree with the statement.		1=strongly disagree	2=moderately disagree	3=don't disagree or agree	4=moderately agree	5=strongly agree
1.	I felt like the information I shared was very personal (by personal, we mean how close the information is related to your private life, relationships, and emotions rather than public or professional careers).					
2.	I felt like I was very emotional during the disclosure session					
3.	I did not often talk about myself					
4.	I usually disclosed positive things about myself					
5.	Once I got started, my self-disclosures lasted a long time					
6.	I was not always honest in my self-disclosure					
7.	In this experience, I often disclosed intimate personal things about myself without hesitation					
8.	In this experience, my partner talked about his/herself for fairly long periods at a time					
9.	In this experience, my partner did not seem honest in his/ her self-disclosures					

Appendix D: Mathematical Explanation of F-Statistic and P-Value

The F-statistic in a traditional F-test is the ratio of two variances, which are the squared deviations of a variable from its mean. In one-way ANOVA, the aim is to determine the extent to which the calculated mean values within three or more pre-established groups differ from each other. The F-statistic ratio for one-way ANOVA is

$$F = \frac{\text{Between-groups variance}}{\text{Within-group variance}}$$

The between-groups variance is

$$\sum_{i=1}^K n_i (\bar{Y}_i - \bar{Y})^2 / (K - 1)$$

\bar{Y}_i is the sample mean in the i th group, n_i is the number of observations in the i th group, \bar{Y} is the overall mean of the data, and K is the number of groups.

The within-group variance can be calculated by

$$\sum_{i=1}^K \sum_{j=1}^{n_i} (Y_{ij} - \bar{Y}_i)^2 / (N - K)$$

Y_{ij} is the j th observation in the i th of the K group and N is the overall sample size.

The p-value approximates the probability of obtaining F-statistics greater than or equal to the actual results under the assumption that the null hypothesis is valid.

An Assessment of Macroplastic Litter Surrounding Four Freshwater Lakes in Columbus, Georgia

Clara Ray

The United Nations Environment Programme identifies plastic pollution as a major environmental issue (Blettler, Ulla, Rabuffetti, & Garello, 2017). Despite this, researchers note a distinct lack of research regarding plastic pollution in the world's freshwater ecosystems (Blettler et al., 2017). The purpose of this study was to find the concentrations and characteristics of shoreline plastic pollution surrounding four public lakes in Columbus, Georgia. A plastic debris assessment was conducted per guidelines from the National Oceanic and Atmospheric Association (NOAA) (Lippiatt, Opfer, and Arthur 2013). The average concentration of macroplastic debris amongst the four sample lakes was 0.151 particles per m², and the primary functional use of this debris was foam food containers. Out of the four sample lakes, Cooper Creek Lake had the highest concentration of macroplastic debris with 0.41 items per m², or 205 items in an area of 500 m².

Keywords: plastic pollution, lakes, freshwater plastic, macroplastic, lakeshore

Introduction

The world is currently in a period of mass plastic production referred to by some experts as 'The Plastic Age' (Wagner et al., 2014). The rise of plastics began in the mid-twentieth century due to the material's durability and wide array of uses (Ryan, 2015). Even though this new material allowed for an increase in global productivity, it did not come without consequences. It is estimated that 192 coastal countries produced 225 million tons of plastic waste in the year 2010 alone (Jambeck, 2015). Ultraviolet radiation from the sun causes plastic to photodegrade into smaller plastic particles, also known as microplastics (5 mm), which means that plastic pollution never completely cycles out of the environment naturally (Ryan, 2015). Approximately 4.8 to 12.7 million tons of plastic entered the oceans in the year 2010 (Jambeck, 2015). A lot of this marine plastic pollution originates on land, flowing through miles of freshwater systems before emptying into the ocean. The Joint Group of Experts on the Scientific Aspects of Marine Environ-

mental Protection (GESAMP) reported that in 2010, 70-80% of marine plastic flowed into the ocean via freshwater rivers (GESAMP, 2015).

Due to the durable nature of plastic, the inorganic material can be detrimental to the health of aquatic ecosystems. Fish and aquatic birds can become entangled in plastic nets, which can lead to drowning or reduce their ability to feed (Sigler, 2014). A 2016 report by the United Nations indicated that over 220 marine species sampled had ingested microplastic debris (Smith, Love, Rochman, & Neff, 2018). Ingestion of plastic debris can cause internal damage and blockages, sometimes leading to the death of the organism (Sigler, 2014). However, large portions of plastic debris are not the only threat to aquatic health. Researchers at Johns Hopkins University's Department of Environmental Health and Engineering have determined that when aquatic organisms consume microplastic, the plastic bioaccumulates through the food chain and is then indirectly consumed by humans via seafood (Smith et al., 2018). Plastics of any size may have a negative impact on biodiversity and life in aquatic ecosystems if left unaddressed.

Literature Review: Freshwater Plastic Pollution

Although marine pollution generally gains more public awareness, plastic debris is still prevalent in the world's freshwater lakes, rivers, and streams. A 2017 survey conducted by scientists at the National Institute of Limnology documented the concentration of plastic debris surrounding the floodplain lakes of the ninth largest river in the world, the Paraná (Blettler et al., 2017). The researchers sampled plastics along these lakes in the following sizes: microplastics (< 5 mm), mesoplastics (5 mm to 2.5 cm), and macroplastics (> 2.5 cm) based on the diameter of the plastic debris. These categories are a standardized way for researchers to compare plastic debris based on its size. The goal of the Paraná survey was to determine the spatial distribution of plastic debris along these lakes, as well as their characteristics and resin types. Bletter, Ulla, Rabuffetti, & Garello (2017) reported that an average of 217 macroplastic items were found at each 50 m by 5 m transect of shoreline, or a concentration of 0.868 macroplastics per m². Microplastic debris averaged at 704 fragments per m². The researchers noted that the concentration of debris found was “alarming” and plastic bags and food containers were the primary types of plastic pollutants (Bletter et al., 2017).

In the past decade, several studies have been conducted to quantify plastic pollution around the Laurentian Great Lakes, the largest bodies of freshwater on Earth. One study recorded the distribution and degradation of plastic along the beaches of Lake Huron (Zbyszewski & Corcoran, 2011). This survey sampled seven beaches surrounding Lake Huron and found an uneven distribution of plastic pollution among them. While no fragments were found at three of the beaches, a total of 3,209 plastic fragments of varying sizes, including macro and microplastics, were found among the other four. Those four beaches only had a combined surface area of 85 m², therefore approximately 37.753 pieces were collected per m². Zbyszewski and Corcoran (2011) reported that Lake Huron still had relatively fewer plastic fragments on its beaches when compared to marine environments. However, plastic pellets were comparatively more abundant around the lake per area than is typical of marine beach surveys. This illustrates the importance

of conducting freshwater beach litter assessments to determine if certain types of plastic are more prevalent at each specific lake or stream. Following this study, researchers at the University of Michigan modeled the distribution and transport of plastic pollution inside all of the Great Lakes (Cable, D. Beletsky, R. Beletsky, Wigginton, Locke, & Duhaime, 2017). This study reported that plastic debris inside the lake was distributed most abundantly around coastlines and urban cities, further suggesting the importance of plastic assessments along lakeshores.

Public Awareness and Responses

The large volume of plastic waste entering water systems is partially due to improper disposal. A comprehensive study on the sources of oceanic plastic determined that the majority of marine plastic originates on land (Jambeck et al., 2015). The United States only has one piece of federal legislation requiring the Environmental Protection Agency (EPA) to regulate solid waste disposal: the Resource Conservation and Recovery Act (RCRA) (Juon, 2018). The responsibility is mostly left to U.S. state and local governments to develop laws addressing plastic recycling in their area (Juon, 2018). According to Allen, Coumoul, and Larcote (2019), increasing public engagement is crucial to developing cleanup and prevention methods for issues with little public visibility; the researchers cite freshwater microplastic pollution as an example of a topic that the public may be uneducated on. Engaging volunteers or non-scientists directly in pollution cleanup is known as the “citizen science approach.” When average citizens are involved in or aware of litter cleanup projects, they are typically more motivated to address issues like pollution in their communities (Cepuritis, Ulme, & Graudina-Bombiza, 2017).

Research Objectives

While researchers have begun to assess plastic pollution along some of the world's major lakes, such as the Laurentian Great Lakes and watersheds of the Paraná, the field of freshwater plastic pollution research is still limited. The goal of this research study was to conduct a standard shoreline macroplastic lit-

MACROPLASTIC LITTER SURROUNDING FRESHWATER LAKES

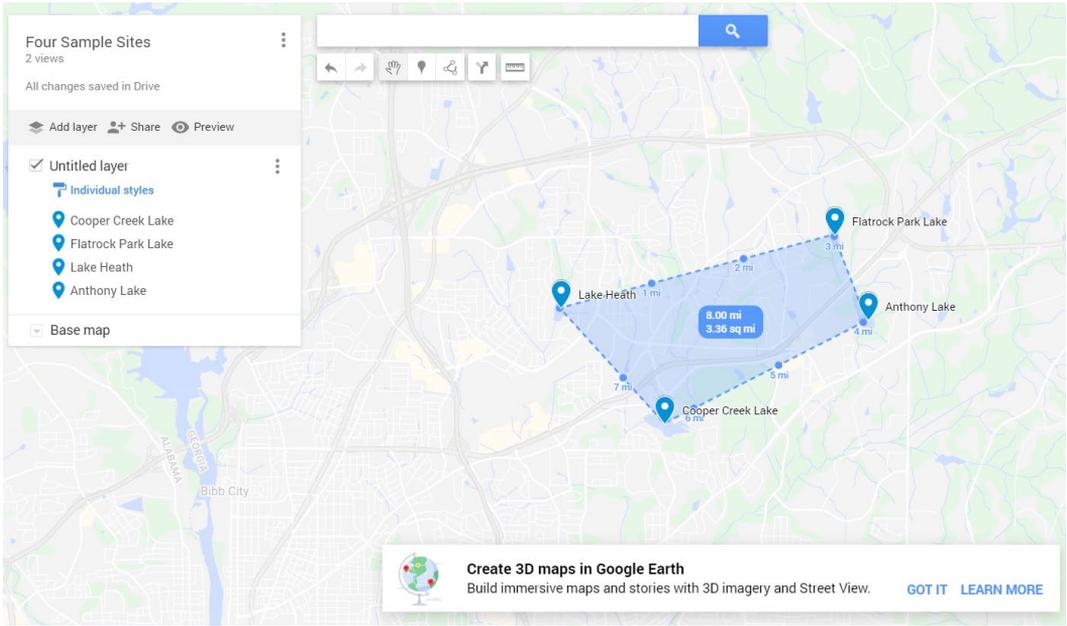


Figure 1
All Four Sample Sites

Note: This map showing all four sample lakes was generated online using the application *Google Maps* (2020). The area between the four lakes measured approximately 5.41 square kilometers (3.36 square miles). The perimeter of this area was approximately 12.87 square kilometers (8.00 square miles).

ter assessment along four public lakes in Columbus, Georgia. This observational study aimed to provide a more comprehensive understanding of the types and quantities of macroplastic litter surrounding some of the lakes in Columbus' environment. The sample lakes were Cooper Creek Lake (also referred to as Bull Creek Watershed Number Three), Flatrock Lake, Anthony Lake, and Lake Heath. Figure 1 below shows all four sample lakes and their proximity to one another.

The specific research objectives were to determine the following:

- Which of the four sample lakes had the highest concentration of shoreline plastic pollution?
- Which form of plastic pollution was most prevalent at each sampling location?

- What were the resin types of the plastic pollution based on the ASTM (American Society for Testing and Materials International) International Resin Identification Coding System?

Methodology

The sampling sites for this study were Cooper Creek Lake, Flatrock Lake, Anthony Lake, and Lake Heath. Each of these are public lakes in Columbus, GA. Macroplastics (2.5cm) were chosen to represent the extent of plastic pollution at these lakesites because there is currently no standardized way to collect and measure microplastics (5 mm) in a water source. A lack of sampling standardization makes it difficult

to compare microplastic content at different water sources (Mai, Bao, Shi, Wong, & Zeng, 2018). Furthermore, the equipment required to sample microplastics, such as a manta trawl and a density separation solution, were not readily available for this survey. This methodology was modified because according to the NOAA, quantifying macroplastic is a viable way to quantify plastic pollution, as it can easily be conducted and compared at multiple lake sites (Lippiatt et al., 2013).

Sample-Site Analysis

The guidelines for collecting and analyzing the macroplastic particles was derived from NOAA Technical Memorandum NOS-OR&R-46, titled, "Marine Debris Monitoring Assessment" (Lippiatt et al., 2013). The methodology was slightly modified in the Blettler, Ulla, Rabuffetti, and Garello (2017) study for use on the shoreline of a freshwater lake. One of these modifications was the collection of macroplastic at only one time of day. In a marine environment, it would be necessary to sample at varying tidal levels, but Bletter et al. determined that this was not necessary during their study on lakes. This research study combined the recommended collection guidelines from Lippiatt, Opfer, and Arthur (2013) and the methodology used by Blettler, Ulla, Rabuffetti, and Garello (2017).

The NOAA recommends that at least one sampling site be selected that is 100 meters long and parallel to the shoreline (Lippiatt et al., 2013). For this research study, the shoreline of each lake was visually inspected to find the portion with the most visible plastic present. At each lake, this was typically the portion of the shoreline that was most accessible to people (such as being near a parking lot or restroom). The mobile application software *MilGPS* was used to measure a section of shoreline that was 100 meters in length. The application, found on the Apple App Store, uses satellite imaging to precisely measure selected distances in meters. The application was also used to provide satellite images of each sample lake. During the sampling process, plastic was not collected more than 5 meters from the shoreline. A meter stick was used on site to determine this distance. Flag markers were then placed in the soil at each corner of the transect.

Macroplastic Sampling

Each sampling transect was visually inspected for macroplastic fragments. Plastic fragments were recorded on a data sheet and collected in a large garbage bag for further analysis in the lab. The plastic items were measured in the field to ensure that they were classifiable as a macroplastic. All visually identifiable plastics were collected, but plastics under 2.5 cm in diameter were not used as data in the survey since this research study specifically examined macroplastics. The sampling transects were surveyed multiple times to reduce the possibility of human error when visually collecting the macroplastics. Then, the materials were transferred to the lab for further analysis.

Sample Analysis

First, each plastic item was washed, thoroughly dried, and counted. Then, the items were classified based on their functional origin and type. The following guidelines for sample classification were created in Technical Memorandum NOS-OR&R-46 (Lippiatt et al., 2013). Multiple fragments, that appeared to have once been one item, were counted as multiple pieces. If a fragment was identifiable as a specific item, such as a fragment of a drink bottle, it was counted as such if it was at least 50% of the original item. Any unidentifiable items were photographed next to a ruler for size reference and described based on physical appearance. The categories for functional origin included: beverage bottles, bags, food wrappers, other hard food containers/food service items, foam food containers, personal care product containers, fishing line, other (any item that does not fit into one of the categories were placed here and described), and unidentifiable. Similarly to the research study conducted by Bletter et al. (2017), each plastic item was then classified by type (hard plastic, film, line, or foam).

The plastic items were examined for their American Society for Testing and Materials (ASTM) Resin Identification Code (RIC), which were explained in the *D7611: Standard Practice for Coding Plastic Manufactured Articles for Resin Identification* manual (ASTM, 2016). This label is printed on plastic products to identify their resin type, and the varying labels with their corresponding resins can be found in Figure 2. The collected plastics with their RIC labels intact were

sorted into additional categories based on their resin type. However, this was not possible for all fragments, as not all of them maintained their RIC label.

Finally, the macroplastic item concentration (number of debris items per m²) per lake was calculated by dividing the number of items observed by the area of the sampling transect. The mean item concentration and standard deviation for all four lakes was calculated.

Resin	Resin Identification Code-Option A	Resin Identification Code-Option B
Poly(ethylene terephthalate)	 1 PETE	 01 PET
High density polyethylene	 2 HDPE	 02 PE-HE
Poly(vinyl chloride)	 3 V	 03 PVC
Low density polyethylene	 4 LDPE	 04 PE-LD
Polypropylene	 5 PP	 05 PP
Polystyrene	 6 PS	 06 PS
Other resins	 7 OTHER	 07 0

Figure 2
Standard Resin Identification Codes

Note. Published by the American Society for Testing and Materials in the ASTM D7611: *Standard Practice for Coding Plastic Manufactured Articles for Resin Identification* (2016).

Findings

All four lakes were sampled on Sunday, February 9th, 2020, between the hours of 10:00 AM and 1:30 PM. Based on the NOAA’s functional classifications created by Lippiatt, Opfer, and Arthur (2013), the following types of plastic were found at these sample lakes: beverage bottles, hard food containers, foam food containers, fishing line, personal care products, bags, and others. No “unidentifiable” macroplastics were found. According to NOAA guidelines, all macroplastics placed in the “other” category were described below when discussing the lake where they were located.

The primary type of plastic collected amongst the four lakes in Columbus was foam food containers, comprising 44% of all plastic collected. Foam beverage cups were the primary form of foam food containers found, but foam plates and containers were collected as well. Table 1, located below, shows the proportions in which each type of plastic was found. Overall, 302 pieces of macroplastic were collected in the sampling transects at each lake. The mean concentration of macroplastic was 0.151 particles per m², with a standard deviation of 0.177 particles per m². The standard deviation of this data being higher than the mean suggested that the

data (concentrations of macroplastic) had a relatively high variability between the sample areas. Out of all 302 macroplastic collected, 103 pieces still had their RIC label intact. Amongst those plastic pieces, PETE, or polyethylene terephthalate, was the most common resin type documented.

The most polluted shoreline, according to the transect sampled, was Cooper Creek Lake. Approximately 67.9% of all plastic collected was recovered at this lake, and Cooper Creek had the highest concentration of macroplastic debris per m².

MACROPLASTIC LITTER SURROUNDING FRESHWATER LAKES

Table 1
Functional Use Categories and Resin Types

Functional Use Category	Type	No. of Items	Resin	Percentage out of Total
Foam food containers	Foam	133	PS	44%
Beverage Bottles	Hard	96	PETE, HDPE	38.1%
Other hard food containers/food service items	Hard	31	PP	10.3%
Bags	Film	14	–	4.6%
Food wrappers	Film	12	–	4.0%
Others	Hard	10	PP	3.3%
Personal care product containers	Hard	4	–	1.3%
Fishing Line	Line	2	–	0.7%
Total	–	302	–	–

Note. The functional use categories are sorted by decreasing order of frequency. Resins within each “Resin” box are sorted by decreasing order of frequency. Dashes indicate that no data was present. Percentages may not add to 100% due to rounding. PETE = polyethylene terephthalate, PS = polystyrene, HDPE = high density polyethylene, PP = polypropylene.

Anthony Lake

During a field survey of Anthony Lake, it was noted that the lake is surrounded by two residential neighborhoods and one apartment complex. The lake primarily serves as a watershed of Bull Creek and the Chattahoochee River, but it is also used for recreational fishing. The 100 meter sampling transect that was surveyed is shown in Figure 3 below. The concentration of macroplastic debris along the shoreline of Anthony Lake was 0.112 items per m². In total, 56 pieces of macroplastic were collected in the sampling transect at Anthony Lake. The primary

type of plastic debris collected at Anthony Lake was beverage bottles, with 33 out of the 56 items being bottles. Out of all plastic debris collected, 23 pieces still had their Resin Identification Code (RIC) intact. The most common type of resin discarded along these lakes was Polyethylene Terephthalate (PETE). Five macroplastics were collected that did not fall under one of the fixed functional use categories, and were therefore placed in the “other” category. These macroplastics included two hard plastic chewing tobacco containers, two hard plastic toy balls, and one hard plastic pen cap. None of these items had an RIC label present.



Figure 3
Satellite image of Anthony Lake

Note. The red line from point A to B represents the sample transect. Image retrieved from the mobile software application *MilGPS* (2020).

Lake Heath

Lake Heath is located inside Heath Park, which is surrounded by a residential neighborhood. A walking trail surrounds the entire lake, which makes the shoreline of the lake highly accessible to the public. Figure 4 below shows the 100 meter sampling transect parallel to the shoreline where plastic was collected. Lake Heath was the least polluted by macroplastic according to this debris assessment. Eight pieces of macroplastic were collected in the sampling transect at Lake Heath. When calculated, the concentration of macroplastic in this transect was 0.016 items per m^2 . The primary functional use of this plastic was beverage bottles. The most common type of plastic resin found was PETE, according to the RIC label found on some of the plastic debris. One macroplastic item from Lake Heath was placed in the “other” category: a hard plastic pair of toy eyeglasses. The item did not have an RIC label present.



Figure 4
Satellite image of Lake Heath

Note. The red line from point A to B represents the sample transect. Image retrieved from the mobile software application *MilGPS* (2020).

Cooper Creek Lake

Cooper Creek Lake is located inside Cooper Creek Park. The lake primarily serves as a watershed for Bull Creek, also located in Columbus, GA. Cooper Creek Lake is alternatively named Bull Creek Watershed Number Three. The lake is also a recreational fishing location in Columbus, and the park features amenities inside it such as tennis courts and concessions. A total of 205 macroplastic items were collected in the sampling transect along Cooper Creek Lake. The image below, Figure 5, shows the portion of the shoreline that was sampled. The concentration of macroplastic debris was 0.41 items per m^2 . At Cooper Creek Lake, four macroplastic items were placed in the “other” category. The “other” items included: one hard plastic chewing tobacco container, one hard plastic toy ball, and two hard plastic pill bottles. The two pill bottles were labeled as the resin type PP.

MACROPLASTIC LITTER SURROUNDING FRESHWATER LAKES

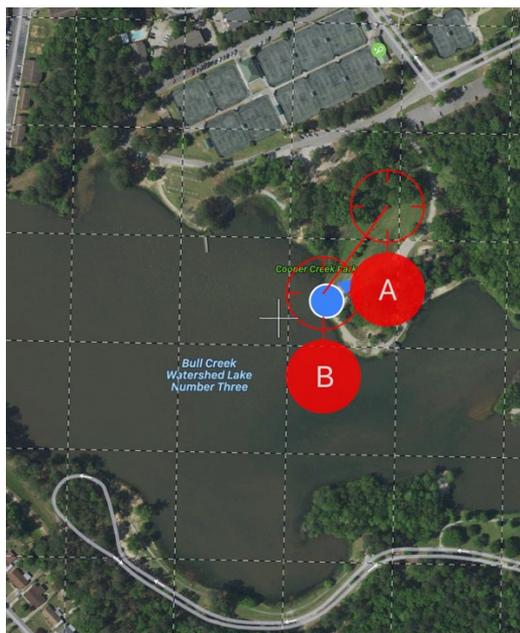


Figure 5
Satellite image of Cooper Creek Lake

Note. Cooper Creek Lake is also known as Bull Creek Watershed Number Three. The red line from point A to B represents the sample transect. Image retrieved from the mobile software application *MilGPS* (2020).

Flatrock Lake

Flatrock Lake is located in Flatrock Park, one of the largest parks in Columbus according to the Columbus Parks and Recreation web page titled, "Parks" (n.d.). This was the only lakesite that was not within viewing distance of any residential homes or industries. A total of 33 pieces of macroplastic were collected in the following sampling transect along the shoreline of Flatrock Lake. The concentration of macroplastic debris was 0.066 items per m^2 . No "other" macroplastic items were collected here.



Figure 6
Satellite image of Flatrock Park Lake

Note. The red line from point A to B represents the sample transect. Image retrieved from the mobile software application *MilGPS* (2020).

Discussion

Limitations

Before discussing the results of this macroplastic assessment, the following limitations should be taken into consideration. There was opportunity for human error during the macroplastic collection process because plastics were visually removed from the sampling transect. There was room for human error once again during the process of counting the macroplastics collected at each lake. This type of error could have caused the collected number of macroplastics to differ from the true number of macroplastics in each transect. Although the NOAA guideline specifically requires the description of infrastructures and water sources surrounding the sample sites, it does not provide an explanation for the correlation between these

features and the macroplastic concentrations (Lippiatt et al., 2013).

Furthermore, the findings about resin types were limited because not all macroplastic items had their Resin Identification Code (RIC) intact. This means that the primary resin type collected at each sample transect may be influenced by the durability of that resin, and not truly representative of the present quantities of each resin. Previous research studies have used a device called a FT-IR spectrophotometer to determine the resin type of all other plastic items, but this device was not available for this study (Bletter et al., 2017).

Because samples were only collected on one date, the weather, season, or one event may have influenced the concentration of macroplastics. The time constraints of this study meant that it was not possible to sample these lakes during both the summer and winter seasons. The human interference at these lakes could have had a varying impact during a different time of year. However, this study was merely observational and did not test that hypothesis. Specific figures regarding the level of human traffic were not available for these sample lakes, meaning that no concrete data about this could be provided.

Any correlations between variables were not implied to show a causal relationship. For example, if a lake with a recycling bin was proven to have a higher shoreline macroplastic concentration, this study does not prove that those two variables have a cause and effect relationship. The results of this assessment were also limited to the four lakes which they were conducted and may not be applied to any other lakes in the area. The limitations of this macroplastic assessment mean that these results should only be taken in context and applied to the areas sampled.

Results in Context

The findings at these four sample lakes, including macroplastic concentration and primary type of plastic found, were then compared with previous studies at other lakes. The Bletter et al. (2017) research study was the most similar to this study because it assessed macroplastic along the shoreline of a freshwater lake. Bletter et al. (2017) also used the same methodology for collection that was used in this study, as recom-

mended by Lippiatt et al. (2013). Surrounding their sample lake, the researchers collected an average of 0.868 macroplastics per m² amongst all sampling transects. The average concentration of macroplastic was lower at Columbus lakes, where it was 0.1510 particles per m². Bletter et al. (2017) found the following types of plastic most often (in descending order of abundance): food wrappers, bags, and foam food containers. This differed from the four Columbus lakes sampled where foam food containers were the most abundant type of macroplastic, followed by beverage bottles and other hard food containers.

Resin Types

Each type of plastic resin has different physical properties and therefore different specific advantages. However, there was a commonality among all resin types found in the sampling transects: according to a web page published by the American Chemistry Council (n.d.), each resin type found in this study is primarily used for some type of food/beverage container. Four of the major seven types of plastic resin were represented in this study: Polyethylene Terephthalate (PETE), High Density Polyethylene (HDPE), Polystyrene (PS), and Polypropylene (PP), in decreasing order of frequency. The American Chemistry Council (n.d.), states that PETE is a relatively tough form of plastic, "...making it ideal for carbonated beverage applications and other food containers." This application is evident in the results of this study, as all PETE collected was in the form of a beverage container. Furthermore, the durable nature of PETE may have increased the frequency in which it was located at the sample lakeshores. HDPE is also primarily used for food packaging. Although it is more versatile than PETE, it does not create a barrier for gases, making it ineffective as a carbonated beverage container. Because it can be molded into a film, it is often used to package snack foods (American Chemistry Council, n.d.). All HDPE collected at the sample sites was formed into a non-carbonated beverage bottle. The American Chemistry Council notes that PS and PP are both versatile types of plastic which are primarily used in packaging. PP may have been overestimated in this study compared to other resin types due to its noted resistance to water allowing it to persist in the lake environments. PS may be formed into foam or

hard plastic. However, it is mainly used for foam food containers, which is supported by the results of this study.

Recycling Systems

The Columbus Consolidated Government collects recyclable materials, including some plastics, from residences via a curbside collection system. Besides residential collection, Columbus, Georgia has four recycling drop-off trailers, but only one is located at a public park (Columbus Recycling & Sustainability Center, n.d.). A recycling drop-off trailer is placed approximately 18 meters from the shoreline of Cooper Creek Lake. This was the only lake in the survey that was located near any type of container for recyclable waste. Despite the convenient location of this recycling drop-off container, Cooper Creek Lake still had the highest concentration of macroplastic debris of all sampled lakes. Normal waste disposal bins were located around the shoreline of each lake except for Anthony Lake. This was likely due to the fact that the other three lakes are located inside a public park, while Anthony Lake is not.

The primary functional use of macroplastic collected at the four sampling transects was foam food containers. The majority of these were foam beverage cups, but foam take-out containers and foam fragments were also collected in high frequency. This is concerning because Columbus' city recycling department does not recycle polystyrene or styrofoam (Columbus Recycling & Sustainability Center, n.d.). This provides another obstacle for citizens of Columbus who wish to recycle styrofoam waste. On the Columbus Recycling & Sustainability Center's webpage, it states that they do not recycle some other plastic items, including plastic bags, plastic toys and plastic straws.

Conclusions

The results of this macroplastic assessment conducted on Cooper Creek Lake, Flatrock Lake, Anthony Lake, and Lake Heath have expanded the current knowledge about lakeshore pollution in Columbus, Georgia. The specific conclusions to each of the previously stated research questions were the following:

The sample lake with the highest shoreline macroplastic concentration was Cooper Creek Lake with a concentration of 0.41 items per m^2 . The concentrations of macroplastic at the sample sites of each other lake were as follows: Anthony Lake (0.112 items per m^2), Flatrock Lake (0.066 items per m^2), and Lake Heath (0.016 items per m^2). The average concentration between the four lakes was 0.151 particles per m^2 , with a standard deviation of 0.177 particles per m^2 . In total, 302 macroplastic pieces were collected.

The dominant functional use of the macroplastic debris amongst the sample lakes was foam food containers.

According to the ASTM's Resin Identification Codes, the primary type of plastic resin located along these shorelines was PETE, or polyethylene terephthalate. Out of the seven main plastic resin types, PETE, PP, HDPE, and PS were found at the sampling sites (with their RIC label intact). The other types of plastic resin may have been located at the lakeshores; however, they were either unlabeled or their label was no longer present.

Future Implications

When considering these conclusions, this study suggests that more plastic cleanup projects should be focused at these sample lakes, specifically at Cooper Creek Lake. One possible solution to this plastic debris would be the "citizen-science approach" suggested by researchers Cepuritis, Ulme, and Graudina-Bombiza in 2017. They argued that getting the public involved in environmental science projects would increase their knowledge and care for these issues. Using that logic, if the public were to engage in future macroplastic assessments, they would be able to clean up more plastic while simultaneously gaining awareness of the issue.

Considering that the lake with the highest concentration of macroplastic debris was the only one near a recycling receptacle, this evidence recommends further research to evaluate the effectiveness of Columbus' recycling system. As suggested previously in the study, the results of this macroplastic assessment could be used to make targeted recycling campaigns. For example, the city government, or even local restaurants, could make flyers encouraging the proper

MACROPLASTIC LITTER SURROUNDING FRESHWATER LAKES

disposal of foam food containers. This research particularly highlights the issue of foam plastic debris in the environment. Between all four sampling transects, 133 pieces of foam were recovered, accounting for approximately 44% of all macroplastic particles. This type of plastic had no chance of being recycled by the city government's recycling system.

More macroplastic assessments should be conducted on lakes in the future in order to provide context for the concentrations of macroplastic found at these sample lakes. In the field of lakeshore pollution, it is still unclear when a concentration of macroplastic becomes a significant threat to the lake. Although the results of this study bridge a small gap in understanding in this field, the characteristics of macroplastic around Columbus' lakes, the lack of freshwater plastic research makes it difficult to place these results in context. As discussed previously, the results of this study are only directly comparable to the results of the Blettler et al. (2017) research. Furthermore, if another plastic assessment were to be conducted on these lakes in the future, mesoplastics and microplastics should be sampled as well. This would provide a more detailed extent of plastic pollution in these lakes because plastic degrades and becomes less visible to the public eye. This would also fill another gap in freshwater plastic research, as few studies have been published regarding microplastics in freshwater compared to marine environments (Blettler et al., 2017).

MACROPLASTIC LITTER SURROUNDING FRESHWATER LAKES

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The Effect of Creative Computer Science Workshops on the Interest Levels of Female Middle School Students

Ella Hilton

Literature suggests that the lack of female involvement in computer science (CS) is detrimental to the field. The disconnect between females and CS is not due to their ability to succeed in the subject, but rather the perceptions and stigmas surrounding it. This paper will focus on female interest in CS at a medium sized suburban middle school in Western Pennsylvania. The two guiding points for the paper include 1) the idea that female role models are thought to be crucial in the advancement of closing the gender division and 2) Harvey Mudd College's approach to female CS learning. The measure of each subject's CS interest was collected through pre and post-surveys during workshops led by the researcher. The paper ultimately argues that yes, the girls at the specified middle school are more interested in computer science after engaging in creative problem solving led by a female role model.

Keywords: Computer science, middle school interest, creative problem solving, female role model

I. Introduction and Literature Review

Computer science is a rapidly developing field of study that impacts every other discipline; however, it is also one in which women are largely underrepresented (NCWIT, 2014). This issue is so imperative that hundreds of today's "leaders and trend-setters" believe that computer science and/or computer programming is essential in shaping today's world ("Leaders and trend setters...", 2019). Therefore, beneficial research has been conducted and must be conducted further in order to reach conclusions as to what could encourage more women to engage with computer science. If not, the voices of women around the world will be continuously disregarded in the conversations and opportunities that computer science presents. Throughout

this literature review, prior studies regarding women in computer science will be compiled to explore the issue that can be seen in a medium sized suburban district in Western Pennsylvania and ultimately answer the following question:

Compared to their initial perceptions, do girls at a medium sized suburban middle school in Western Pennsylvania demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model?

Key Terms

... found in literature review

Computer Science

While coding/programming is included in computer science, it certainly does not represent the entire discipline. Computer science “develops students’ computational and critical thinking skills and shows them how to create, not simply use, new technologies” (“Computer science develops...”) The study of computer science entails algorithmic problem solving, computing and data analysis, human computer interaction, graphic design, security, programming, etc. (“Computer science develops...”).

Perception

Many of the historical issues surrounding the gender imbalances of computer science are perception-related. A perception is “a thought, belief, or opinion, often held by many people” (Meaning of perception...).

Social Cognitive Theory

Within a cornerstone work of this literature review, researchers use social cognitive theory “to identify and understand reasons why students choose to study computer science” (Alshahrani, 2018). Their definition for social cognitive theory has four components: “prior experience, social support, self-efficacy and outcome expectation” (Alshahrani, 2018). This keyword relates to the perceptions and biases presented throughout the literature.

... found in research question

Creative Problem Solving

When the research question is justified, the notion of creativity will be stressed. Creativity is “the ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated phenomena, and to generate solutions” (Naiman, 2019).

When the researcher presents the concept of “creative problem solving”, they are using Maria Klawe’s idea of real world application capturing “interest and enthusiasm”, an idea that is returned to in the “Current

Solutions” section of the paper (Nickelsburg, 2019).

Female Role Model

A female role model can be any female that others look up to in some fashion, but “local examples provide more easily imaginable visions of success” (The Power of Role Models).

Attitudes and Perceptions / History of Problem

Boys tend to create an environment surrounding computer science that proves difficult to penetrate by outsiders (Margolis & Fisher, 2003). This thesis was explored through the collection of data regarding attraction of programming and other like factors to reach the conclusion that slight differences in computer upbringing between the sexes leads to an experience gap in the future (Margolis & Fisher, 2003). According to their study, something as slight as 5 and 6-year-old boys crowding the classroom computers during free time can play a role in the decision to move forward with computer science (Margolis & Fisher, 2003). Exposure differences such as this has led to differing perceptions of abilities, as seen in a 2015-2016 Google Gallup survey, where, when asked the question “How confident are you that you could learn CS if you wanted to?”, 65% of twelfth grade boys surveyed reported to feel “very confident” in their abilities, while a mere 48% of twelfth grade girls surveyed felt “very confident” in theirs (“Students who have been told...”).

The idea of it being a “boy thing” is not the only developing attitude around computer science. In an “interview with 17 mixed gender subjects currently studying CS at three Scottish universities”, the students shed light on the perceptions concerning computer science (Alshahrani, 2018). Of these 17, a total of 9 perceived characteristics coinciding with people in the field being nonsocial, 6 used the words “nerd” or “shy”, and 3 used “geek” (Alshahrani, 2018).

Contradicting the students from the interviews, a vast majority of Pennsylvanians have a positive perception of the field (“To inform the public on progress...”). Despite these positive perceptions in Pennsylvania, action is not being taken to give children ample opportunities for computer science learning,

which prolongs the issue of those within the coding environment (mostly boys) to have a consistent leg up on those who have yet to enter the discipline at all (mostly girls) (“To inform the public on progress...”).

Women in Computer Science

“When computer technology first emerged during World War II and continuing into the 1960s, women made up most of the computing workforce” (“The Bureau of Labor Statistics...”, 2013). Today, “the percentage of women working in computer science-related professions has declined... , dropping from 35% to 26% between 1990 and 2013” (“The Bureau of Labor Statistics...”, 2019). However, according to the American Association of University Women, we can reverse this trend by removing negative connotations around women in computer science” (“The Bureau of Labor Statistics...”, 2019).

Creativity

The cornerstone work that is *A Report on the Status of Women in Information Technology* goes into detail on how gender diversity in computing is important on the basis of enhancing innovation (NCWIT, 2014). The discipline requires creativity because “computing is a field created by innovative thinkers whose products and systems have become critical to our daily lives” (NCWIT, 2014) “Research shows that under the right circumstances, diverse teams improve creativity, problem-solving, and productivity. A large study spanning 21 different companies showed that teams with 50:50 gender membership were more experimental and more efficient” (NCWIT, 2014).

Current Solutions

Role Models

From the same literature that studied the perceptions of computer science from boys and girls, the importance of female leadership is stressed in the journey towards a solution (“Students who have been told...”). Luckily, interest surrounding the need for these female role models has been generated with research into understanding why students do or do

not choose to study computer science (Alshahrani, 2018). Pulling again from the study surrounding social cognitive theory, the subjects believed that having female role models might sway more girls into joining suit (Alshahrani, 2018). When these role models are weaved into out of school programs they become some of the greatest opportunities for growth in reasoning as well as social interaction while learning (Deschenes et al, 2010).

Harvey Mudd College

A prime example of an institution that was able to pose a solution to the gender gap is Harvey Mudd College in Claremont, California (Klawe, 2017). As stated by Maria Klawe, president of Havery Mudd, “five years after Harvey Mudd redesigned its introductory computer-science course, women went from being 10 percent of computer-science graduates to 40 percent” (Klawe 2017). Klawe reported that when teaching students computer science, it is important to express that the concepts have real world application because that “can capture the interest and enthusiasm of more students — including women” (Nickelsburg, 2019; Klawe, 2017).

Assumptions

In setting up their work, the researcher assumes that computer science skills and knowledge could be retained by middle school girls with the use of “problem-solving groups in class” as NCWIT Senior Research Scientists Barker and Cohoon proved could be done with undergraduates (Barker & Cohoon, 2009).

Additionally, the researcher assumes that using the same techniques as carried out by Harvey Mudd College (teaching that stresses creative problem solving) would produce similar results in the district being studied (Klawe 2017). They also assume that they themselves could fill the role of a leader, as inconsistent female leadership has led to imbalances in field engagement and is a large factor in the disparity seen in the field (Blaney, 2018). Also, the researcher is both local and relatable, which is important according to the definition of female role models presented earlier (The Power of Role Models).

Justification of Research

Justification of researching female interest in computer science

When comparing the number of male and female students taking AP exams in mathematics and science during 2009, most STEM subjects can be closely compared, while the girls significantly dropped off for the two computer science tests (Dawson, 2014). Yet interestingly enough, the small number of girls who did take the AP Computer Science A test scored relatively similar to the boys, showing that they can succeed at the same rate (Dawson, 2014). These statistics narrow the need for attention from STEM as a whole to the problem that spurs with computer science. Once within the computer science field, research can be further justified because negative perceptions of computer science have led to mass decline of women engagement (Women in Computer Science, 2019).

Justification of using creative problem solving and a female role model

The method in which the researcher chooses to measure interest is justified for the following three reasons: 1) female role models are thought to be crucial in the advancement of closing the gender division (Alshahrani, 2018). 2) Harvey Mudd as well as the NCWIT found real world applications, or problem solving, to be useful in generating interest (Klawe, 2017; Barker & Cohoon, 2009). 3) The computing field needs more girls for the creativity they bring to the table (NCWIT, 2014). Therefore, the researcher has the ability to use this literature to fuel their research question.

Research Question

Compared to their initial perceptions, do girls at a medium sized suburban middle school in Western Pennsylvania demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model?

II. Methodology

Throughout the literature review, the researcher was able to draw the conclusion that a widespread issue with computer science is the lack of female involvement (NCWIT, 2014). On a more personal level, the researcher is interested in solving this problem within the specific school district due to her involvement with the computer science curriculum, which includes being the only female enrolled in AP Computer Science A during the 2018-2019 school year.

When considering methods, the researcher first contemplated interview techniques as seen in a cornerstone study from the literature review. However, because the interviews were conducted with adult subjects majoring in computer science, the researcher decided that the middle school girls (with little to no exposure) would have more difficulty in an interview setting (Alshahrani, 2018). Secondly, the researcher considered descriptive research; however, because *Practical Research* describes this method as not involving modifying the situation but simply collecting a judgment sample, this method was also dispelled (Leedy, 2019). Instead, a mixed-method study implementing pre and post-surveys was the best choice. With this method, the researcher is able to integrate findings from qualitative and quantitative data through a convergent design of structured and open-ended questions (Leedy, 2019). Although the interviews from Alshahrani's study were dismissed, the researcher included his style of content analysis within the mixed-method study by categorizing the open-ended responses into "clusters of similar entities" and using these clusters to identify "consistent patterns and relationships between variables or themes" (Alshahrani, 2018).

The researcher drafted the following study of which all parts were approved by the IRB:

Study Design

In order to assess their research question, the researcher created and implemented three "creative computer science" workshops for the middle school girls in sixth and seventh grade. They consisted of three parts:

The girls completed a pre-survey concerning their current perceptions and interest levels surrounding computer science. They were only able to complete the

survey if their parent/guardian had returned a signed consent form. See the consent form in Appendix A.

For each workshop, the researcher created three programmed scenes using Carnegie Mellon University Computer Science Academy that centered around the shape that was to be learned during that particular workshop. Each of the girls received an anonymous login to the course and the researcher's starter code was copied into each of their "sandboxes". The first workshop was built around circles, the second rectangles, and the third three-sided polygons. The researcher chose these shapes because they are building blocks for all of the scenes that the researcher coded using CMU CS Academy. There is not enough time in a forty minute workshop to learn all of these shapes, which is why they were split up in that manner. The learning of a single shape does not expand upon the last; therefore, if a participant attended the second workshop but not the first her progress was not hindered. The researcher was cognizant of standardization throughout their workshops, making sure that they administered each lesson with the same format and similar content.

The researcher passed out a worksheet that explained how to create and color the shape that the workshop focused on that day. See the workshop handouts in Appendices B-D.

The researcher chose to work with Carnegie Mellon University Computer Science Academy (a free, browser-based Python course) in the first place because it is user-friendly and analyzes mistakes. This way, when the researcher was unable to come around and answer their questions immediately, the girls could either problem solve together or receive feedback from the computer itself.

The girls completed a post-survey concerning their new (possibly changed) perceptions and interest levels surrounding computer science. A debriefing form was sent home for their parent/guardian. See debriefing form in Appendix E.

Pre and Post-Surveys

The pre and post-surveys were administered through google forms, with all personal-information collecting features turned off to ensure anonymity; however, the girls were assigned to a number at the beginning of the workshop and asked to state that number in both surveys. This is how the researcher

linked their pre and post- surveys together without collecting personal information.

See both full surveys in Appendix F.

Study Setting

The workshops took place in the middle school on January 7, January 28, and February 18 of 2020. Although there were three different workshops, the researcher performed each twice: once 7th period and once 8th period on each of the designated days. The workshops were offered both periods because half of the students that participated have their study hall during 7th and the other half during 8th. The workshops took place in the robotics lab because this is the usual setting of the STEAM Girls Workshops (workshops offered at the middle school every few weeks where female students can participate in planned activities related to STEAM, not connected to the researcher), and computer science falls into the STEAM category. The lab has extra computers if any of the participants forgot their personal device.

Study Population

Participants were "recruited" through emails sent home to all parents of the students as well as announcements made during the students' lunches. The middle school age group seemed appropriate because after interacting with the researcher's experiment the students have the information and experience needed to make an informed decision as to their future involvement with computer science as they move into high school and beyond. The girls all have their own district devices, meaning every participant had access to her own editable code that the researcher provided. Although they could edit the program individually, they sat at tables to spark conversation and solutions.

In the end, a total of 15 sixth and seventh grade girls attended the workshops, three of which came to one workshop, five who came to two, and seven who came to all three.

Presentation of Findings

As shown in Table 1, the researcher dissected the research question into three parts and presented the findings in that manner.

CREATIVE COMPUTER SCIENCE WORKSHOPS FOR FEMALE MS STUDENTS

Table 1: Breakdown of Research Question in Relation to Findings

<p>“Compared to their initial perceptions, do girls at a medium sized suburban middle school in Western Pennsylvania demonstrate a heightened interest in computer science...”</p>	<p>The researcher gathered the perceptions of interest from the following questions both in the pre and post- surveys:</p> <p style="text-align: center;">How interested are you in computer science?</p> <p style="text-align: center;">Would you continue with computer science in the future?</p> <p>For the comparison of interest, the researcher conducted a Paired T-test for the true mean difference in interest levels (post - pre). They also recorded the difference in the participants’ reported likelihood of continuing with computer science in the future before and after the workshops. (see Tables 2-4)</p>
<p>“... after engaging in creative problem solving...”</p>	<p>To address the creative problem solving point, the researcher asked the following questions in the final post survey:</p> <p style="text-align: center;">Which workshop was your favorite?</p> <p style="text-align: center;">During which workshop were you able to be the most creative?</p> <p>The researcher recorded how often participants favorite workshops were also the one in which they felt the most creative. (see Table 5)</p>
<p>“...led by a female role model?”</p>	<p>To address the female role model point, the researcher asked the following survey question in the final post survey:</p>

Findings & Data Analysis

Introduction

The findings demonstrate that girls at a medium sized suburban middle school in Western Pennsylvania do demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model. As the breakdown in Table 1 suggests, this overarching claim is made based on data drawn from each subsection of the research question: 1) a paired t-test assessing the true mean difference in their interest levels from pre to post as well as their thoughts on continuing with computer science from pre to post, 2) a comparison between their favorite workshop and the one during which they were able to be the most creative, and 3) categorized answers to the question of if they enjoyed working with the female role model. Although this claim does not seem evident after the first step of analyzation, parts two and three suggest a “yes” to the research question. With this in mind, the researcher’s findings paired with those from the literature review solidify the understanding of how young girls in the specified township respond to such exposure to computer science in ways that could be expected based off of Alshahrani’s interviews and trends seen at Harvey Mudd College.

Interest Levels

Table 2 presents each participant’s reported interest levels from the first pre-workshop survey they completed to the last post workshop survey they completed. In the last column, the difference in this quantitative measure of interest is calculated and is used as the data in the paired t-test seen in Table 3.

Table 2: Interest Levels in Pre and Post-Tests

Participant's Assigned Number	Pre-Test Interest (1)	Post-Test Interest (2)	Difference (2-1)
1	4	5	1
10	4	5	1
11	5	4	-1
12	4	4	0
13	2	4	2
14	3	3	0
15	5	4	-1
16	2	2	0
17	3	5	2
18	5	5	0
19	4	3	-1
2	4	4	0
20	3	3	0
21	3	3	0
22	5	5	0

CREATIVE COMPUTER SCIENCE WORKSHOPS FOR FEMALE MS STUDENTS

Table 3: Paired t-Test for the True Mean Difference in Interest Levels (Post - Pre)

Null Hypothesis (H_0)	Alternative Hypothesis (H_a)	Sample Mean	Sample Standard Deviation	Sample Size	Degrees of Freedom	t-value	alpha	p-value
$\mu_2 - \mu_1 = 0$	$\mu_2 - \mu_1 > 0$	0.2	0.95	15	14	0.823	0.05	0.212

The null hypothesis for this scenario is the pre and post-interest levels being the same, showing that the participants' interest levels did not change before and after engaging in the workshop(s). The alternative hypothesis for this scenario is the post interest levels being greater than the pre-interest levels, showing that the participants' interest levels increased. When the p-value is greater than the alpha, the null hypothesis is unable to be rejected. However, when the p-value is less than the alpha, the null hypothesis can be rejected.

Because the p-value of 0.212 is greater than the alpha of 0.05, the researcher failed to reject the null hypothesis.

There is not enough evidence to convince that the sample's mean interest level after participating in the workshop(s) increased from the mean interest level before.

Table 4 presents each participant's reported interest in continuing with computer science from the first pre-workshop survey they completed to the last post-workshop survey they completed. The yellow rows show that 5/15 participant's interest in continuing with computer science increased (maybe to yes), the red row shows that 1/15 participant's interest in continuing with computer science decreased (yes to maybe), and the white rows show that the remaining 9/15 participant's interest in continuing with computer science stayed the same (maybe to maybe or yes to yes). At no point did a participant answer "no" to the question: Would you continue with computer science in the future?

Table 4: Thoughts on Continuing with Computer Science in Pre and Post-Tests

Participant's Assigned Number	Pre-Test Interest	Post-Test Interest
1	Maybe	Yes
10	Maybe	Yes
11	Yes	Yes
12	Maybe	Yes
13	Maybe	Yes
14	Maybe	Maybe
15	Yes	Yes
16	Maybe	Maybe
17	Yes	Yes
18	Yes	Yes
19	Maybe	Maybe
2	Yes	Maybe
20	Maybe	Yes
21	Maybe	Maybe
22	Yes	Yes

CREATIVE COMPUTER SCIENCE WORKSHOPS FOR FEMALE MS STUDENTS

From the quantitative data in Tables 2 and 3 alone, it is not evident that the middle school girls demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model. The calculated p-value from the t-test in Table 3 is far too high to reject the null hypothesis of the mean interest level before and after being equal, and therefore there is a very good chance that the null hypothesis is true, meaning that the girls' interest levels did not increase after participation with the researcher's workshop(s). In Table 4, the claim of their interest levels remaining stagnant is further strengthened by 60% of participants having the same thoughts on continuing with computer science after the workshop(s) as they had before partaking in the workshop(s).

The Bureau of Labor Statistics' estimation of the decline of "women working in computer science-related professions" becomes further validated as an issue because the researcher did not find evidence to prove their methods worked to reverse the trend. Additionally, the researcher's initial assumption that

"using the same techniques as carried out by Harvey Mudd College would produce similar results in the district being studied" is dismantled at this point, and the importance of gender diversity within the computer science field remains a goal unmet (NCWIT, 2014). Therefore, one can be reasonably certain that based off of the quantitative data alone it appears a "no" would answer the research question and refute the general tendency seen in the body of knowledge.

Creative Problem Solving

Contrary to the results stemming from the general interest rates, the findings convey that the participants responded favorably to the creative problem solving aspects of the workshop(s) in which they attended. Table 5 proves that more often than not the participants' favorite workshop aligned with the one in which they felt most creative. So while the researcher failed to conclude that the general interest levels increased from pre to post-workshop, the second portion of the research question regarding creative prob-

Table 5: Creativity's Alignment with Favorite Workshop

Participant's Assigned Number	Favorite Workshop	Workshop During Which They Felt the Most Creative
2	Creating Rectangles	Creating Three-Sided Polygons
10	Creating Rectangles	Creating Rectangles
12	Creating Three-Sided Polygons	Creating Three-Sided Polygons
13	Creating Three-Sided Polygons	Creating Three-Sided Polygons
15	Creating Three-Sided Polygons	Creating Three-Sided Polygons
17	Creating Three-Sided Polygons	Creating Three-Sided Polygons
19	Creating Three-Sided Polygons	Creating Rectangles
22	Creating Three-Sided Polygons	Creating Circles

CREATIVE COMPUTER SCIENCE WORKSHOPS FOR FEMALE MS STUDENTS

Table 6: Participant Feelings Towards the Female Role Model

	Nice/Kind	Explanatory	Fun/Funny
Number of responses in which specified theme was mentioned	5	3	2
Full quote example of theme	“yes she is a very nice girl and she worked with us and i think its amazing that she did this with us.”	“Yes, because she explained the instructions good and is nice.”	“yes, she was really nice and funny”

lem solving can be seen as being a convincing factor for girls at a medium sized suburban middle school in Western Pennsylvania to partake in computer science.

Table 5 conveys that 5/8 responding participant’s favorite workshop was the same as the workshop during which they felt the most creative (depicted by yellow rows), while only 3/8 responding participant’s favorite workshop was not (depicted by red rows). This shows that a majority of respondents preferred a workshop in which they felt the most creative.

Therefore, the researcher can draw similarities after all between their research and the work at Harvey Mudd College - both groups responded well to creative problem solving / application (Klawe, 2017). Ultimately, these findings support the idea that Hampton Middle School girls enjoy computer science more when creativity is involved.

Female Role Model

Shown in Table 1: Breakdown of Research Question in Relation to Findings, the third portion of the research question’s purpose was to determine if the participants responded well to a female role model. Depicted in Table 6, the participants very much enjoyed having a female role model to walk them through the workshop(s) that they attended. All 8 respondents provided a favorable response to the question: Did you like working with the leader of the workshops? Explain why or why not. While there were only 8 responses, some responses contain more than one theme. See Table 6 for theme breakdown and examples of each theme in a direct quote from a par-

ticipant.

The unanimous positive perception of computer science as taught by a female role model is in line with the interviews from Alshahrani’s social cognitive study, where subjects believed that having a female role model would have a positive impact on how young girls viewed computer science (Alshahrani, 2018). Additionally, the researcher’s assumption of them being able to embody such a role was obviously brought to fruition. With that, it is evident that the participants were interested in computer science when an older, seasoned female was involved.

Limitations

The major limitations of this study are issues with the sample regarding size and randomization. First of all, the sample size of n=15 is small. For a paired t-test as used by the researcher, it is preferred that the sample size be at least n=30 in order to generalize the findings to the population. Despite efforts made to gain as many participants as possible through emails sent home to all parents/guardians of the middle school girls and announcements made during all lunches (as mentioned in the study setting section of the methodology), the limitation of a small sample size could not be overcome. Additionally, the sample was not randomly selected: the participants signed up for each of the workshop(s) they wanted to attend. However, this sign up method was necessary in recruiting participants because the workshops were held during study halls due to the alignment of the researcher’s schedule with that of the middle school, and students cannot

be forced to partake in an activity during their free period. With this non-random selection, bias occurs because the sample is made up of students that chose to partake in this study, many of whom already had an interest in science, technology, engineering, and/or math.

Finally, again due to the researcher's availability and the study hall schedule at the middle school, only sixth and seventh graders were able to participate in the workshops. This limitation is addressed by Bowling Green State University professors Booth and Gerard's findings of uniform school climates with "shared perceptions of the academic environment" (Booth and Gerard, 2014). Due to these shared perceptions throughout a school, the researcher assumes that the eighth grade students would have similar feelings towards the workshops as the sixth and seventh graders.

In future studies, these limitations could be avoided if the workshops could be taught to each of the three grade levels within a random selection of mandatory classes rather than study halls. This way, the sample would be larger, more inclusive, and more representative of the population. However, this solution assumes that 1) neither the researcher nor the school had scheduling conflicts and 2) all guardians would be willing to sign a consent and debriefing form for their minor, as they had in the original study.

Conclusions

A significant imbalance in the ratio of girls to boys in computer science was found through the literature. The researcher saw this imbalance firsthand in a medium sized suburban township in Western Pennsylvania specifically and framed their research to address the following question: Compared to their initial perceptions, do girls at a medium sized suburban middle school in Western Pennsylvania demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model? After three workshops addressing all three aspects of the research question through appropriate methods, the sweeping conclusion that yes, girls at a medium sized suburban middle school in Western Pennsylvania do demonstrate a heightened interest in computer science after engaging in creative problem

solving led by a female role model was reached after assessing each part of the research question separately. The implication of such a conclusion is that if this middle school implements a computer science curriculum that allows girls to be creative and engage with females that they look up to, the imbalance could be rectified.

Further research could be conducted using similar methods applied to the larger county and beyond. With a wider variety of schools, a conclusion could be further generalized in a way that applies to many more middle schools. For now, this research applies to the medium sized suburban middle school in Western Pennsylvania in allowing its computer science program be better equipped in serving its young women.

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Appendix A

Dear Parents/Guardians,

Hello, my name is [REDACTED], and I am a senior at [REDACTED High School]. During my junior year, I was the only girl enrolled in AP Computer Science A at [REDACTED]. This is an issue for the district and community because of the gender difference it creates when girls are not continuing into higher level computer courses. This year I have chosen to take AP Research, a class where students have the ability to research a topic that interests them for the duration of the year. With this opportunity, I am exploring a possible avenue through which to remedy the situation: creative problem solving as led by a female role model. My goal is to ultimately give girls at [REDACTED Middle School] information and experience that they can use to make an informed decision on whether or not to continue with computer science, rather than making that decision based off of the "it's a boy thing" attitudes seen far too often.

Your daughter has the opportunity to take part in a research study that measures her interest in computer science before and after engaging in creative problem solving led by a female role model. I am inviting your daughter because of her prior interest in the [REDACTED] STEAM Girls workshops at [REDACTED Middle School]. Please read this form carefully and ask any questions you may have before agreeing to your daughter's participation in the study.

What the study is about: The purpose of this study is to explore if [REDACTED Middle School] girls demonstrate a heightened interest (compared to their initial perceptions) in computer science after engaging in creative problem solving led by a female role model.

What I will ask of your daughter: If you agree to this study, your daughter will engage in the creative problem solving tasks I have created using Carnegie Mellon University Computer Science Academy. They will also complete pre and post-surveys. The surveys will include a multiple choice question about their interest level, as well as open ended questions asking to explain their answer.

Risks and benefits: This study has been approved by [REDACTED]'s Institutional Review Board and they do not anticipate any risks to your daughter participating in this study. There is also no benefit in terms of compensation, although they do get to explore computer science in a safe and fun environment.

Your daughter's answers will be confidential. The records of this study will be kept private. The completed consent forms will be kept in a locked safe. The survey results will be stored in a digital spreadsheet only accessible to myself and my advisor, [REDACTED]. In any sort of report I will not include any information that will make it possible to identify your daughter. While each student will be given a login for CMU CS Academy, this login will be anonymous and not connected to any personal contact information (ex: [REDACTED] User1). The surveys will be administered through Google forms, and all personal information collecting features will be turned off.

Taking part is voluntary: Taking part in this study is completely voluntary. In the surveys, your daughter may skip any questions that she does not wish to answer. If you choose not to consent to the surveys, your daughter is still welcome to participate in the workshop while being excluded from the data set.

THE EFFECT OF CREATIVE CS WORKSHOPS ON THE INTEREST LEVELS OF FEMALE MS STUDENTS 22

If you have questions: Please feel free to contact me at [REDACTED] if you have questions about the study. You may also contact [REDACTED] or my supervisors, [REDACTED].

Statement of Consent: I have read the above information, and have received answers to any questions I asked. I consent for my daughter take part in both the workshop and the survey.

Parent/Guardian Signature _____ Date _____

Parent/Guardian Name (printed) _____

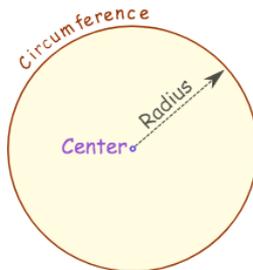
Student Participant Signature _____ Date _____

Student Participant Name (printed) _____

Appendix B

Creating Circles

Radius: the distance from the center of a circle to any point on the circumference (outside of circle)



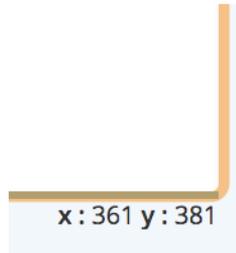
Plan your circle:

1. Decide what point (x,y) to call the center
2. Decide what size you want for your radius
3. Decide what color you want your circle to be

Create your circle:

Circle(centerX, centerY, radius, fill='color')

There is an arrow tool that displays your location in the sandbox.



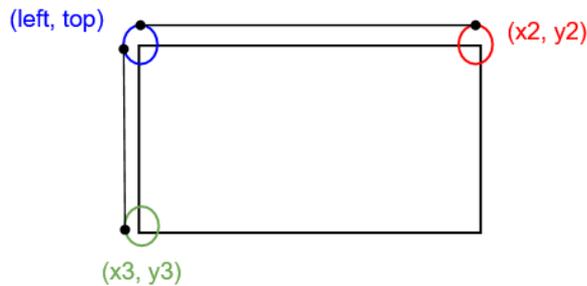
Move the arrow tool around until you find a point to put your circle and use that point as your circle's center.

Remember that the sandbox only goes to 400 in each direction!

Please let me know if you have any questions!

Appendix C

Creating Rectangles



Plan your rectangle:

1. Decide what point (x,y) to call the left-top corner
2. Decide the width you want for your rectangle
3. Decide the height you want for your rectangle
4. Decide the color you want your rectangle to be

How do I find width?

Find the change in the x-values. In the rectangle above, that would be **x2 - left** (or just use trial and error to find which dimensions result in the rectangle that you wanted)

How do I find height?

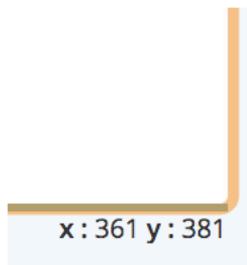
Find the change in the y-values. In the rectangle above, that would be **y3 - top** (or just use trial and error to find which dimensions result in the rectangle that you wanted)

Create your rectangle:

Rect(left, top, width, height, fill='color')

How do I know where to put the left-top corner of my rectangle?

There is an arrow tool that displays your location in the sandbox.



Move the arrow tool around until you find a point to start your rectangle and use that point as your rectangle's left-top corner.

For the width and height, you can use the subtraction strategy demonstrated above or just use trial and error to find which dimensions result in the rectangle you wanted.

Remember that the sandbox only goes to 400 in both directions!

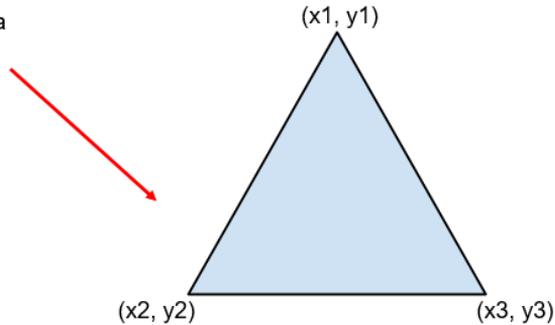
Please let me know if you have any questions!

Appendix D

Creating Three-Sided Polygons

A polygon is a shape formed with straight lines.

So a three-sided polygon is a triangle!



Plan your polygon:

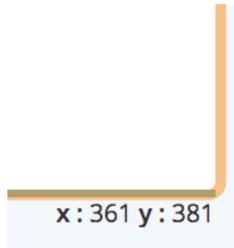
1. Choose three points to be the three corners of your triangle. You will be connecting these points with straight lines.
2. Decide what color you want your triangle to be

Create your polygon:

Polygon(x1, y1, x2, y2, x3, y3, fill='color')

How do I know where to put my three-sided polygon?

There is an arrow tool that displays your location in the sandbox.



Move the arrow tool around until you find a point to put a corner of your three-sided polygon / triangle and start with that point. From this point, find two others that would appear to make the triangle you were hoping for.

Remember that the sandbox only goes to 400 in each direction!
Please let me know if you have any questions!

Appendix E

Project Title: Creative Computer Science for Girls

Principal Investigator: [REDACTED]

Department/Course: Social Sciences / AP Research

Contact Information: [REDACTED]

Taking part is voluntary

Although your daughter has already completed the survey, your daughter's involvement is still voluntary, and you may choose to withdraw the data she provided prior to debriefing, without penalty. Withdrawing your submission will not adversely affect your relationship with [REDACTED], the researcher, or any of our affiliates.

Privacy/Confidentiality

If you agree to allow us to use your daughter's data, here is how we will maintain confidentiality of the information:

The records of this study will be kept private. The completed consent forms will be kept in a locked safe. The survey results will be stored in a digital spreadsheet only accessible to myself and my advisor, [REDACTED]. In any sort of report I will not include any information that will make it possible to identify your daughter. While each student will be given a login for CMU CS Academy, this login will be anonymous and not connected to any personal contact information (ex: Steamgirl1). The surveys will be administered through Google forms, and all personal information collecting features will be turned off.

The main researcher conducting this study is [REDACTED], a student at [REDACTED].

If you have questions later, or would like to know about the results of the study, you may contact [REDACTED] at [REDACTED]. You may also contact her faculty advisors [REDACTED] and [REDACTED].

If you have any questions or concerns regarding your daughter's rights as a subject in this study, you may contact the Institutional Review Board (IRB) for Human Participants at [REDACTED]. Please sign below (or in the case of phone, online or other media where signed debriefing is waived, use another method to get participant preference) if you do, or do not, give permission to have your data included in the study:

I have been debriefed by the Research team, and I understand the true intent of and the purpose of my daughter's participation in the Creative Computer Science Workshop. I agree that the data collected during the study may be included for the purpose of the study. _____

I have been debriefed by the Research team, and I understand the true intent of and the purpose of my daughter's participation in the Creative Computer Science Workshop. I **DO NOT** give permission for the data collected during the study to be included for the purposes of the study. _____

*adapted from Cornell University Office of Research Integrity and Assurance

<https://www.irb.cornell.edu/forms/>

Appendix F

Creative Computer Science Pre-Survey

Please answer these questions honestly before we begin the workshop.

1. Have you turned in a signed parental consent form?

Mark only one oval.

Yes

No

2. Enter the number that was assigned to you.

3. What grade are you in?

Mark only one oval.

6

7

8

4. How many of the other Creative Computer Science workshops have you been to before this?

Mark only one oval.

This is my first time

I've been to one before

I've been to two before

5. Which Creative Computer Science workshop are you attending today?

Mark only one oval.

Creating Circles

Creating Rectangles

Creating Three-Sided Polygons

CREATIVE COMPUTER SCIENCE WORKSHOPS FOR FEMALE MS STUDENTS

6. How interested are you in computer science? (0- I do not know what computer science is ; 1- I am not interested ; 2- I have no opinion ; 3- I am interested ; 4- I am very interested ; 5- Computer science is my favorite thing to do)

Mark only one oval.

	0	1	2	3	4	5	
I do not know what computer science is	<input type="radio"/>	Computer science is my favorite thing to do					

7. Explain why you rated your interest level in that way.

8. Would you continue with computer science in the future?

Mark only one oval.

- Yes
 No
 Maybe

Thank you!

You have completed the pre-survey. Thank you for your time.

This content is neither created nor endorsed by Google.

Google Forms

Creative Computer Science Post-Survey

Please answer these questions honestly to end the workshop.

1. Enter the number that was assigned to you.

2. How interested are you in computer science? (0- I do not know what computer science is ; 1- I am not interested ; 2- I have no opinion ; 3- I am interested ; 4- I am very interested ; 5- Computer science is my favorite thing to do)

Mark only one oval.

	0	1	2	3	4	5	
I do not know what computer science is	<input type="radio"/>	Computer science is my favorite thing to do					

3. Explain why you rated your interest level in that way.

4. What was your favorite part of the workshop today?

5. Would you continue with computer science in the future?

Mark only one oval.

- Yes
 No
 Maybe

Final Workshop Survey

6. Which workshops have you attended? (choose all that apply)

Check all that apply.

- Creating Circles
 Creating Rectangles
 Creating Three-Sided Polygons

CREATIVE COMPUTER SCIENCE WORKSHOPS FOR FEMALE MS STUDENTS

7. Which workshop was your favorite?

Mark only one oval.

- Creating Circles
 Creating Rectangles
 Creating Three-Sided Polygons

8. How creative were you able to be in the workshop(s)? (0- Not creative at all. I was told exactly what to do. ; 1- Barely able to do my own thing ; 2- Creative, but not as much as I'd like to be ; 3- Creative ; 4- Very creative ; 5- I was able to be super creative and explore my own solutions to problems.

Mark only one oval.

	0	1	2	3	4	5	
Not creative at all. I was told exactly what to do.	<input type="radio"/>	I was able to be super creative and explore my own solutions to pro					

9. During which workshop were you able to be the most creative?

Mark only one oval.

- Creating Circles
 Creating Rectangles
 Creating Three-Sided Polygons

10. During which part of the workshop(s) were you able to be the most creative?

Mark only one oval.

- Changing the colors of shapes
 Creating my own shapes
 Making pictures out of the shapes

11. What was your SINGLE favorite part out of all of the workshops you attended?

12. Did you like working with the leader of the workshops? Explain why or why not.

Thank you!

You have completed the post-survey. Thank you for your time.

Chemotaxis of *Chlamydomonas reinhardtii* towards AHLs

Esha Patel

Quorum sensing is a widespread phenomenon in various environments, allowing organisms to display symbiosis, pathogenicity, etc. This mechanism has recently been of great interest with the newfound discovery that quorum sensing not only occurs in prokaryotic organisms like bacteria, but also eukaryotes like the green algae *Chlamydomonas reinhardtii*. With this novel information, the question remains regarding how these eukaryotes and prokaryotes interact amongst one another, potentially enhancing human health, biotechnology, pharmaceuticals, etc. Through a chemotaxis assay using liquid algae cultures and capillary tubing along with pixel density analysis using the image processing program *ImageJ*, the movement of *Chlamydomonas reinhardtii* was tested in response to molecules released by bacteria during quorum sensing called AHLs. Through various assays of AHLs, sucrose, and deionized water, the results were shown to be statistically insignificant. However, the setup of the experiment showed great potential and provides a promising future for the direction of this research.

Keywords: quorum sensing, chemotaxis, *Chlamydomonas reinhardtii*, AHLs, pixel density

Introduction

Many Gram-negative bacteria regulate gene expression through the phenomenon known as quorum sensing (QS) (Palmer et al., 2018). QS is a mechanism that produces change based on the population density of the organism, in which genes are activated that in turn cause changes in phenotype, or the observable characteristics of an organism (2018). QS is responsible for behaviors like bioluminescence and virulence, and is even used in finding nesting sites in some insects (2018). This phenomenon is regulated by autoinducer (signaling) molecules known as *N*-acyl L-homoserine lactones, or AHLs (2018). Studying QS pathways is vital to developing a better understanding of influential bacterial behaviors, such as their ability to evade immune response by activating molecules that enhance their effectiveness called virulence factors (2018).

In the past, it was thought that QS was only exhibited by bacteria, which are prokaryotic, meaning they lack a cell nucleus and many organelles (Teplitski et al., 2004). However, it has recently been discovered that QS is also seen in some eukaryotes, or organisms with membrane-bound nuclei and organelles, through the secretion of substances that mimic AHLs (2004). *Chlamydomonas reinhardtii*, a unicellular freshwater green algae, is currently of great interest in the scientific community for its newfound QS behaviors (2004). It is being widely studied due to its well-known genetic sequence in addition to how easy it is to obtain and manipulate as a model organism in the laboratory (Arrieta et al., 2017). *C. reinhardtii* is also known for its motility, using organelles called flagella to swim in a path known as a helical trajectory (2017). The motility of the organism has also been used with various molecules to study its chemotaxis, which refers to the movement of an organism towards or away

from a stimulus (Choi et al., 2016).

Scientists have yet to establish a clear connection between bacteria and algae in regards to quorum sensing. Finding the relationship between these organisms can create a link between QS in prokaryotes and eukaryotes while also shedding light on the ecological relevance of the organisms' behaviors by understanding its interactions with organisms found in various ecosystems. These connections can potentially create a model system for understanding the QS behaviors of other eukaryotes, which could be integral to biotechnology, human health, etc. These effects may be vital in the development of new pharmaceuticals as well as in the improvement of current techniques in research and clinical medicine. Studies have been conducted that display the phenomenon in both organisms individually, but their interactions through AHLs and motility have not been thoroughly explored, thus presenting a gap in the research. Therefore, the question remains: Does *Chlamydomonas reinhardtii* display movement towards bacterial AHLs within an environment lacking key nutrients?

Literature Review

Quorum Sensing/AHLs

Quorum sensing, a density-dependent mechanism that affects behavior, has long been studied in bacteria, but recently the focus has shifted towards QS in eukaryotic organisms. Researchers have found that AHLs, the molecules released to signal quorum sensing, have an effect on various eukaryotic organisms. Dr. Andrew Palmer (2018) tested the effects of AHLs on the plant *Arabidopsis thaliana* in order to identify the phenotypic effects of these molecules. Using this organism allowed him to find that AHLs primarily affect auxin levels, a hormone involved in all plant development (2018). Thus, this finding can be translated to other plants as well as other eukaryotic organisms.

Conversely, research has also found that eukaryotes themselves can affect bacteria and their ability and efficiency to display quorum sensing behavior. Teplitski et al. (2004) investigated the production of AHL mimic substances by the algae *Chlamydomonas reinhardtii*, using agar plate spreads with suspensions of quorum sensing reporter strains to detect luminescence responses.

After learning that luminescence was inhibited by the algae, the authors further tested the substances on proteins in bacteria and found that many of the proteins were altered (2004). This provides evidence of eukaryotes affecting bacteria and their signaling molecules, showing the two-way relationship between eukaryotes and the prokaryotic bacteria in terms of quorum sensing. This statement provides a foundation for this study's inquiry. Further, using mass spectral analysis, Teplitski also found that some compounds in *C. reinhardtii* are very similar to bacterial AHLs structurally, providing evidence of quorum sensing in the algae (2004). Working off of this finding, scientists at the University of California, Davis have found some vitamins, namely riboflavin and its derivative lumichrome, in *Chlamydomonas* that mimic AHL activity and are capable of activating quorum sensing receptors in the common bacteria *Pseudomonas aeruginosa* (Rajamani et al., 2013). This provides concrete evidence that quorum sensing is exhibited by prokaryotes, more specifically in these studies, the green algae *Chlamydomonas reinhardtii*. Thus, firm evidence proves QS in *C. reinhardtii*, setting a foundation for this study.

In addition, researchers from the University of Haifa have also discovered evidence of quorum sensing active in marine organisms in the form of inhibitors that use this mechanism to defend against virulence (Saurav et al., 2017). Through the use of biosensors that react to quorum sensing signals, the authors identified various quorum sensing inhibitor (QSI) molecules while also creating the potential for using these marine sources as a form of treatment, since many display anticancer activity (2017). In fact, these QSIs have the potential to be very useful in many types of drugs and antimicrobial therapy, and many patents have already been published related to their use (Jiang & Li, 2013). Thus, this evidence gives further support on eukaryotic QS and how it has already begun to impact pharmaceuticals.

Therefore, sufficient research has been done regarding the evidence of quorum sensing in various eukaryotic organisms from many different ecosystems as well as their effect on bacterial AHLs and vice-versa. The studies have also highlighted the potential benefits of these relationships and quorum sensing activity, from creating model systems for further studies to potential human treatment.

Structure of *C. reinhardtii*

Chlamydomonas reinhardtii is a freshwater green algae and its physiology is well known (Sasso et al., 2018). In 1833, Christian Gottfried Ehrenberg described the genus *Chlamydomonas*, and in 1888, Pierre Augustin Dangeard described the species *C. reinhardtii* (2018). In the early 1950s, *C. reinhardtii* was developed as a model organism as the first mutants were generated (2018).

The motility structures of *C. reinhardtii* are very well-known. Its flagella, an outside organelle used for movement, is composed of centrioles and basal bodies that help distribute the organism's organelles, which are structures within cells that perform specific functions (Aliouche & Greenwood, 2019). The arrangement in *C. reinhardtii* is called "9+2", as there are nine doublets and two central microtubules, and this overall structure helps produce the motions allowing flagella to propel the organism forward (2019). Aliouche further states that *C. reinhardtii* has four basal bodies, two of which are used in flagella. The structures of these two vary: one is centrin-based fibers, and the other is microtubular roots (2019). The movement of *C. reinhardtii* flagella is an asymmetric movement of the two (*cis* and *trans*) flagella (2019). As is seen in this detailed description, the well-understood anatomy of *C. reinhardtii* and its motility structures makes it an ideal organism for studying in a laboratory, especially when testing movement.

In addition to its motility structures, *C. reinhardtii* is also very useful for genetic investigations due to its well-understood organelles, like the nucleus, mitochondria, and chloroplasts (Haire, 2017). The algae is also photosynthetic, which indicates plant-like behavior, and many strains are also phototactic, meaning they display movement toward light (2017). Additionally, the haploid nature of the organism, which refers to its growth and reproductive style, allows creating mutants to become efficient, as the mutant phenotypes are immediately expressed (Sasso et al., 2018). Thus, the wide variety of strains and the ease with which it can be cultured, or grown, make it an attractive option for many research studies.

Chemotaxis

Chemotaxis is the movement of an organism in response to a chemical stimulus, where positive chemotaxis refers to movement towards the stimulus and negative chemotaxis refers to movement away (Choi et al., 2016). This behavior is used by many organisms to find nutrients as well as avoid toxins and predators (though only in multicellular organisms), and is fundamental to processes including biofilm formation, virulence, and carbon cycling (Ahmed et al., 2010). *Chlamydomonas reinhardtii* has been shown to exhibit chemotaxis towards various chemicals, such as bicarbonate, ammonium, and sucrose, but has yet to be tested for chemotaxis towards bacterial AHLs. For instance, researchers at Korea University used microfluidic assays, which utilize diffusion as a method to test the chemotaxis of *C. reinhardtii* towards bicarbonate (HCO_3^-), a molecule often used as a carbon source in aquatic environments (Choi et al., 2016). They found a positive chemotactic response to bicarbonate, suggesting the importance of chemotaxis and *C. reinhardtii* to carbon utilization. Similarly, in 1992, researchers at Vanderbilt University used capillary tube assays, a method that measures the distance traveled in small tubes, to test the chemotaxis of *C. reinhardtii* towards ammonium (NH_4^+) molecules, and also found that the algae displayed positive chemotaxis (Byrne et al., 1992). Ermilova et al. (1993) used capillary tube assays to discover the relationship between *C. reinhardtii* and sugar molecules, namely sucrose and maltose. Their results showed that *C. reinhardtii* displayed positive chemotaxis towards both maltose and sucrose, providing yet another molecule that interacts with *C. reinhardtii* (1993).

In addition to movement towards chemical stimuli, *C. reinhardtii* also exhibits movement towards light stimuli, known as phototaxis (Arrieta et al., 2017). The ability of the algae to move towards light is an evolutionary characteristic as maximum light exposure allows for more photosynthesis thus more productivity and growth (2017). Scientists at the Mediterranean Institute for Advanced Studies along with at the University of Cambridge tested the movement of *C. reinhardtii* towards light by measuring the change in chlorophyll, which is a pigment used for light absorption to provide energy for photosynthesis (2017). In this way, they were able to create a quantitative connection

between phototaxis and photosynthesis (2017). Additionally, Yu et al. (2019) conducted a study testing *C. reinhardtii* and its phototactic response to the element cadmium, which is known for being a hazardous pollutant in aquatic ecosystems. They found that cadmium inhibited cell growth and photosynthesis, while also providing oxidative stress to the algae, ultimately showing the negative association of phototaxis and cadmium-induced toxicity (2019). These studies provide sound evidence of *C. reinhardtii* behavior towards a different type of stimulus: light, which is yet another type of catalyst causing its movement. The evidence of chemotaxis found throughout these studies provide ample information on many types of molecules; however, there is a gap in the study of chemotaxis towards bacterial AHL molecules. Thus, this study focuses on testing the chemotaxis of *C. reinhardtii* towards these AHL molecules, by creating an environment without some necessary nutrients along with a stimulus that allows the algae to have an opportunity for movement.

Method

This study features a quantitative approach with a true experimental method (Creswell, 2014). This method was conducted in a traditional lab setting, which allows for sterile equipment and environments. This true experimental method was chosen in order to allow one variable to be restricted, so that there was a control group and an experimental group (2014). In this study, the control variables were defined as the water and sucrose trials, and the experimental group was defined as the bacterial AHL trials.

The strain of algae chosen for this experiment is called CR-125 (*C. reinhardtii* strain 125). This specific strain was chosen for its particular sensitivity to light, since many other strains do not react as well to light. The algae were cultured in tris-acetate-phosphate (TAP) media, a liquid medium used to help the algae grow ("TAP"). This contains NH_4^+ (ammonium), which is a nitrogen source used as nutrients; Tris, which is an organic compound used as a buffer for the pH; and other trace elements ("TAP"). This media solution allows an optimal growth environment for CR-125, as it provides all the nutrients needed for it to flourish. This liquid culture was left to grow in an Erlenmeyer (cone-shaped) flask for at least 48 hours on a lab shaker to keep the contents evenly dispersed. Once the algae was properly cultured, it was transferred into a test tube and put into a centrifuge, a machine that

spins the liquid at very high speeds, allowing the algae to separate from the used TAP media. Using a centrifuge, the algae was able to solidify at the bottom of the test tube, while the remaining TAP media remained in liquid form at the top of the tube. This excess media was decanted, or poured off, into a general waste container, which allows any toxic materials to be disposed of properly (rather than poured down the sink, which could cause contamination in the water supply). Then, the algae were resuspended in TAP media without acetate (which can act as a nutrient source), and heterogenized in the tube using a vortex mixer, allowing the media and algae to effectively mix together and become a single liquid solution. The solution was then transferred into multiple plates with wells. Each plate had six wells, and using a pipette, each well received 2 mL of the algae solution. **Appendix A** displays an example of a plate used for experimentation. As seen in the image, each circle represents one well, which each acts as a single trial.

A capillary tube cutter was used to cut the glass capillary tubes into precise, small pieces that would fit inside of each well. These tubes were left in a small volume of each variable solution, with the controls being deionized water and sucrose since they should show no chemotaxis and positive chemotaxis, respectively. Through capillary action (the ability of the liquid to flow through a narrow space without external forces), the tubes filled up with these test liquids. A tube was then placed into each individual well, with an equal amount of wells testing the control and experimental variables. These tubes can be seen in **Appendix A** within each well. The plates were then covered and scanned in an Epson Perfection V500 Photo Scanner and saved to a computer. After scanning, the plates were placed in a dark environment so as to prevent light and phototaxis from being confounding variables. After 48 hours, the plates were scanned again and the image was saved.

The analysis method includes using a photo-analysis software program called *ImageJ*, which uses Java and was developed by the National Institute of Health. This analysis procedure closely mirrors the one used by Margrethe Boyd (2018) in a study featuring the motility of *C. reinhardtii* in regards to unicellularity and multicellularity. The program was used to analyze the pixel density, or the number of red-green-blue pixels in a given area, in each experimental well by scanning

each plate initially and after 48 hours. Once scanned, the images of the plates were opened in *ImageJ* and cropped to each well in order to analyze each individually. Then, by selecting “Edit<Selection<Specify” and setting the width and height of the chosen area to 200 each, a uniform area was chosen for analysis for each well. **Appendix B** provides an image of a single well from the experiment, in which the yellow box represents the area chosen for analysis. In this manner, the software analyzed an identical area of each well, and the same area was then compared 48 hours later. These results provided a numerical representation of pixel density, in which the before and after numbers could be compared to show change in the pixel density which translates to change in the movement of the algae.

Before testing the bacterial AHLs as the experimental molecule in the capillary tubes, sucrose molecules were used first. In 1993, Ermilova et al. found that *C. reinhardtii* displays positive chemotaxis towards sucrose in similar conditions. Thus, this molecule was used on the experimental design to test its effectiveness. In a similar manner, deionized water was also used as a control molecule because the algae should show no movement towards the water. Thereafter, the AHL molecules were used.

In regards to safety protocol, proper protection was used throughout the lab experiment. Gloves and protective eyewear were used at all times to protect the researcher from harmful substances. In addition, the experiment was completed entirely under at least a BSL-1 (biosafety level 1) hood, which is usually used with non-toxic organisms to ensure that all of the equipment and materials remained sterile. Thus, the safety and sterile protocols throughout the experiment displayed ethical practices and removed any extraneous variables and thus potential bias.

Results

Using the “Analyze<Measure” feature of the *ImageJ* software, numerical results were collected that represent the pixel density of each well (refer to **Appendix B**). The tool converts RGB (red, green, blue) pixels into brightness values, of which a number was calculated for each sample. The mean for each test molecule (deionized water, sucrose, AHLs) is shown in **Table 1**.

Sample Molecule	Mean (initial)	Mean (48hr)
Deionized Water	88.177	82.614
Sucrose	74.558	73.007
AHL	147.550	128.146

Table 1: Mean pixel densities of various sample molecules from ImageJ analysis. The table shows the average pixel density of wells for each sample molecule at both the initial and 48 hour points.

From this simple average, it is seen that all three molecules displayed a decrease in pixel density between the initial and 48 hour plates, even though the current literature indicates that water and sucrose should have shown no change and an increase, respectively. Since these results appear inconsistent with the literature, there is room to believe that the methodology in question had some flaws. This suspicion is further justified through a paired t-test for statistical significance. With the 30 samples of AHLs, a paired t-test was performed in which the 30 initial AHL pixel densities were compared to the 30 densities from the 48 hour AHLs. The exact numbers used in this analysis can be found in **Appendix C**. From this t-test, a p-value of 0.999 was obtained. This number shows a great lack of significance in the data. However, the lack of significance in the results can most likely be attributed to methodology errors, as the results from the water and sucrose samples showed that the method did not prove information present in current literature. Additionally, the standard deviations for the initial AHL scans and 48 hour AHL scans were quite high — the standard deviation between the initial wells was 48.86 and between the 48 hour wells was 35.98. Considering the initial and 48 hour AHL plates had mean pixel densities of 147.55 and 128.15 respectively, these standard deviations were very large, which means that the data within the different trials varied greatly. These large standard deviations further decrease the significance of the results.

As mentioned in the literature review and the methods section, *C. reinhardtii* has been shown to display positive chemotaxis towards sucrose molecules. In reference to this study, this would mean the 48 hour samples have a higher pixel density than the initial

Sucrose Samples

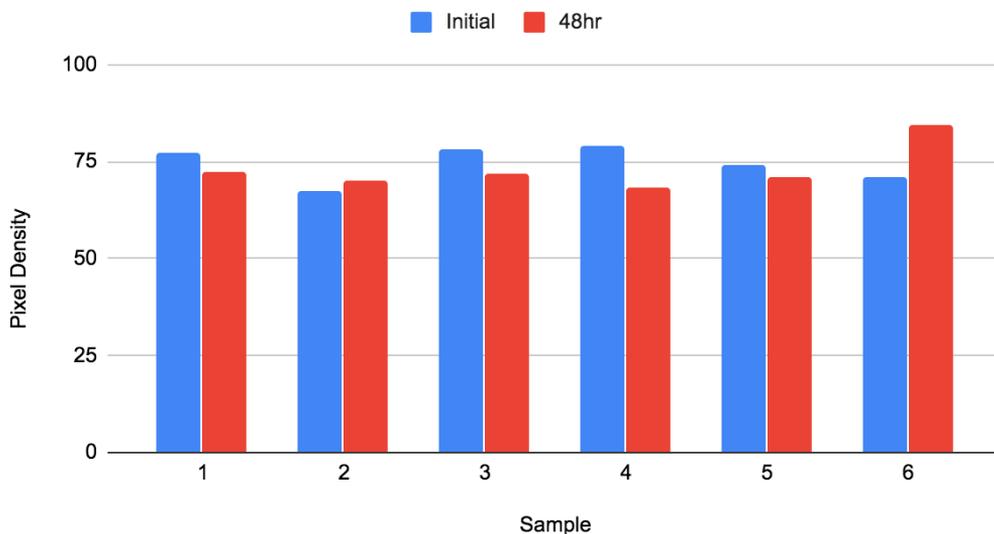


Figure 1: Comparing initial and 48 hour pixel densities of sucrose samples. The bar graph shows the pixel densities of six individual sucrose wells at the initial and 48 hour points.

samples, since the algae should theoretically be more concentrated near the capillary tubes filled with sucrose, which was the area analyzed from the samples. However, looking at six sucrose samples in **Figure 1**, they all showed a miniscule change in density, and in fact many showed a negative change where there should have been a positive change. The mean percent change of these six samples is -1.64%, showing that the change was negative and very small. This demonstrates that the method most likely had an error, as it should have proven the sucrose control to be positive.

Furthermore, a similar result occurred in the water control samples, in which the percent change between initial and 48 hour samples was -6.26%, again a negative change, when as control it should have been a 0% change. The results from both the water and sucrose samples thus prove that there must have been an error that caused results even for the controls to be skewed.

Discussion

These results show that the data does not support the movement of the algae towards the AHL molecules. In fact, it does not support movement of any of the three test molecules. Extensive research has proven that algae display positive chemotaxis towards sucrose and no chemotaxis towards water (Ermilova et al., 1993), yet the results showed slightly negative chemotaxis in both. This suggests that there was most likely a fault in the procedure, and decreases the confidence of the AHL results.

There are a number of possible reasons for skewed data. For instance, the plates were left on the scanner for 48 hours, and from the 48 hour images it seems that most algae moved either to the top or the bottom of each well. This suggests that gravity may have played a role in the algal movement due to uneven ground underneath the plates. Another large factor in the physical setup of the plates that may have af-

fecting the results was the placement of the capillary tubes. Although the plates were not moved in between the initial and 48 hour scans, there was not a measure set in place to keep the capillary tubes fixed in place. Thus, the tubes may have moved slightly between scans, which would impact the results during analysis through *ImageJ*. In addition to these physical limitations, an error with the analysis procedure may also explain the results. While scanning, there is the possibility of having a difference in lighting between scans as well as the presence of dust particles. Due to the nature of the *ImageJ* software, it also counts these unwanted pieces in the brightness values. Beyond the specific issues that may have occurred with the plate setup and analysis, the underlying problem may have simply been that the culture of algae used was not concentrated enough, or that 48 hours was not enough time for the algae to display proper movement.

Alongside these unforeseen issues, there were some limitations present from the very beginning that could not be controlled in the scope of the study, including time limits and cropping errors. As mentioned previously, there were only 48 hours after the initial scan for the algae to display movement before another scan was taken. Should this time frame have been longer, the results may have differed. However, with the number of trials that needed to be completed, it was impractical to elongate this period during the experimental phase of the research. Additionally, some aspects of *ImageJ* posed limitations, including the cropping and RGB functions. While cropping images with the software, exact dimensions could not be reached for each well, so the initial and 48 hour images may have been a few pixels off based on human error by cropping. This limitation is similar to the capillary tubes not being able to be fixed in place, as the initial and 48 hour images may have a few pixels shifted. In addition, the software is only capable of measuring a combination of red, blue, and green pixels, rather than just the green pixels that were the target of this research. This means pixels other than green were included in the analysis. However, the scans did not show a significant amount of red or blue coloring, so this most likely did not have a great effect on the analysis measures.

Despite the plethora of potential errors, there is still a possibility that the results obtained were valid and that *C. reinhardtii* performs negative chemotaxis

towards bacterial AHL molecules. However, the large p-value of 0.999 obtained from t-testing suggests that the confidence in these results actually being significant are extremely slim. Therefore, the results of the study cannot confidently claim that the algae perform either positive or negative chemotaxis towards AHLs. However, these errors and limitations provide very useful information for future researchers in terms of methodology and analysis techniques.

Future Directions

Despite the errors faced in methodology and analysis, the researcher believes that this procedure using capillary tube assays should be further studied in the future. This present method has been a learning opportunity, and working on setbacks in this procedure will hopefully lead to improvements and significant results in the future. In repeating this study, more improvements may be made in order to eliminate confounding factors. For example, repeating the procedure with a stronger concentration of algae or leaving a longer period of time between scans could reveal better results or simply improve the method, getting closer to the ideal procedure to testing the algal chemotaxis.

Furthermore, addressing the limitations from this study and applying them to another experiment may also advance the direction of this research. Although the researcher believes many of the factors discussed were not a large factor in the results, such as cropping and unwanted dust particles, eliminating any such variables may reap significant data. Therefore, the researcher is confident in this study's implications for improving the process used to find the relationship between AHLs and *C. reinhardtii*.

Conclusion

This study sought to find the relationship between *Chlamydomonas reinhardtii* and bacterial AHLs in order to further understand their interactions under the premise of quorum sensing, a density dependent behavior displayed by bacteria and, as recently discovered, by algae as well. Although the data did not provide significant results, the study provides direc-

CHEMOTAXIS OF *CHLAMYDOMONAS REINHARDTII* TOWARDS AHLs

tion for future studies in terms of methodology. For example, changes can be made to the concentration of algae and time between scans, as well as the lighting surrounding the scans. In terms of analysis, better methods of cropping and analyzing merely green pixels can be found, in order to eliminate small differences between scans. Also, new mechanisms to improve uniformity must also be found, such as a method of fixing the capillary tubes so as to prevent them from moving between scans.

Overall, this study reveals what changes must be made to the experimental design in the future in order to effectively test the chemotaxis of *C. reinhardtii*. Although this study could have been improved in many ways, it is unique in how it contributes to current work on algal chemotaxis and its novel approach in testing chemotaxis towards AHLs, a scarcely studied area of the topic. It is imperative to continue building off of this study's findings in the future as discovering this algal-bacterial connection could open up new possibilities in human health and pharmaceuticals and provide a greater understanding of various ecosystems. All in all, in light of the new findings on quorum sensing in algae, this study provides a great first step in exploring the interactions of algae with bacterial quorum sensing molecules, paving the way for further research to be conducted on these interactions.

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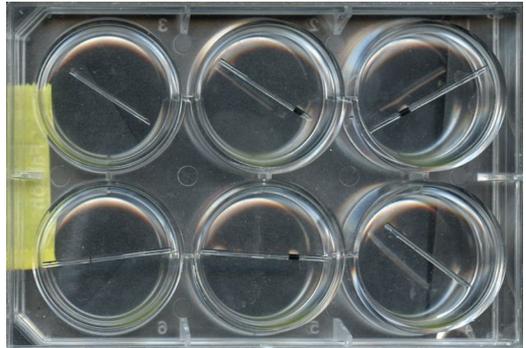
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CHEMOTAXIS OF *CHLAMYDOMONAS REINHARDTII* TOWARDS AHLs

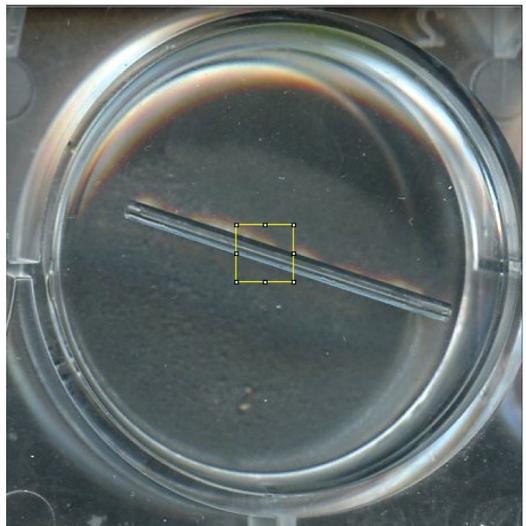
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Appendix

Appendix A: Sample Plate with 6 Individual Wells



Appendix B: Sample Well Used for ImageJ Analysis



CHEMOTAXIS OF *CHLAMYDOMONAS REINHARDTII* TOWARDS AHLS

Appendix C:

AHL Pixel Densities (Initial and 48 Hour)

Trial	Initial Density	48hr Density	Trial	Initial Density	48hr Density
AHL1	88.106	76.667	AHL16	187.589	163.339
AHL2	90.494	91.312	AHL17	178.389	159.306
AHL3	96.447	97.817	AHL18	157.226	140.315
AHL4	90.562	95.154	AHL19	189.851	158.742
AHL5	76.429	73.028	AHL20	186.757	156.668
AHL6	105.426	89.234	AHL21	196.897	164.386
AHL7	73.185	89.005	AHL22	186.102	153.249
AHL8	92.127	79.654	AHL23	187.912	156.822
AHL9	87.287	90.867	AHL24	184.127	135.808
AHL10	82.961	89.428	AHL25	194.41	160.973
AHL11	71.974	75.816	AHL26	183.496	155.031
AHL12	134.452	85.06	AHL27	187.759	156.657
AHL13	187.728	159.991	AHL28	177.343	150.788
AHL14	184.125	162.623	AHL29	183.635	152.687
AHL15	206.693	177.196	AHL30	177.01	146.77

A Flawed System of Accessibility: A Mixed-Methods Study of the Shortcomings of Disability Accommodations for Female Undergraduate Students with Autism Spectrum Disorder, Level One

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As women continue to receive diagnoses for Autism Spectrum Disorder (ASD), L1 (L1), later in life, there continues to exist a pervasive misunderstanding of how the condition affects women, specifically. This study aims to identify the extent to which women are disadvantaged under the current system of disability accommodations on university campuses through the understanding of how many female students lack access to accommodations and which accommodations would best supplement their academic plan. Through a mixed-methods approach with an exploratory-sequential design and participatory framework, interviews involving three groups of participants categorized as a medical professional, a secondary school learning strategist, and eight female students with ASD, L1, who currently attend a private, American, undergraduate school, took place. From the data gathered, it was concluded that most female students with ASD, L1, felt underserved by their university campuses in regard to disability accommodations.

Keywords: Autism Spectrum Disorder, disability accommodations, Autistic Masking, university disability services, women with Asperger's Syndrome

Introduction

Throughout the 20th century, sociological and medical research has become far more inclusive of those with developmental disabilities moving towards diverging from the exclusionary and antagonistic discourse often associated with past studies. Nevertheless, vulnerable demographics, particularly women with Autism Spectrum Disorder, Level One (L1), otherwise recognized as high-functioning autism, continue to be overlooked in the development of practical diagnostic improvements and even general discourse surrounding the experiences of those with Autism Spectrum Disorder (ASD) as a whole. (American Psychiatric Association, 2013). As a result of a persistent one-dimensional diagnostic process and, by exten-

sion, ineffective disability accommodation guidelines based on that process, it is necessary that the unique experiences of women with ASD, L1, are explored and understood in order to formulate a female-specific diagnostic evaluation. Current accommodation guidelines for these students fall short in three key respects: i) time, ii) environment, and iii) support. In each of these areas, female students with Autism Spectrum Disorder, Level One continued to be neglected and under-supported through academic accommodations (i.e. extended testing times, private testing locations, and tutors) which are rarely provided, or which only marginally benefit the student. With the absence of existing studies that specifically investigate the long-term impacts of this system on women, this gap must be filled by examining the question: to what extent do ineffective disability accommodation guidelines in

private, American, undergraduate universities delegitimize the experiences of female students with Autism Spectrum Disorder, Level One?

Literature Review

Establishing Historical Relevance

According to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-IV), *Asperger Syndrome* is now classified as Autism Spectrum Disorder, Level One. Despite its semantic changes, the diagnostic process for Autism Spectrum Disorder (ASD) is particularly stagnant (American Psychiatric Association, 2013). Austrian pediatrician, Hans Asperger (1906-1980) – from whom the term Asperger Syndrome derives its etymology – delineated the process by which autistic children would be diagnosed during his exploration into the disorder in a series of experiments spanning almost a decade from 1943-1952 (Hippler & Klicpera, 2003, p.291). The diagnostic process, as defined by Asperger – who notably used the term “autistic psychopathy” (AS) in his 1944 publication to define autistic behaviours – still serves as the fundamental basis for the Autistic Diagnostic Observation Schedule (ADOS) and the Autism Diagnostic Interview-Revised (ADI-R). Both ADOS and ADI-R serve as the primary resource for establishing conclusive diagnoses for ASD by focusing on three behavioural domains: i) quality of social interaction, ii) communication and language, and iii) repetitive, restricted, and stereotyped interests and behaviours; an additional emphasis is placed on supplemental factors deemed “relevant for treatment planning, such as self-injury and over-activity” (Western Psychological Services, 2003). While the acknowledgment of both ADOS and ADI-R are pertinent to the exploration of the stagnancy of ASD diagnostic approaches, the format of ADOS serves greater importance in evaluating this quality as a result of i) its functional similarities with the original testing conducted by Asperger and ii) the increased dependency of its scoring system (in contrast to the quantitative data collected by the

observational approach taken by ADI-R) (Ehmke). In Hippler and Klicpera’s study – which compares the original approach to AS diagnosis as prescribed by Hans Asperger and current ISD-10¹ directed approaches to diagnosing ASD – the results demonstrated that “68% of the children would be diagnosed with AS according to ICD-10 criteria” (p.298). Ultimately, through the data analyzed, the comparative study concludes that the current diagnostic criteria exhibits archaic qualities reminiscent of those inherent in the initial experiments by Asperger; notably identified is the discrepancy in male-focused criteria over gender-neutral or female-focused criteria (p.294). Though the past century has seen significant advancements within the field of psychology, women with autism continue to be left behind by means of a diagnostic process which is structurally incompatible with their behaviours.

Identifying Different Behaviour Patterns

Autistic camouflaging is the discrepancy between extrinsic behaviour in social-interpersonal contexts and intrinsic mental/emotional status (Lai et al., 2018, p.5). The notion that camouflaging is far more prevalent with autistic women is explored in a study led by Dr. Meng-Chuan Lai from the Toronto Hospital for Sick Children – in association with the University of Toronto – and Dr. Michael V. Lombardo from the Laboratory for Autism and Neurodevelopmental Disorders (LAND) at the Italian Institute of Technology (IIT) (2018). While pre-existing clinical studies would suggest a 4-5:1 male: female ratio of autism prevalence, it is far more likely that such a ratio is around 3:1 (p.6). It is hypothesized and ultimately proved within the paper that such a discrepancy exists more prominently in women on the spectrum², thus, leading to heightened rates of misdiagnosis and underdiagnosis for ASD in comparison to their male counterparts (2018, p.26). Psychological specialist, Francine Russo, then expands on this premise by connecting the increased prevalence of autistic camouflaging in women to the unique pressures that women are faced with in society surrounding such ideas as fitting in, being

1 The 10th revision of the International Statistical Classification of Diseases and Related Health Problems, a medical classification list by the World Health Organization with comparable criteria and reputability to DSM-IV.

2 A term used to describe the autism spectrum in relation to Autism Spectrum Disorder (ASD).

polite, and romantic interaction (Russo, 2018, p.2). As a direct result of these pressures, young girls with autism tend to exhibit more “societally palatable”, or by extension, more insignificant, characteristics and behaviours associated with their autism in three key respects: i) special interest³, ii) repetitive behaviours, and iii) public perception (Lester & Paulus, 2012, p.265-269). In contrast to the stereotype of a young autistic male (often with a special interest focused on a particular niche such as U.S. presidents or licence plate numbers), autistic girls tend to manifest their special interest in socially acceptable topics such as animals, dolls, or celebrities (p.4). Stimming⁴ actions like hand twitching, noise making, and foot-tapping also tend to be less dramatic or almost impossible to identify in women and girls with ASD (p.5). Thus, in an attempt to behave “normally” by mimicking the behaviours and actions of neurotypicals⁵ as a result of the societal pressure for women to uphold to a certain standard, it is concluded that women not only exhibit camouflaging to a greater extent than men, but also suffer more as a result of the emotional and psychological trauma of consistently masking their true identity and behaviours around others (p. 7). Consequently, this analysis questions how camouflaging affects the intellectual and physical abilities of women on the spectrum and whether they ultimately require more extensive assistance to combat these pressures.

Experiences of Disabled Students

With the enrollment rate of young adults with ASD to four-year universities sitting at a low 17% and the rate of successfully obtaining a degree from any post-secondary institution for people with ASD being 39% (in contrast to the 52% of neurotypicals), it is apparent the unique challenges faced by autistic people when seeking any kind of post-secondary education (Borrell, 2018, p.3). It is critical to recognize that the non-disclosure of disability on behalf of the student is a significant factor in post-secondary degree comple-

tion rates (Jarman & Thompson-Ebanks, 2018, p.3-4). Unlike in K-12 public schools, where the institution is obligated by law to provide accommodation to any student with a disability, the regulations surrounding universities operate mutually exclusive from the dogma of the K-12 school practices (p.286). Colleges and Universities do not have the legal obligation to provide disability accommodation services to their students outside of the realm of academic adjustments (and, if offered, unique student housing for those with physical disabilities) unless that student provides full disclosure to the necessities of their disability directly to their post-secondary institution (U.S. Department of Education, 2011)(Harris, 2019, p.941-943). In a 2018 study conducted in association with the University of Wyoming, it was discovered that students with nonapparent⁶ disabilities felt more at risk for humiliation, misunderstanding, and stigmatization based on their disability if disclosed to the appropriate post-secondary accommodation services platform/group (p.13). Notably, 60% of student participants who did not formally disclose their disability to their university reported their reason to be directly correlated with the perception that faculty, staff, and students may lack knowledge, sensitivity, and understanding for their nonapparent disability (p. 12). Ultimately, it is concluded that the experiences of the students in this study are generally congruent with the experiences of an average student with similar nonapparent disabilities at most American post-secondary institutions. Furthermore, it is critical to note that

Gap Analysis

Research suggests that the current diagnostic criteria for ASD, Level One (L1), is not only vastly outdated, but also nearly analogous to the original diagnostic criteria for the disorder’s original title, Autistic Psychopathy (Hippler & Klicpera, 2003, p.299-300). Though there is a case to be made for the reformation of ASD diagnostic criteria, as a whole, the most perti-

3 One particular topic, place, thing, etc. that an individual with ASD has a complete obsession within terms of both admiration and knowledgeability on the interest.

4 Self-stimulatory behaviour (otherwise known as “stimming”) is the repetition of physical movements, sounds, words, or moving objects often used as a calming mechanism for people with ASD.

5 A term used to describe the autism spectrum in relation to Autism Spectrum Disorder (ASD).

6 An individual who displays none of the characteristics or patterns associated with ASD.

ment modifications are those that are concerned with accommodating the unique experiences of females on the autism spectrum, particularly those who exhibit characteristics relating to ASD, L1. The importance of exploring the female experience with ASD stems, not only from the absence of research focused *uniquely* on this demographic, but also from the archaic diagnostic practices that are not reflective of the behaviours of women with the disorder (Sisti & Johnson, 2015, p.84-85). The type and manner of expression of inherently “autistic” characteristics such as the lack of maintenance of eye contact, an obscure special interest, or dramatic self-stimulatory behaviour, are far more camouflaged and thus are less observable in women with ASD, L1 (Russo, 2018, p.2)(Hull et al., 2017). In a 2016 study, this gender-based discrepancy is demonstrated to be amplified through increased rates of anxiety and depression associated with the mental exhaustion of camouflaging such characteristics (Bargiela, 2016, p.3285). In this study, 93% of participants reported an anxiety score above the recommended clinical cut-off. In addition, the mean score of all participants for the General Health Questionnaire was below the clinical threshold – an indicator of mental disorder (p. 3285).

Though research exists on the broad exploration of challenges faced by students with invisible disabilities such as Attention Deficit Hyperactivity Disorder (ADHD) in most post-secondary institutions, the research falls short on specificity, namely the impact of the challenges of private university life with the behaviours and characteristics of female students with ASD, L1. Furthermore, it is critical to note that, as a consequence of the limited exploration on this topic, anecdotal evidence from students serves as the current indicator of any flaws within the accommodation offering process as no official statement of behalf of an American university has been made to address this particular issue. This paper intends to fill the gap that exists not only from the broad perspective of introducing more female-focused studies into discussions surrounding Autism Spectrum Disorder, but also through the introduction of data that analyzes the unique college experiences of young women on the spectrum. As a result, a comprehensive solution will be created in order to solve the issue of under-recognition and unsubstantial accommodation in private American universities for female students with ASD.

Overview of Methodology & Design

The design which fits most appropriately within the confines of this research project is mixed methods. $\neg\neg$ As dictated by American academic, John W. Creswell, mixed methods research is unique in that it combines both quantitative and qualitative data to formulate some analytical conclusion within one single investigation (Creswell, 2013). Additionally, the mixed methods approach is pertinent to health-related research as it allows for a more holistic perspective on a given problem, thus making it suitable for application in this study. Within mixed methods exists three basic designs and four advanced frameworks. This research project will utilize the principles of an exploratory sequential design with a participatory framework. The exploratory sequential design is used with research that first collects and analyzes qualitative data to then inform the subsequent quantitative data collection (Venkatesh et al., 2013, p.22). In a participatory framework, the primary focus involves the voices of a targeted population in order to guide the research effectively in a particularly insightful way, typically related to social justice. Critically, the participatory framework utilizes qualitative data collection to register the target demographic’s perspectives and quantitative data to support the argument of the research (Klingner & Boardman, 2011, p.213). In the context of this research, data collected from the three unique demographics will be evaluated and compared in order to solidify the claims made in the initial hypothesis.

Data Collection

The process of data collection required a heightened level of detail and specificity considering the unique sensitivities that are associated with social interaction for individuals on the autism spectrum. Within the context of this research paper, there are three categories of interviewees i) expert medical opinion in the form of psychiatric medical professionals, ii) professional teaching opinion in the form of a learning strategist from a college preparatory high school, and iii) women with ASD, L1, who are currently attending an undergraduate institution in the United States. Critically, each demographic was asked different questions

A FLAWED SYSTEM OF ACCESSIBILITY

during their interviews (see appendix for a full list of interview questions). Category I and II interviewees will be involved in a semi-structured interview commenting on the experiences of the people they work with (ASD patients/students). The Category I interview is critical in establishing the fundamental understanding of the data acquired from the other demographics. A key question for this demographic is: how have recent studies regarding the disparities between the ways in which autistic men and women behave impacted the diagnostic process from a clinical perspective? For Category II interviews, while similar to the former, differ in that no medical perspective can be offered. Rather, Category II interviewees will comment only on the perceived experiences of students on the spectrum. A key question for this demographic is: What factors do you consider when suggesting accommodation options for post-secondary school to students with ASD? Finally, the most complex demographic in the interviewing process is Category III interviewees. Contrary to the semi-structured format of Category I and II interviews, Category III did require a hybrid format between semi and completely structured interview. While still allowing for qualitative data to be acquired, every question in this interview will remain in a consistent order with consistent instructions. Since people on the autism spectrum often require little to no distractions and explicit details to remain focused and engaged, maintaining a quiet space (and potentially one without harsh lighting for those interviews conducted over skype video chat) will be a necessity for ensuring the stability of the interview process. A key question for this demographic is: have you sought out academic accommodations at your university because you have ASD? Why or why not? For Category I, the participant was selected for their expertise diagnosing women with ASD. Participants in categories II and III are obtained either i) directly through a university's student disability services or ii) through the recommendation of a learning strategist at a college preparatory school in the Greater Toronto Area who works with high school students with disabilities.

Ethical Notes

Since the data collected in this research paper involves members of a vulnerable group (women on the

autism spectrum), the interviews must be conducted with caution, deliberate planning, and a consistent setting. The risk of the participant experiencing an anxiety/panic attack, or any other similar reaction will be in constant consideration when asking questions or interacting with the participants at all. This research project has been approved by the Appleby College Internal Ethics Review Board.

Findings

The data was gathered from eight female students currently attending an elite, private, American undergraduate institution. All participants identified themselves as having Autism Spectrum Disorder, L1. With the exception of one participant, who noted that her disability was self-diagnosed, all student interviewees have received a medical diagnosis Autism Spectrum Disorder (ASD), Level One (L1). 63% of student participants reported that they made an active attempt to seek out disability accommodations at their university. Only four of those five participants received any tangible disability support from their institution. Additional interviews were conducted with a psychiatrist and a secondary school learning strategist. Findings focused on the responses of the Category III interviews are divided into subgroups of Accommodation Affirmative (currently has access to accommodations) and Accommodation Negative (does not currently have access to accommodations).

Figure 1



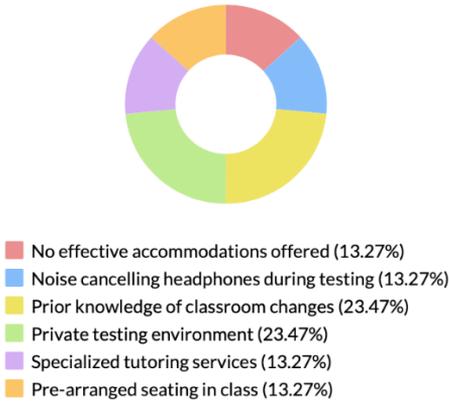
Accommodation Affirmative

Among students with access to formal disability accommodations provided to them by their institution's disability services office, the most common forms of accommodation were: i) private testing environments and ii) premature awareness of classroom and sched-

uling related changes. Notably, one of the participants who had previously requested disability accommodations had not been provided with any effective applications based on their request.

Figure 2

Existing Accommodations Offered

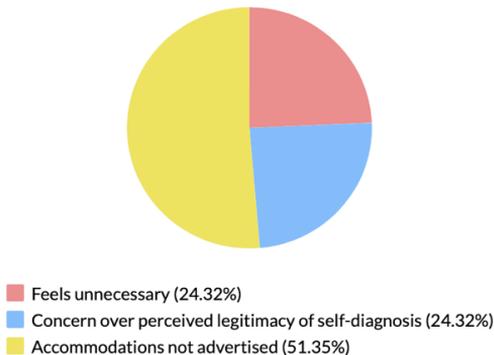


Accommodation Negative

Among students without access to formal disability accommodations, the primary reason for lacking this access is the absence of awareness at their academic institution.

Figure 3

Reason for not Accessing Accommodations



Among Accommodation Negative participants, access to academic supports has a perceived holistic benefit towards the student's academic and emotional wellbeing. Comparatively, a stronger perceived positive outcome was associated with academic benefits, specifically.

Figure 4

Extent of Perceived Emotional Benefit if Provided Accommodations

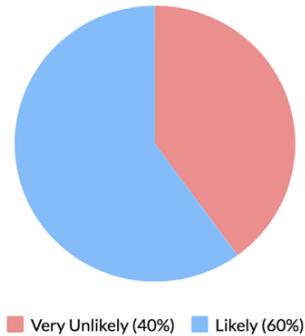
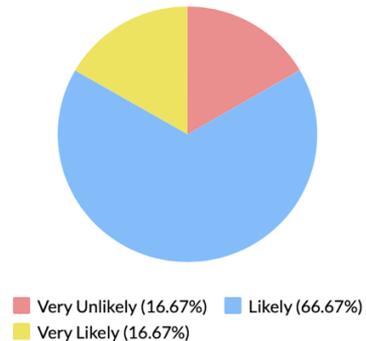


Figure 5

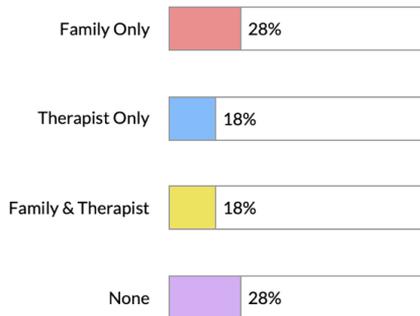
Extent of Perceived Academic Benefit if Provided Accommodations



Participants in the Accommodation Negative Category were also asked whether they have received any influence on seeking out accommodations and, if so, what the source of that influence was. Most participants saw influence from family or no influence at all.

Figure 6

Source of Influence to Pursue Disability Accommodations

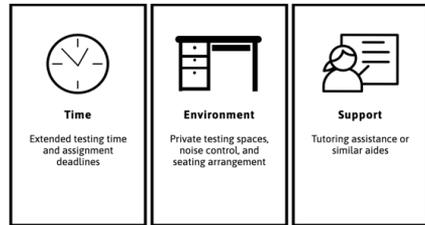


Accommodation Neutral

Regardless of whether participants responded affirmative or negative to accessing any form of academic supports, all interviewees were asked what additional supports they feel as though they would benefit from. Notably, one Accommodation Affirmative participant and one Accommodation Negative participant reported no interest in any new or additional academic supports. Additionally, one Accommodation Affirmative participant noted additional accommodative supports that would be more effective than the student's current plan. New or additional accommodation interests were broken down by theme: time, environment, and support.

Figure 7

Most Desired Accommodations not Currently Offered:



Overwhelmingly, participants believed that their university is not inclusive to autistic people. Correspondingly, all participants reported the presence of at least some autism-related stigma at their academic institution. Notably, $\frac{3}{4}$ of all female students interviewed stated that their university was not at all inclusive towards autistic students.

Discussion & Analysis

The purpose of this study was to examine the impact of ineffective disability accommodation guidelines at private, American, undergraduate institutions on the delegitimization of the experiences of female students with Autism Spectrum Disorder (ASD), Level One (L1). It is established in the Literature Review that a disconnect exists between disability accommodations accessed in secondary school and undergraduate school by virtue of the accessibility system in post-secondary institutions – which does not formally mandate the tangible application of disability accommodation guidelines provided by medical professionals.

Though additional data was collected in the form of the Category I & II semi-structured interviews with a licenced psychiatrist and a secondary school learning strategist, the bulk of the data analysis will focus on the data collected from the eight female undergraduate students with ASD, L1.

Understanding the Disincentive for Disability Accommodations in Post-Secondary School

The data suggested that, although influence exists from external sources to seek out accommodations in post-secondary school, female students with ASD,

L1, continue to study without intervention from on-campus disability services.

Lack of Awareness

Approximately 50% of the participants reported that their lack of access to disability accommodations was the product of the absence of awareness that these services were: i) available at their institution and ii) specifically available for women with ASD, L1. Recognize, an inherent barrier exists for women with invisible disabilities, especially ASD, L1, because none of the current legislature regarding supports for disabled students and workers prescribes that institutions must provide accessibility supports, but rather that they may provide those supports when prompted.

Nature of Access

Both, the interview with the secondary school learning strategist and the psychiatrist, indicated that there exists a consistent trend of female students with ASD, L1 who had access to disability accommodations in high school who do not continue their accessibility plan into undergraduate school. Though this shift could be attributed to the student's development of the academic and social skills necessary to succeed in university without any formal accommodations, the psychiatrist in the Category I interview stated that "fewer woman on the spectrum seek accommodations in university because they must take it upon themselves to deliberately acquire them". Since people with ASD often struggle with conventional social interactions, the absence of any mandate to ensure that accommodations are offered directly to the student makes the process by which students access academic supports a particularly difficult one.

Stigma & Exclusivity

Though not directly correlated with the diagnostic process, the presence of stigma towards students with autism, in addition to the strong feelings of exclusivity that autistic students have in regard to their university campus serves as a strong deterrent towards seeking out academic accommodations. It was noted in the Category II interview that "autistic students may fear feelings of otherness that stem from the stigma sur-

rounding autism in general, seeing that as enough of a disincentive to rule out accommodations which may be noticeable to their peers". From this, it can be concluded that the presence of stigma is a significant factor in the decision to seek academic supports for female students with autism.

Improving the Application of Disability Accommodations

Notably, the 75% of student participants indicated their desire for new or improved disability accommodations at their university. On average, participants from the Accommodation Negative group reported that supports related to their disability would likely serve to both emotionally and academically benefit them. Despite the anomaly of one participant who indicated that they did not see any benefit of disability supports in their academic plan, all other interviewees regarded such accommodations as being considerably helpful to achieving academic success in undergraduate school. Desired accommodations were divided into three themes: environment, time, and support.

Extended Timelines

The primary theme of interest for female students with ASD, L1 was time. More specifically, accommodations in this Category included extended testing time and extended submission dates for written assignments. It was stated in the Category I interview that "it isn't uncommon for women with high-functioning autism to exhibit behaviours associated with Obsessive Compulsive Personality Disorder. This can include the unrelenting desire for perfectionism rather than a need to subdue any negative thoughts such as those associated with Obsessive Compulsive Disorder". For people with ASD, L1, particularly women, this characteristic for perfectionism may extend into prolonged working periods which often require extending due dates or time frames in order to satisfy the needs of the student. Although,

the interview with the psychiatrist (Category I) also stated that "since perfectionism is a trait commonly associated with neurotypical women, female students [with autism] seeking extended time as an accommodation will likely see lower rates of success in acquir-

ing support due to already being perceived as perfectionist in nature”.

Classroom Environment

Similarly, female students with ASD also regarded environment as a significant factor in improving the status of their present or potential accommodations. Overwhelmingly, this Category saw the greatest support for private testing environments in which distractions would seldom exist. Following that, the mention of noise regulation through headphone usage in addition to preferred in-class seating also saw considerable support from participants. More specifically, the desire for headphone usage during testing either within the classroom or in a private testing was particularly valued by participants. The accommodations under the theme of environment are categorized by two key behaviours associated with ASD: i) desire for order and organization and ii) hyper-sensitivity relating to the environment of the student.

The desire for pre-arranged or preferred seating is correlated with the same desire for order mentioned under the previous subheading. Conversely though, the desire for private testing environments and noise controlling devices in the classroom stems from the presence of hyper-sensitivity and over-stimulation of an autistic student's senses. According to the Category I interview, the vast majority of patients with ASD, male and female, exhibit similar ranges of sensitivity towards sounds, light and texture. With regard to sound, headphones can serve as a supporting mechanism for autistic students who require improved noise-control.

Conversely, lighting can be more difficult to accommodate considering that only so much of the lighting arrangement can be altered within a particular class. Though only mitigatory, the placement of a student in a private testing environment can aid in the control of harsh lighting. Both the Category I and II interviews suggested that female students may not be presented with accommodations within the environment Category as often as their male counterparts as a result of the masked behaviour that women with ASD often manifest. This suggestion was confirmed through the Category III interviews in which one Accommodation Affirmative participant reported the desire for a private testing environment as a part of

her accessibility plan but was only offered the ability to wear headphones during in-class testing.

While it is no fault of their own, there exists an innate issue regarding the legitimization of disability when women with ASD mask their autistic behaviours. Thus, the suggestion can be made that disability accommodation guidelines must be more explicit when outlining to academic institutions how the student expresses the characteristics of their disability, particularly when the expression of those characteristics is not always congruent with the true severity of the student's disability.

Formal Support Systems

Though time-based and environmental changes represented the accommodations with the strongest interest among female university students with ASD, L1, there still exists a third Category of supports that demonstrated considerable support amongst participants. The desire for academic tutors with specific knowledge and understanding of the characteristics and struggles of students with ASD, L1, particularly in relation to the experience-based nuances of women with autism was particularly strong.

The Category I interview clarified that many female students with disabilities ranging from ADHD to ASD often acquire access to private tutors independently – that is to say, without the support of student disability services. The issue then presents itself twofold as female students with ASD are not currently provided sufficient access to tutors directly through disability services on their university campus, but also do not have access to tutors who specialize in working with students with autism. It is established in the Category II interview that tutors without any substantial experience working with autistic students, especially autistic female students, often get frustrated by the behaviours and organizational demands of their tutees resulting in a poorer dynamic between the pair and often a reduced level in quality of learning.

The solution then emerges in the form of learning strategists with a particular focus on and background in working with autistic students. Ultimately, it is individuals in specialized roles such as those mentioned above that can best serve as the immediate proxy between students and professors in instances of conflict surrounding academic plans and inconsistencies in the

application of the student's accessibility plan within the classroom.

Limitations

Though the findings of this study resulted in the establishment of precedent for improving the current system by which female students with Autism Spectrum Disorder (ASD), Level One (L1), access disability accommodations in undergraduate school and the identification of the accommodations that these students feel are paramount in achieving academic success, there still exist a few limitations in regard to the holistic outcome of the study. Though there exists diversity in the origin of the student participants based on current academic institution, the pool of interviewees was still limited. While the number of participants in the Category III interviews was small, the lower population lends itself to the small population of female students who both i) self-identify as having autism and ii) are comfortable enough with their identity to willingly provide feedback to their unique experience as a woman with ASD.

In addition, the absence of feedback related to the differences between disability accommodation plans in secondary school and undergraduate school directly from the student participants contributed to a gap in the study's findings – one that could only be partially filled by the insight of the Category I and II interviews. By virtue of the structured nature of the Category III interview, another issue presented itself when one of the student participants reported an attempt at accessing disability accommodations on their campus but being denied any effective supports. The format of the Category III interview did not consider this as a possible response from an interviewee and thus, only a limited exploration into the experience of that student could be conducted.

Suggestions for Further Research

While the findings and analysis presented by this study set an important precedent for the changes that need to be made to the current system of disability accommodation accessibility in American universities, future research could do more to explore the

mechanisms by which these changes could take form, especially with the understanding that not all academic institutions may be equipped, both structurally and financially, to handle a large-scale reconstruction of their accommodation services. Nevertheless, the suggestions made by this paper advocate for a considerable overhaul of the current status of disability services on university campuses, specifically in relation to how those services are communicated and then later applied to female students with disabilities such as ASD, L1. Thus, there holds great promise and congruency in future research with the intention of exploring: i) why existing legislature does not mandate universities to provide disabled students with the necessary accommodations that they likely had access to in secondary school, ii) how disability accommodation guidelines developed by psychiatrists and other medical professionals can be more explicit in the accommodations that they suggest and the methods by which those accommodations should be materialized, and iii) how disability services on university campuses can provide greater awareness for their resources with a specific focus on targeting groups of students whose disabilities are often unrepresented or misrepresented in the status quo – in this case, women with ASD, L1.

Conclusion

Female students with Autism Spectrum Disorder (ASD), Level One, who are currently studying at private, American, undergraduate institutions are not accessing disability accommodations despite the overwhelming desire for such related supports and the perception that those supports would drastically improve their academic performance and even emotional wellbeing. Much of this lapse in accessibility can be attributed to a system of disability services that is out-of-touch with the needs of a diverse demographic of autistic students, particularly autistic female students. It was discovered that, even for female students with ASD who have access to disability accommodations at their institution, those supports are not effective enough in supplementing their academic plan. As a result, the conclusion is drawn that a massive restoration of the system by which students with invisible disabilities, specifically female students with ASD,

access disability accommodations in post-secondary school must occur. Thus, through heightening the level of transparency between psychiatrists, universities, and students, a more aware environment for disability accommodation guidelines to be discussed and applied is created, ultimately providing more students with access to the most effective disability supports that their school can offer.

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Appendix A – Category I Interview Questions

1. How much of your clinic's patient demographic is occupied by youth with Autism Spectrum Disorder, L1?
2. From that portion, how many patients [with ASD, L1] are female?
3. Do you find that most of the female patients seeking a diagnosis for ASD, L1 are comparably older than their male counterparts?
4. Do you use the same diagnostic criteria when evaluating both female and male patients?
5. Do female patients that have been medically diagnosed with ASD, L1 opt-out of the pursuit of external academic accommodations (in comparison to male patients)?
6. Do you think that the existing diagnostic criteria for ASD, L1 lacks the nuances associated with the unique behaviours of women on the spectrum? Why or why not?
7. Do you think that it is difficult for women/girls to access academic accommodations in high school and post-secondary school as a result of the diagnostic criteria and/or other factors?
8. For female students with ASD, L1 who choose to seek academic accommodations, what are the most common forms of accommodation you recommend to patients?

Appendix B – Category II Interview Questions

1. In the context of secondary school, is there a considerable discrepancy between the accommodations suggested by physicians for female versus male students with ASD, L1?
2. When academic accommodations are offered to high school students [with ASD, L1], do you find that this generally improves their learning experience?
3. When supporting students through the transition from high school to post-secondary school, do you notice an increased disinterest in academic accommodations? If so, is this disinterest more common amongst female students with ASD, L1?
4. Do you think that the need to self-advocate for accommodations in post-secondary school is a contributing factor to why students may choose not to seek disability support at this level?
5. Do you think that the current system by which academic accommodations are provided in post-secondary school should more closely resemble the disability support system of secondary schools?
6. What, if any, additional factors may contribute to an autistic student's unwillingness to seek accommodations in post-secondary school?

Appendix C – Category III Interview Questions

1. Have you been formally diagnosed with Autism Spectrum Disorder, L1?
YN
2. If you have received formal diagnosis, when did this occur?
Date: _____
3. At which university do you currently attend?
USCYaleNESFOther: _____
4. Have you sought out academic accommodations at your university because you have ASD?
YN
5. If yes, what accommodations do you have? Ex. Quiet test space, extended timelines, etc.
6. If no, why have you chosen not to seek out academic accommodations?
7. On a scale of 1-10, how supportive are your professors in satisfying your accommodations?
Least 1 2 3 4 5 6 7 8 9 10 Most
8. Do you think you would benefit (emotionally or academically) from accommodations?
9. On a scale of 1-10, how supportive are your guidance counsellors in satisfying your accommodations?
Least 1 2 3 4 5 6 7 8 9 10 Most
10. Have academic accommodations been advertised to you through your school, family, or doctor?
11. Are there academic accommodations that you would benefit from that are not currently offered to you? If yes, what are they?
12. On a scale of 1-10, how inclusive is your university towards people with autism?
Least 1 2 3 4 5 6 7 8 9 10 Most
13. Do you think there is a stigma surrounding disability accommodations at your university or other, similar, academic institutions?

The Effect of Reading Literary Fiction on Theory of Mind in Children

Julia Werner

Theory of Mind is the ability to make inferences about the mental states of others. A positive correlation was drawn between theory of mind and language. Studies have shown that reading literary fiction positively impacts Theory of Mind abilities in adults, but no research has delved into a focus on younger age groups. This study investigates whether reading literary fiction increases Theory of Mind abilities in children. A quasi experimental quantitative method was conducted using matched sampling. Paired T-tests were run to compare pre and post test scores. The results indicate that reading literary fiction may cause an increase in children's Theory of Mind abilities at least temporarily, emulating the effect it has in adults. This research is of relevance to the recent debates on the inclusion of fiction in school curriculums and emotional intelligence in business. Further research should be conducted to ensure a more representative population is tested; these findings can be used to inform future work in this area.

Keywords: Affective Theory of Mind (Theory of Mind), Cognitive Theory of Mind (Theory of Mind), literary fiction, emotional intelligence

Introduction

First coined in 1990 by Salovey and Mayer, the term Emotional Intelligence (also referred to as EI) is defined as a type of social intelligence guiding one's abilities to observe, interpret, and react to the emotions of one's self and others. Emotional intelligence is widely researched (Institute for Health and Human Potential, 2011) and is a key indicator of success in several aspects. The importance of EI is seen in business where 70% of capabilities that distinguish top performers from one another are classified as EI capabilities (Freedman, 2010). Further Feist and Barron report, EI was four times more important than IQ in the determination of professional success (1996, cited in Cherniss, 2000).

In the last ten years, research has been conducted to investigate the relationship between literature and Theory of Mind. The term Theory of Mind refers to the ability of one to infer the mental state of others (their beliefs, intentions, desires, etc.) and use said inferences to understand and foretell behaviors (Mark and Martin, 2018). Theory of mind is a seminal aspect in the facilitation of EI because of Theory of Mind's role in the interpretation of emotions (Ferguson and Austin, 2010). Overall, research has found that there is a positive correlation between fictional reading and Theory of Mind and that over time fictional reading can result in an increase in empathy in adults (Mar et al., 2009). Additional research supports that the reading of a single passage of literary fiction serves to at least temporarily increase Theory of Mind abili-

ties in adults (Kidd and Castano 2013). Research on literary fiction and Theory of Mind has not yet been conducted on younger age groups despite the countless educational institutions globally that are presently mandating social and emotional learning for youth.

Literature Review

The subject of reading in conjunction with Theory of Mind was first introduced by several researchers who found that the same cortex of the brain that showed activity while a participant was having a real life experience showed activity when the participant was reading about that same experience (Paul 2012). For example, a participant reading about the scent of cinnamon had very similar brain activity displayed by a functional magnetic resonance imaging (fMRI) brain scan as when the participant was actually smelling cinnamon (Bado et al., 2016). Further studies found that exposure to social interaction in text elicited the same response from the brain as real-time social interaction. This phenomenon of emotional 'transportation' into a story, is known as transportation theory (Johnson, 2012).

Further research into transportation theory examined the hypothesis of Mar et al., that people who read fiction are inclined to have better empathy and Theory of Mind abilities (2006). Such conjecture seemed plausible as exercise of the parts of the brain that process social interaction would logically strengthen and reinforce behavior and reactions. The study found that there was a positive correlation between how well a subject performed on an author recognition test and scores on empathy level tests. Author recognition tests are used to generalize a subject's reading ability (Moore and Gordon, 2015). The drawbacks of these findings are that they are purely correlational and therefore serve no role in combating the notion that people with higher empathy and Theory of Mind abilities may simply be more intrinsically attracted to fictional reading. However, in a later study, these same researchers ruled out the possibility that their test results could have resulted from pre-existing personality traits by controlling for "the big 5 personality traits [i.e. openness, conscientiousness, extraversion, agreeableness, neuroticism]" (Mar et al., 2009).

Impact of Literary Fiction on Theory of Mind

Perhaps one of the best-known and thoroughly debated studies stemming from this research is Kidd and Castano (2013). This study found that after reading only one passage of literary fiction, Theory of Mind is improved at least temporarily (no tests were done at a later date to verify permanent increase) (2013). The study tested whether nonfiction, popular fiction, or literary fiction best facilitated transportation theory with the conclusion that only literary fiction did so at all. Literary fiction is defined as incorporating themes and symbolism while tending to be more character than plot-driven. Of all categories of literature, literary fiction most consistently engages a reader in the interpretation of social situations. For this reason, Kidd and Castano proposed literary fiction is the only type of literature capable of facilitating transportation theory because it is the only type of literature that consistently features empathetic interactions between characters. However, Kidd and Castano's strongest claim was that after reading a single passage of literary fiction, Theory of Mind abilities would increase.

Multiple replications of this study have found varied results. The most prominent opposition argues that it is more likely that reading literary fiction and Theory of Mind are linked because people with strong Theory of Mind are naturally drawn to fiction or that long term reading of fiction strengthens Theory of Mind over time. Further, they argued affective Theory of Mind is not affected by the reading of literary fiction (Panero et al., 2016). Matthijs and Veltkamp observed that empathy was raised over a one week period in participants who read and were emotionally transported into a story and lowered in those who read but were not emotionally transported (2013), suggesting that fictional reading can be a cause of increased empathic abilities, contrasting the skepticism presented in early work on Theory of Mind and literature.

Application of Future Research to Curriculum Development

Education reform calling for less emphasis on fictional reading has been passed in forty six out of fifty

of the US States (Robelen, 2010). The curriculum was designed in part by the president of the College Board David Coleman who said that English classes focus too much on self-expression and that fiction does not have a useful application in one's future (Mosle, 2012). Although well intended, since fiction is often regarded as entertaining in nature with little regard to the actual benefits that may result from reading it, the curriculum edits do not consider increases in the Theory of Mind abilities that facilitate general emotional intelligence. This shows that there is failure in even the United States education system to recognize the potential that fiction has to foster the growth of emotional intelligence in younger populations. If the research done on the positive impact of literary fiction on Theory of Mind (and therefore EI) was generalizable to younger populations, it would be research-based support not only to bring into question the recent edits to the United States Common Core Standards, but to fill a gap in the current literature concerning the impact literary fiction may have on Theory of Mind in children.

termine what emotion a person is feeling based on an image of said person's eyes. It has been inconsistently supported that affective Theory of Mind is increased by reading literary fiction. The work of Kidd and Castano supports such conjecture, while that of Panero rejects it. most common format of the testing is similar to that of a multiple choice test. In each question a photograph featuring a set of eyes is presented along with four words. To respond to the question, a subject is instructed to circle the word that best describes the way the person in the photograph is feeling based on the expression conveyed through their eyes. A sample question is illustrated in Figure 1 below.



Theory of Mind Testing

There are several tests designed to quantify Theory of Mind abilities (U.S. National Library of Medicine, 2013); they have been designed for multiple age groups and by multiple institutions, and are used for many purposes, for example, to test for autism (The Autism Research Center, 2019). There are three main types of Theory of Mind: affective, cognitive, and conative. For the purposes of this literature review, only affective and cognitive Theory of Mind testing will be explicated, because conative Theory of Mind requires interaction between two or more people and thus cannot exist in a study testing a singular person and a text (Dennis et al., 2012). Affective Theory of Mind is the ability to interpret emotions expressed by the facial expressions of others (Vogindroukas et al., 2014), while cognitive Theory of Mind is the ability to understand that other people have thoughts independent from one's own and to be able to make inferences about the thoughts of others.

The most commonly used test for affective Theory of Mind is the Reading the Mind in Eyes Test or REMT (Vogindroukas et al., 2014). REMTs test affective Theory of Mind by asking participants to de-

Figure 1
 "standard REMT test" (Autism Research Institute, 2019)

Note. test published for public use through Autism Research Institute, but designed by researchers at Cambridge University.

There are several REMTs released by Cambridge University designed for children ages six to nine years old. The difference between an adult REMT and a child REMT is the level of difficulty of the vocabulary used in the answer choices for the questions. Additionally, a subset of REMTs called the Face Test is often easier to complete because it includes a picture of a full facial expression instead of only a picture of eyes.

For cognitive Theory of Mind the false-belief test is the most common test measure (Bernstein, 2017). False belief tests ask participants to determine information about an idea being held true or false by an individual. Overarchingly, the research community supports that reading literary fiction most consistent-

ly increases cognitive Theory of Mind abilities. There are several variations of false belief tests. An example which is helpful to understand the general idea of false-belief testing is the Sally-Anne test (Baron-Cohen, 1983). The Sally Anne test is a very simple idea of a false belief test in which a scenario is explained where Sally hides her marble in a box and then leaves, then Anne moves Sally's marble to a basket. The question proposed is "where will Sally look for her marble first when she returns to the room?" The idea behind the test is that it will test the test takers ability to understand that Sally does not know the marble has been moved even though the test taker themselves knows this to be true. Refer to Figure 2 to view the Sally-Anne test.

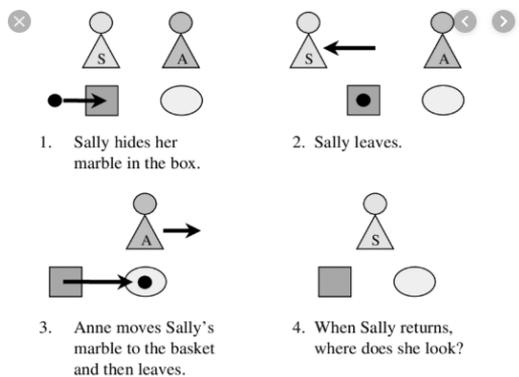


Figure 2
"Sally-Anne Test" (Baron-Cohen, 1983)

There are also versions of False-belief tests available for varying age groups. A common test measure for children ages six to nine is the Yoni Test (Bodden, 2013). The Yoni Test is a computerized version of a false-belief test adapted for children. It has a variation of questions to assess basic aspects of Theory of Mind. For example, if Yoni (the face featured in the center of every question) is looking at an object, basic principles of Theory of Mind would suggest that Yoni is thinking of said object. Refer to Figure 3 to see a sample question from the Yoni Test. A more complex question that may be asked is shown in Figure 4.

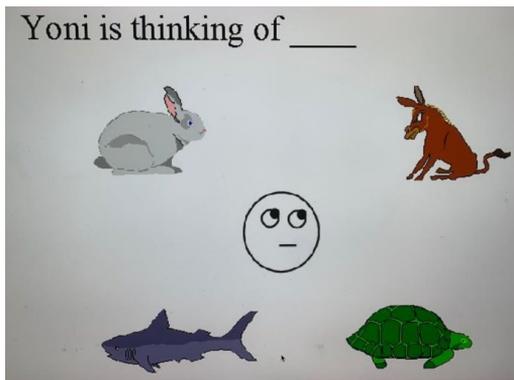


Figure 3
"Yoni Test question example I" (Bodden, 2013)

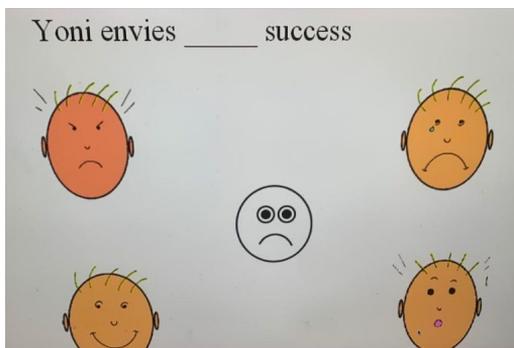


Figure 4
"Yoni Test question example II" (Bodden, 2013)

The Yoni test is made up of three parts (labeled parts A, B, and C). For part A the user answers several questions of similar difficulty, for part B the user answers questions of more difficulty than part A, and for part C the user answers the most difficult Theory of mind questions available on the test.

Gap and Significance

Although there seems to be ample research done on the adult population supporting that reading literary increases Theory of Mind, this issue has not yet been tested on younger populations. This seemed like a valuable population to test because both Theory of Mind and language develop in children, and there is

a strong correlation between language and Theory of Mind. It is widely accepted that Theory of Mind first begins to develop in children at around the age of four to five years old (Hanan Center, 2015), but some evidence suggests that even infants have a basic understanding of the principle aspects of Theory of Mind (Slaughter 2015). It is also widely accepted that language begins to develop in children from a similarly young age (National Institute of Health, 2012). Performance on Theory of Mind and language tasks have a strong correlation ($r = 0.43$), which is much higher than the correlation between either of the two and any other function developing around the same time (Ain et al., 2007). There are several benefits to evaluating the impact of reading on Theory of Mind in children. Not only do children have far fewer preconceptions and biases that have the potential to influence their test results, but they are significantly less literature inclined, so there should not be any unexplainably odd results due to an adult with a deviant development. Additionally, data for a younger population can be used to add to the development of curriculum promoting strong emotional intelligence to facilitate success in business and life.

Therefore, the present study aims to fill this gap in the body of knowledge by answering the following question: What is the effect of reading a single passage of literary fiction on cognitive and affective Theory of Mind in children from first through third grade? It was hypothesized that there would be an increase in Theory of Mind abilities as displayed on a Theory of Mind age appropriate test as a result of reading a single passage of literary fiction because it was assumed that the conclusion developed for the adult population by Kidd and Castano would hold true for children as well.

Methodology

The method used for this research is a quantitative, quasi-experimental design. Quantitative data were collected to determine the difference between the effects of reading a passage of literary fiction on children versus adults.

The sample was made up of 55 children from first through third grade (students ages six to nine). Although Theory of Mind and Language skills begin to

develop at much younger ages, this is the earliest age group in which children can be expected to be able to read (American Academy of Pediatrics 2009), so REMTs for the age range of six to nine year old were used (Autism Research Institute, 2019) and the Yoni test with the same age range was used (Bodden 2013). In-depth testing on validity and reliability has ensured that these tests are accurate and used by reputable institutions such as Cambridge University, the Autism Research Institute, and the NHI (National Institutes of Health), as well as numerous psychology professors and PHDs (Meinhardt-Injac et al., 2012).

Participants were drawn from an elementary school in a suburban area using a convenience sample. As opposed to randomized sampling, convenience sampling was chosen for this study, because it is the quickest and most inexpensive way to obtain a sample with limited resources (2012). Convenience sampling is discouraged because without a randomized sample it cannot be ensured that the sample is representative of the population being tested; however, for pilot studies it is generally acceptable (Sauders et al., 2012). This study paves the way for randomly-sampled controlled trial research to be done (Cadete, 2018).

Before testing took place all research plans were approved by an institutional review board (IRB) at a selective magnet high school, and all students participating were required to have informed consent forms on file (see appendix F) because that is an ethical standard of all experimentation involving human participants (Knapp 2006). Testing consisted of a Theory of Mind assessment pretest (see appendix A), a reading passage (see appendix D and E), and a Theory of Mind assessment posttest (see appendix B). A paired sampling methodology was used to ensure that any observed difference came from changes in an individual's scores, not in the groups (University of Florida Health Biostatistics, 2020).

The pre and post tests were each approximately 75 questions and consisted of a concatenation of three different Theory of Mind tests. Two of the three tests were REMTs released by Cambridge University: a standard REMT and a Face Test. Both the REMT and the Face Test were used in order to provide a wide range of difficulty. Due to the nature of paired sampling in which an individual's score is compared to their own later score, a range of difficulty within the test increases the odds that students of all ability lev-

THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN

els will be able to score between the upper and lower limits of the test (Meyers 2014). The REMTs served to include the affective component of Theory of Mind on the tests. The third test included was the Yoni Test. The Yoni test was included as a component of the Pre and Post examinations in order to assess the cognitive component of Theory of Mind.

To create the pre and posttests each of the Theory of Mind tests included were divided in half, one half of each of the three tests made up the pre assessment, while the other half of each made up the post assessment. Olderback and colleagues (2015) reported that REMTs are not internally consistent, concluding that “Future revisions of the test should seek to reduce the test’s reliance on one’s vocabulary... (2015, cited by the U. S. National Library of Medicine National Institutes of Health)” However, the influence of vocabulary on the difficulty level of the questions was controlled for in the present study because all children were instructed to raise their hand if they did not understand the meaning of a word in any question. Since the study identified vocabulary as the principle factor influencing the difficulty of REMT test questions and this was controlled for the REMT questions were assumed to be of equal difficulty, so the first half of the questions from both the standard REMT and the Faces test were placed on the pre assessment and the second half of each test was placed on the post assessment.

The Yoni test has three different sections. Each section consists of a different difficulty level. Part A is the easiest section of the Yoni test, part B is more difficult than part A, and part C is the most difficult section. Additionally, the questions within each individual section increase in difficulty. In order to effectively divide the Yoni test in half and ensure the difficulty was consistent on the pre and post assessment, each section was divided in half in an alternating fashion (i.e., question one of section A on pretest, question two of section A on posttest, question three of Section A on pretest, etc.). This most nearly ensured that the pre and post assessment were of equal difficulty level. This process of division was under the advisement of the research mentor. Since the Yoni test is a computerized test, in order to divide it in half, a photograph was taken of each individual question and then pasted into either the pre assessment or post assessment document along with the REMT questions.

At the time of testing, all assessments and reading passages were printed on paper. All students were

read the script of instructions released by the makers of the Theory of Mind tests (the REMT script and the Yoni test script) before being given their pre assessment (see appendix C for scripts). Students were also instructed to raise their hands if they did not understand any of the vocabulary included in their assessments and to attempt every question even if they did not know the answer. To indicate they were finished with a section of the testing students were instructed to raise their hands. Students were also instructed to write their name on the pre assessment, the reading passage, and the post assessment in order to match the pre and posttests after testing was completed. Names of participants were not released in order to conform to ethical research standards (Knapp 2006).

When students raised their hands after they completed the pre assessment they were given a grade level appropriate passage of literary fiction from the “K-5 Learning” resource that has been approved by The National Parenting Center. The passages were likely of different length than the ones read by adults; however, due to the age and ability of the children being tested the ability of participants to understand the reading was prioritized over homogeneity between the passages given to adults and the ones used in the present study. Each passage came with five comprehension questions (see appendix D and E for the reading passages and questions). After the students read the passage and completed the comprehension questions, they raised their hands and were given the post assessment. When students were completed their teacher provided work for them to do quietly.

The testing was administered in a classroom setting during the English class of the students on a regular school day. All testing was completed in one sitting and the time frame ranged anywhere from forty five minutes to an hour and a half.

After all of the tests were collected each test was hand graded in comparison to the test keys provided by the test makers. All scores were recorded as a percentage because the Pre assessment had one more question than the post assessment. The scores were recorded in an Excel spreadsheet. Questions that were answered incorrectly by 98% of students were thrown out as according to guidance from a forum of school teachers (Bell, 2019). This resulted in one question being thrown out. Tests were thrown out under the advisement of the research mentor if more than five questions con-

THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN

secutively were skipped. This resulted in 16 tests being thrown out and left the sample size of 39.

Both descriptive and inferential statistics were used to analyze the data. In order to generate a mean difference, each student's pre score was subtracted from the student's post score. The mean percentage score of the pre and post assessments were also generated. Next, the descriptive statistics were evaluated by paired t-tests in order to determine the statistical difference between the mean percentage scores on the before and after assessment. P-values were then calculated to estimate the probability of rejecting the null hypothesis that there is no change between the pre and post assessments. Further, to analyze the increase of both cognitive and affective Theory of Mind specifically, the same process used to generate a mean percentage cognitive score and a mean percentage affective score. The software Minitab was used for analysis. Both Minitab and Excel were used to create all graphics.

Discussion & Results

As shown in Table 1, the mean percentage score of the pretests was 72.5% and the mean percentage score of the post test was 76.04%, generating a mean

increase from pre to post test scores of 3.45%. The paired T-test comparing the pre-test percentage scores and post-test percentage scores was 2.34 ($p < .05$), which indicates the pre-test and post-test percentage means are statistically significantly different. The standard deviation and the standard error mean are both relatively low indicating that the fluctuation in the percentage scores and population sample means is relatively low. Essentially, these results support the conclusion that reading literary fiction may increase Theory of Mind in children like it does in adults.

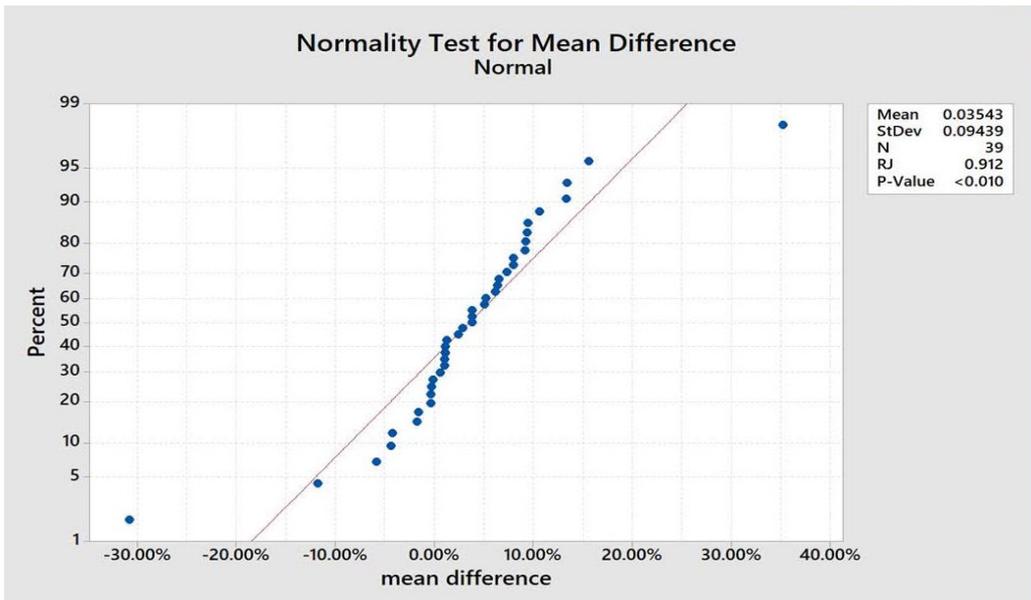
Table 1

Paired T for Pretest % - Posttest %

	N	Mean	StDev	SE Mean	
Pretest %	39	0.7250	0.0828	0.0133	
Posttest %	39	0.7604	0.0922	0.0148	
Difference	39	-0.0354	0.0944	0.0151	
95% CI for mean difference: (-0.0660, -0.0048)					
T-Test of mean difference = 0 (vs \neq 0): T-Value = -2.34					
P-Value = 0.024					

Graph 1

Anderson-Darling Normality Test of Mean Difference



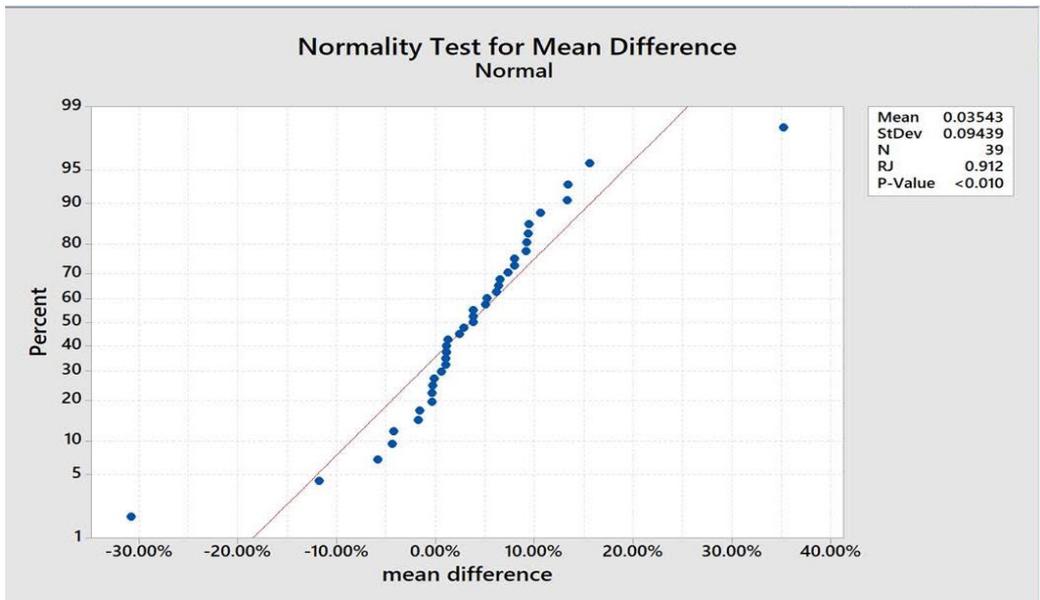
THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN

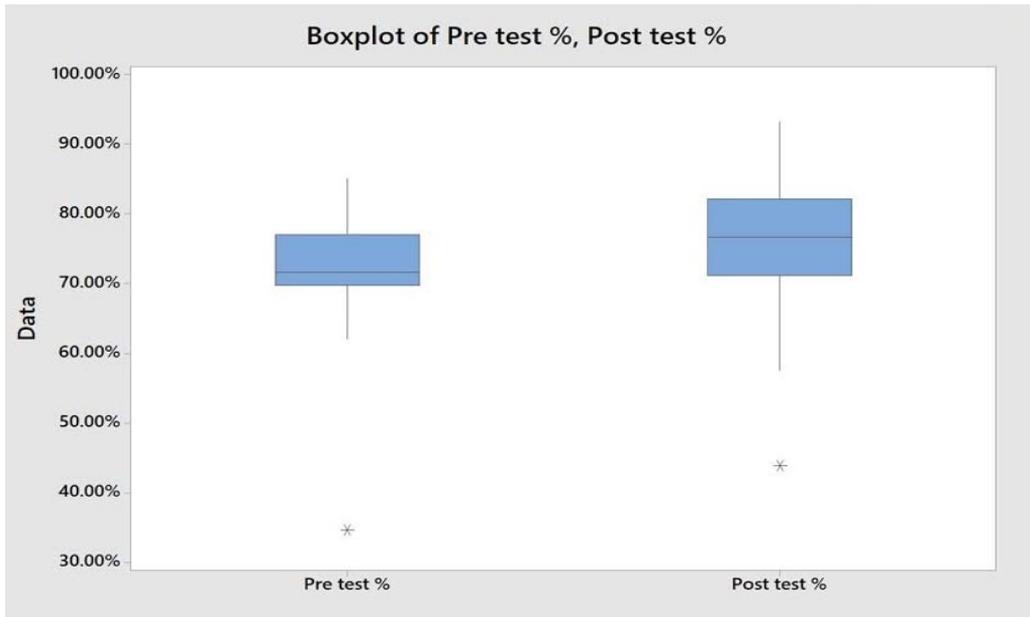
According to both the Anderson-Darling (shown in graph 1) and Ryan-Joiner normality tests (shown in graph 2), the mean difference data is not normal. The shape of the data indicates a more defined pattern than with a normal data set. What's more, the p-values for both of these tests are greater than 0.05 and therefore are not normal.

literary fiction or fatigue after being asked to complete such a long testing process at a young age. Notably, one outlier is shown in both the pre and post test data.

Graph 3 shows two vertical box plots designed to illustrate spread of the data. The range of the pretest scores is smaller than the range of the post test scores. The median of the post test scores is greater than the median of the pre test scores, supporting the conclusion generated by the T test. Additionally, a significant amount of the pre test scores in the first quartile are concentrated at approximately seventy percent, while the post test scores are more evenly distributed. Overall, the post test scores are greater than the pre test scores; however, the greater spread of the post test score can likely be attributed to either increases in Theory of Mind ability after reading a passage of

Graph 2
Ryan-Joiner Normality Test of Mean Difference





Graph 3

As shown in Table 2 the mean percentage pretest score attributed to affective Theory of Mind abilities is 69.91% and the mean of the post test score for affective Theory of Mind is 69.66%, which equates to a less than 1% difference from pre to post test score. The paired T-test yielded a T-value of -0.14 ($p > .05$), so from pre to post test is statistically insignificant.

Table 2

Paired T for Pre affective test % - Post affective test %

	N	Mean	StDev	SE Mean
Pre test %	39	0.6991	0.0933	0.0151
Post test %	39	0.6966	0.1031	0.0167
Difference	39	-0.0025	0.1056	0.0171

95% CI for mean difference: (-0.0323, 0.0372)

T-Test of mean difference = 0 (vs \neq 0): T-Value = -0.14
P-Value = 0.887

As indicated by Graph 4, for the affective Theory of Mind data there were two outliers on opposite ends of the box plot. The data points are more condensed in the third quartile than the first. The null hypothesis is statistically supported. In essence it is shown that reading literary fiction likely does not

increase affective Theory of Mind abilities in children as is suggested by Panero et al.,.

From Table 3 the results of the cognitive Theory of Mind aspect of the testing can be seen. The mean of the cognitive aspect of the pretest is 74.2%, while the mean of the cognitive aspect of the post test is 81.78%. The mean difference is 7.59%. The Paired T test generates a score of 3.98 ($p > .05$), which indicates a statistically significant difference from pre to post test scores.

Table 3

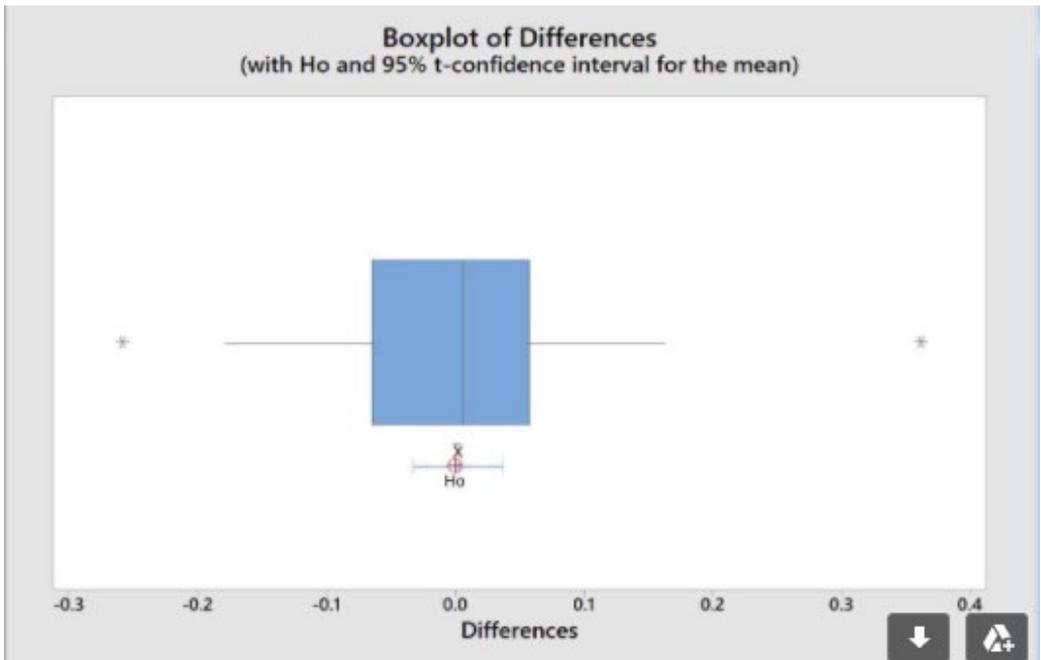
Paired T for Pre cognitive test % - Post cognitive test %

	N	Mean	StDev	SE Mean
Pretest %	39	0.7420	0.1092	0.0177
Posttest %	39	0.8178	0.1025	0.0166
Difference	39	0.0759	0.1176	0.0191

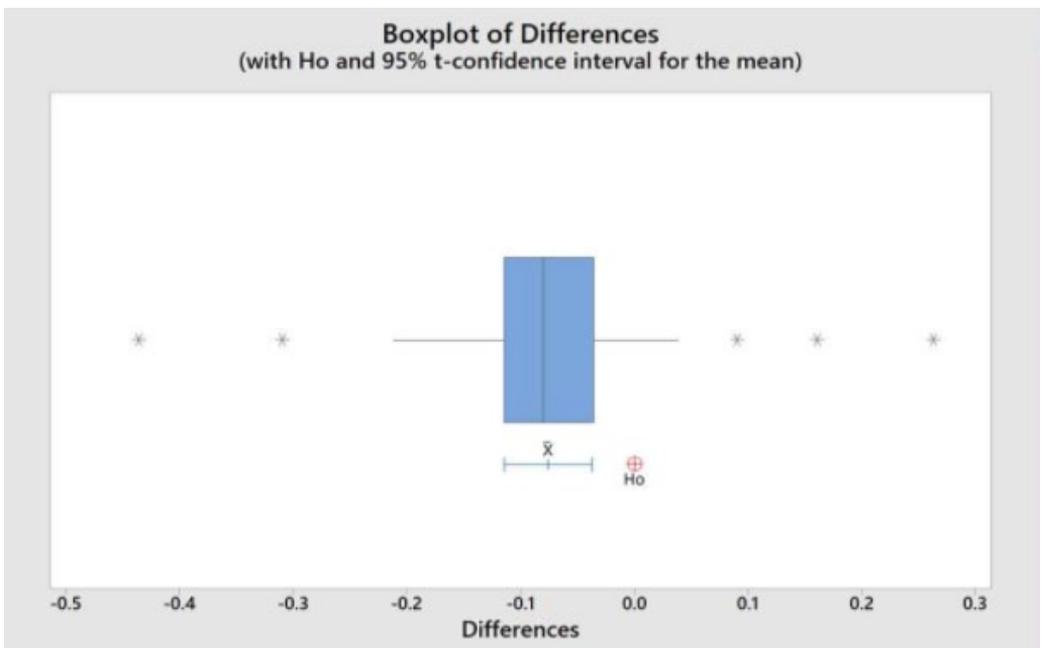
95% CI for mean difference: (-0.1145, 0.0372)

T-Test of mean difference = 0 (vs \neq 0): T-Value = 3.98
P-Value = 0.000

From Graph 5, five outliers can be observed. The scores are more concentrated than the affective scores and have a smaller range. The high T-Value suggests that reading literary fiction does positively influence cognitive Theory of Mind in children. This is likely due to Transportation Theory, which affects cognitive



Graph 4



Graph 5

Theory of Mind skills much more directly than affective Theory of Mind skills (Johnson, 2012). Transportation Theory concerns the thoughts of characters and does little to illustrate facial expression for readers.

Ultimately, this study supports the experimental hypothesis of a new understanding that the conclusion in several studies done on adults may be generalizable to children (Mar et al., 2009; Kidd and Castano, 2013; Panero et al., 2016; Matthijs and Veltkamp, 2013). The statistical significance of the difference between the pre and post assessments scores shows that Theory of Mind is at least temporarily improved in children by reading even a short passage of literary fiction. Upon further analysis, the data supports that cognitive Theory of Mind undergoes a positive change while affective Theory of Mind sees no significant changes.

Implications

This data is the first of its kind to support the hypothesis that reading literary fiction increases Theory of Mind abilities in children at least temporarily as it does in adults. These results are of relevance to the community of academia because Theory of Mind is an essential aspect of human interaction facilitating complex social relationships and characterizing human society (Kidd and Castano 2013). Furthermore, Theory of Mind is a central aspect of Emotional Intelligence. This research generalizes the existing idea that reading literary fiction influences Theory of Mind to the youth population. This research is also relevant to the facilitation and development of the life skill EI because it suggests the addition of literary fiction to current efforts in education to foster EI; an idea previously unrecognized as indicated by the edits to the United States Common Core Standards calling for less emphasis on fictional reading in education. The conclusion of the present experiment may even be additive in the development and reform of the curriculum in order to cater to the teaching of the increasingly valued asset that is EI.

Limitations & Future Directions

Both the pre and posttest were approximately 75 questions, which is a limitation because children have

difficulty concentrating; however, as each Theory of Mind measure had already been halved in order to create the pre and posttests, shortening them any further could have limited their accuracy. This is likely what ultimately resulted in 16 tests being thrown out due to skipped questions and could possibly account for the increase in range of scores from the pre to the post test. In future testing it would be advisable to find a shorter while still accurate assessment of Theory of Mind specifically for young age groups.

Additionally, a significant majority of the population tested was white and middle class. Due to the limitation on both time frame and resources presented this study did not attempt a true experimental design. This study is an indication that more research needs to be done into the subject of literary fiction on Theory of Mind in children as there is potential to be a wealth of new information to be found in the area concerning emotional intelligence development. In the future further research applying a true experimental method should be done to further solidify the conclusion and represent a more demographically accurate sample of the population.

Conclusion

The quantitative data generated represents new perspicacity about the impact of reading literary fiction on Theory of Mind in Children. While previous research has gleaned insight into the effects of reading literary fiction on Theory of Mind in adults, evaluating effects on a younger population revealed that the results are generalizable (Mar et al., 2009; Kidd and Castano 2013; Panero et al., 2016; Matthijs and Veltkamp, 2013). These results indicate that more research should be done to confirm the results of the present study using randomization to obtain a larger and more demographically representative sample. The results of this study serve to provide a foundation for further research investigating the impact of reading literary fiction on Theory of Mind in children and are the first empirical support to indicate literary fiction as relevant to the development of EI in children.

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Appendix A - pre test



SURPRISE HAPPY



ANGRY AFRAID



DISGUST SAD



ANGRY AFRAID



SURPRISE HAPPY



ANGRY AFRAID



DISGUST ARROGANT



SURPRISE SHY

THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN



BORED SLEEPY



DISINTERESTED INTERESTED

jealous

scared



relaxed

hate

hate

surprised



kind

cross

unkind

cross



surprised

sad

friendly

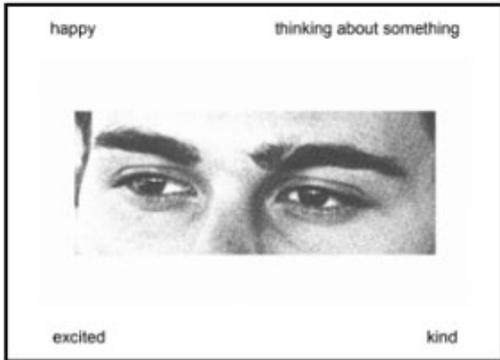
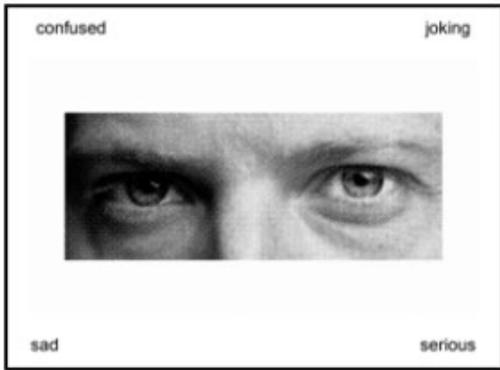
sad



surprised

worried

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This is Yoni

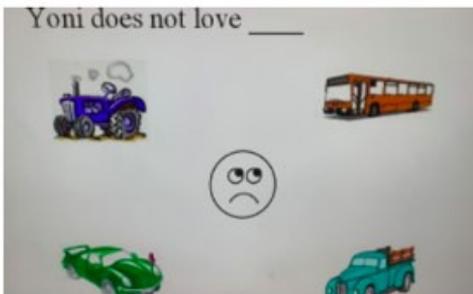
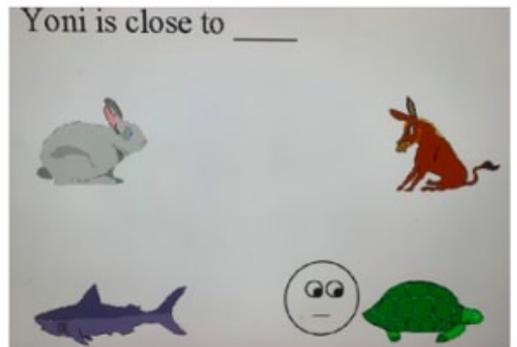
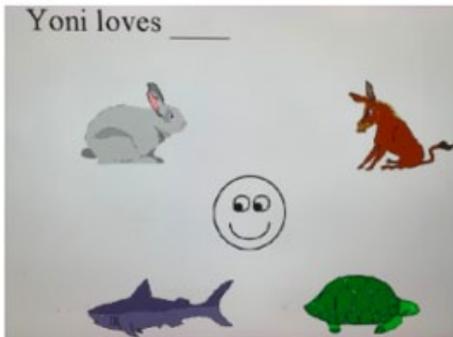
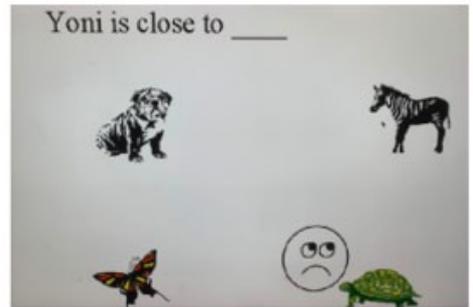
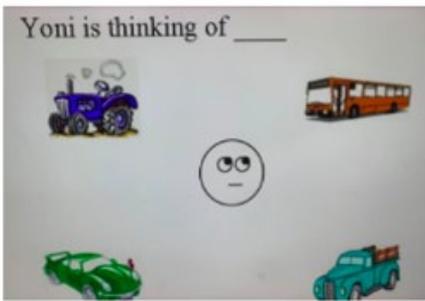
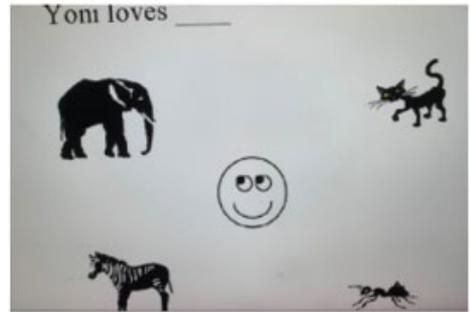
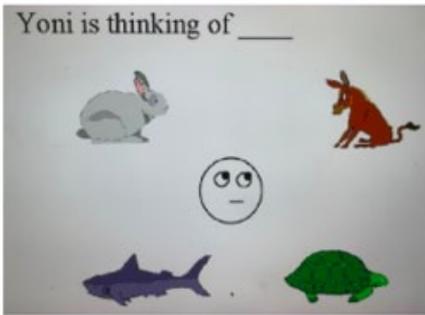


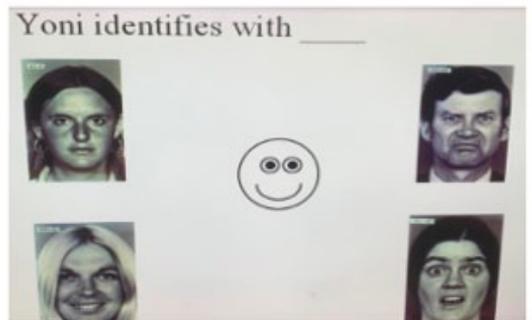
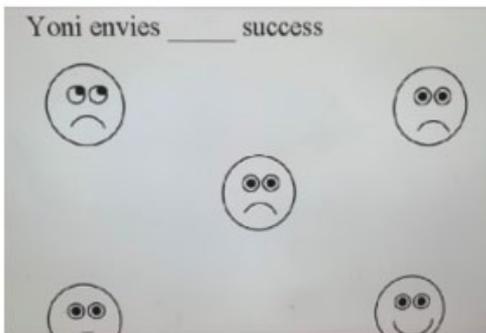
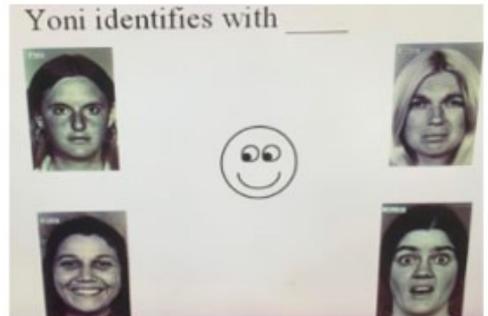
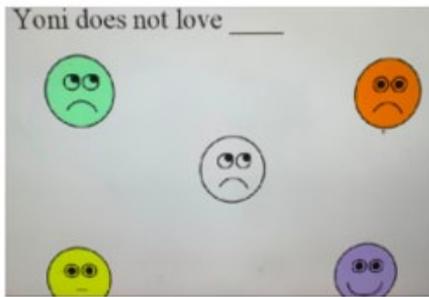
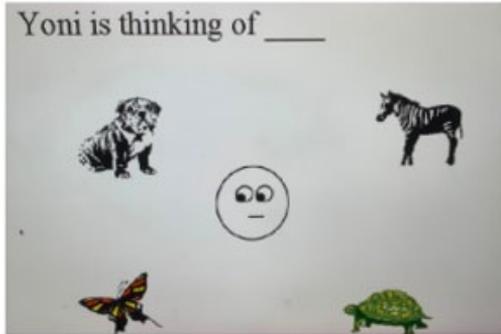
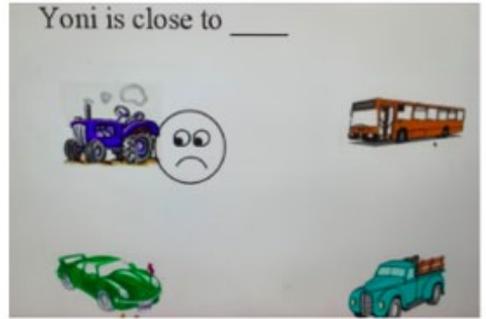
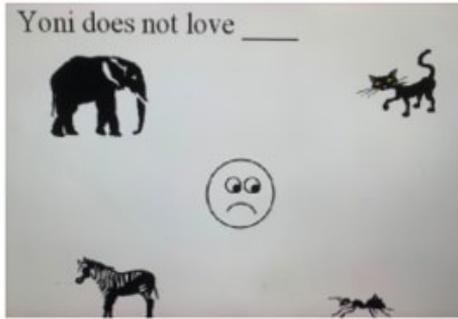
Yoni refers to people and objects around him.
You have to choose the correct object or
person

For example: Yoni refers to the orange,
 the orange.

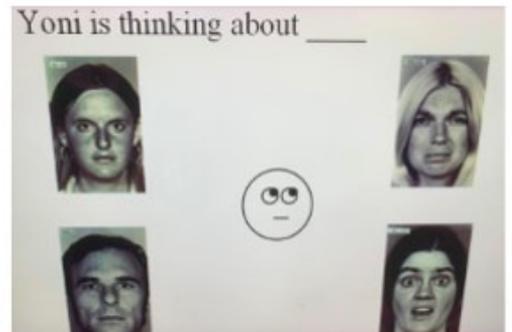
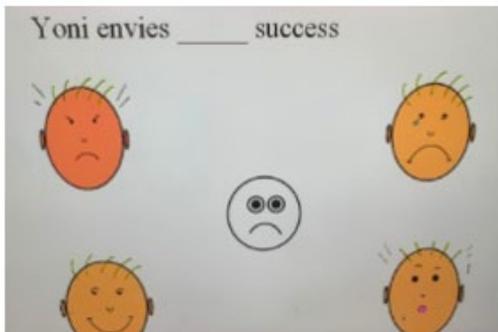
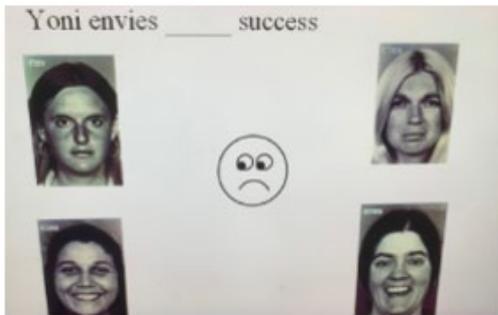


THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN

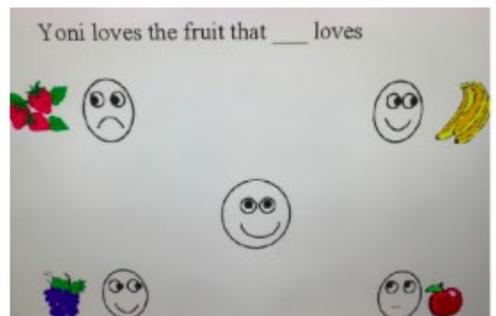
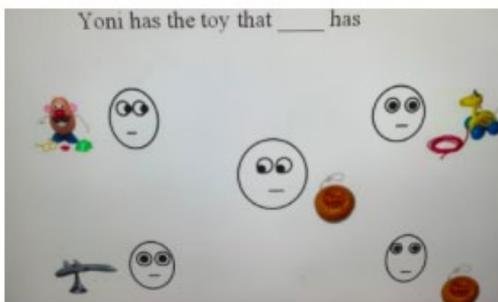
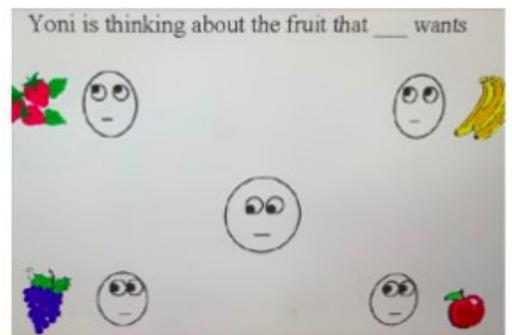
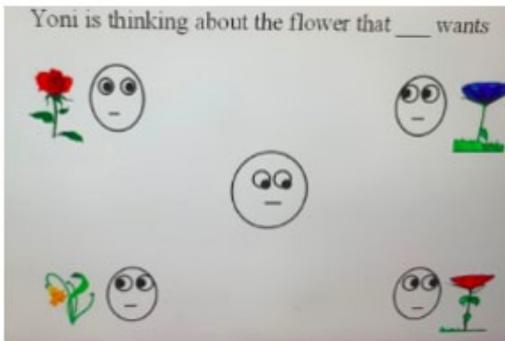




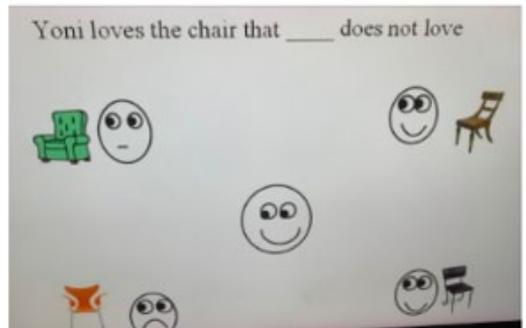
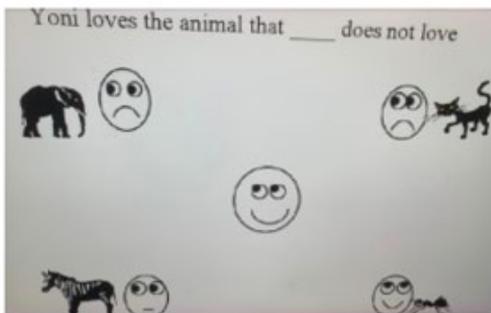
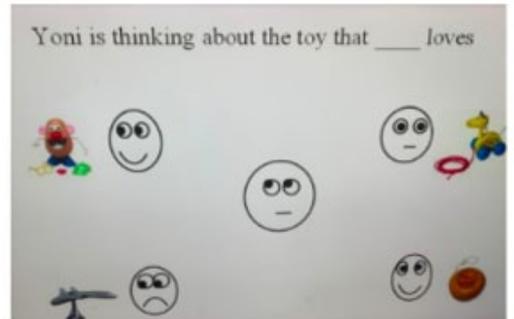
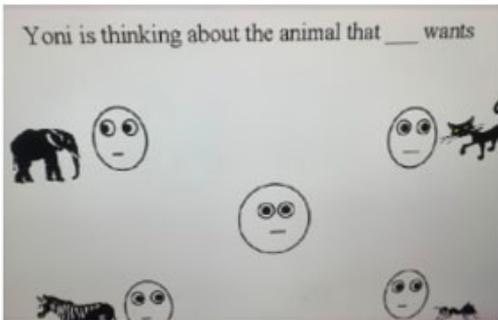
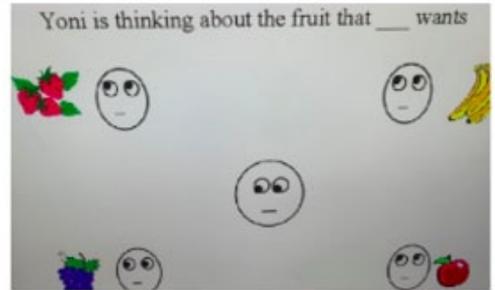
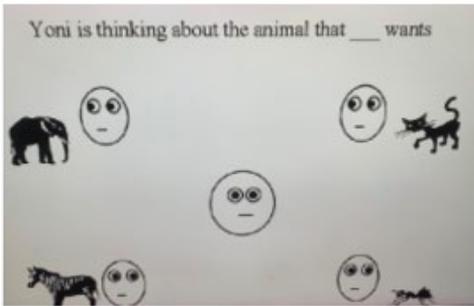
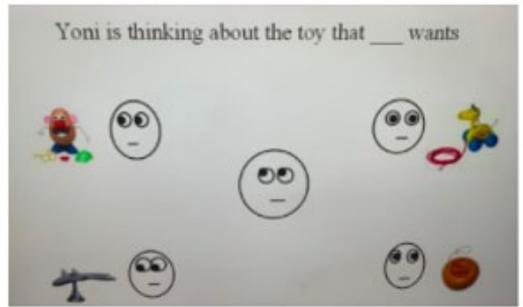
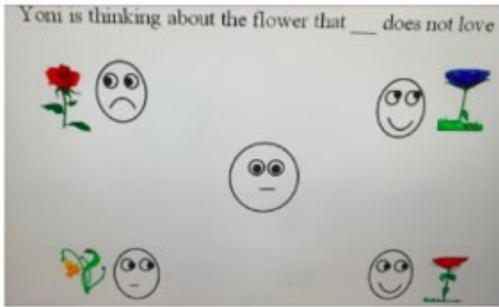
THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN



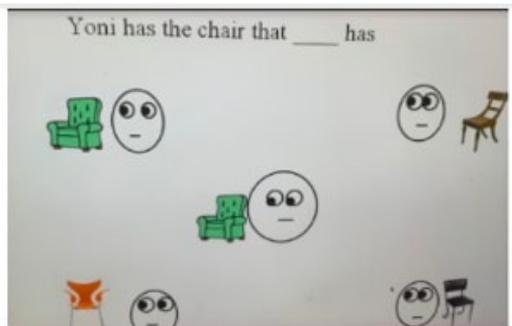
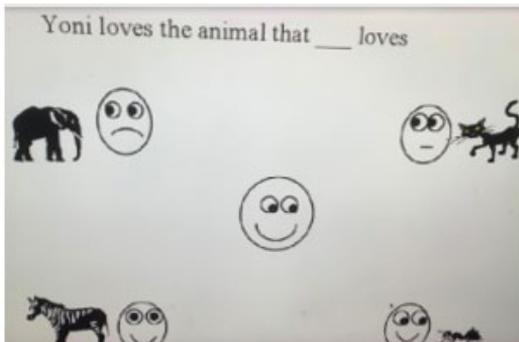
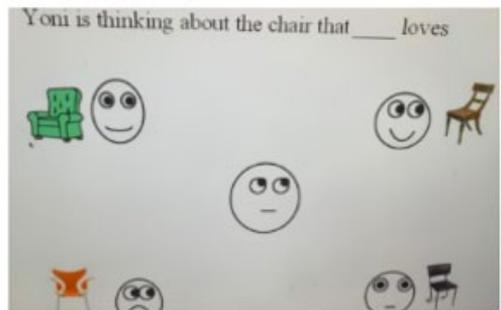
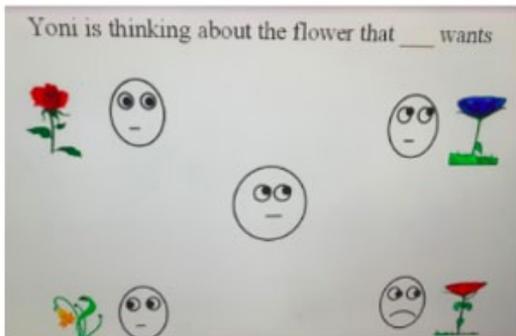
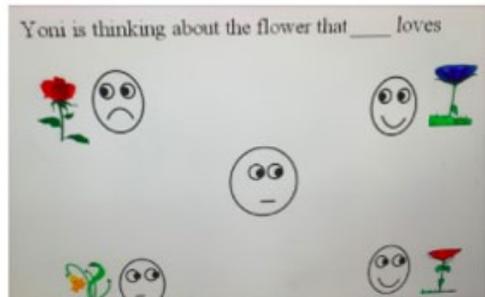
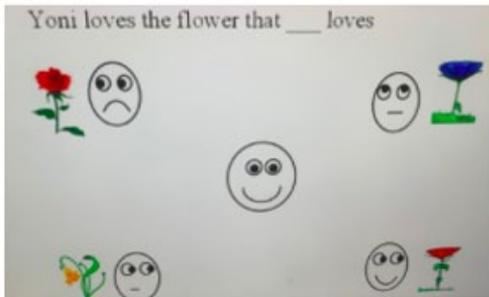
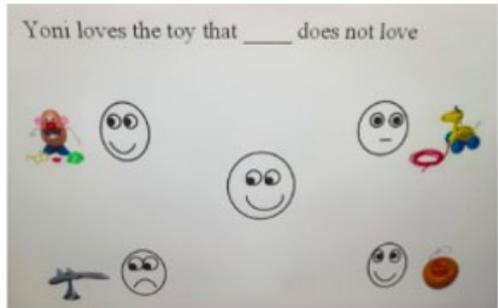
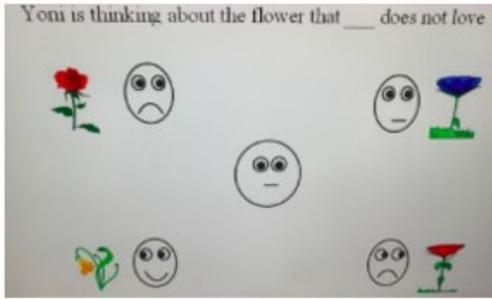
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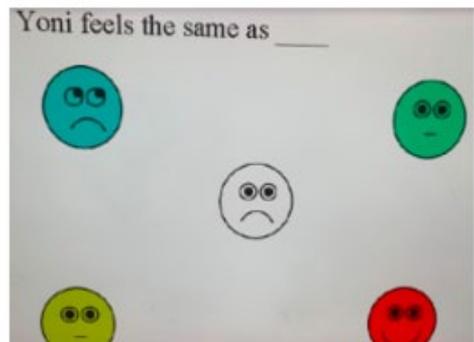
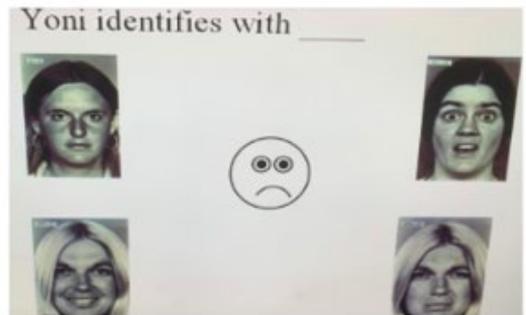
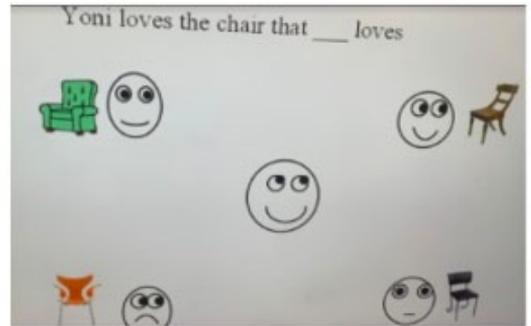
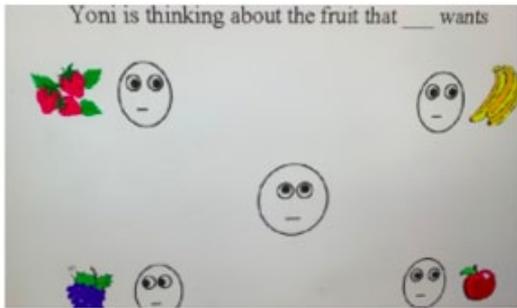
THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN



THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN



THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN



Appendix B - post test



HAPPY SURPRISE



DISGUST SAD



HAPPY SURPRISE



DISTRESS SAD



SCHEMING AMBIGUANT



AMBIGUANT CURIOUS



GUEDICAL GUILTY



HAPPY BLUSHING

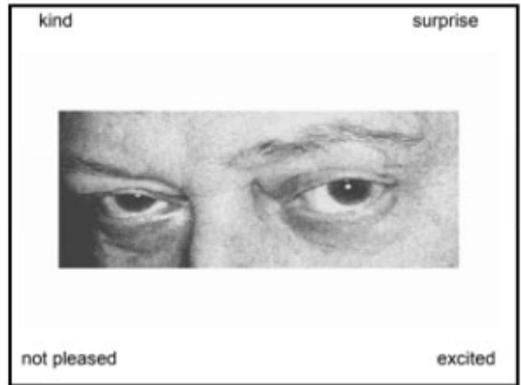
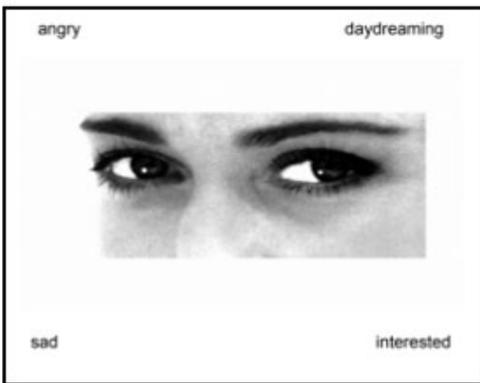
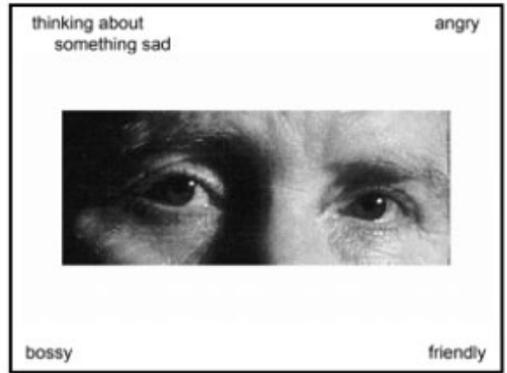
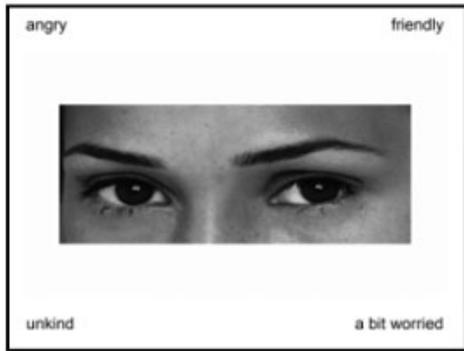
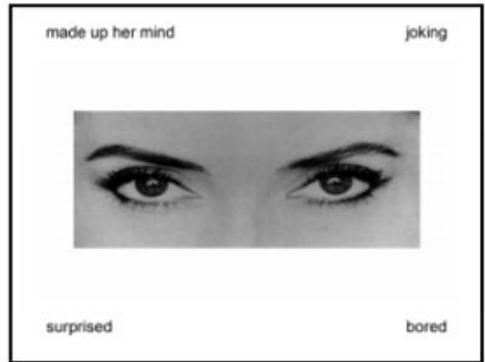


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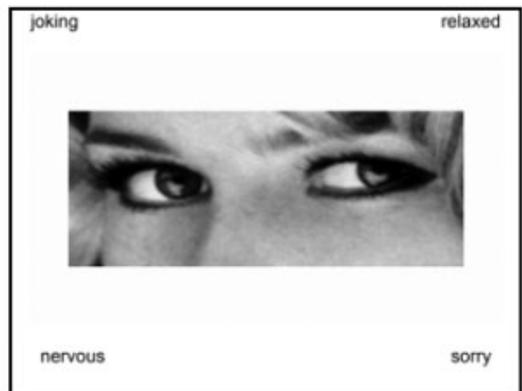
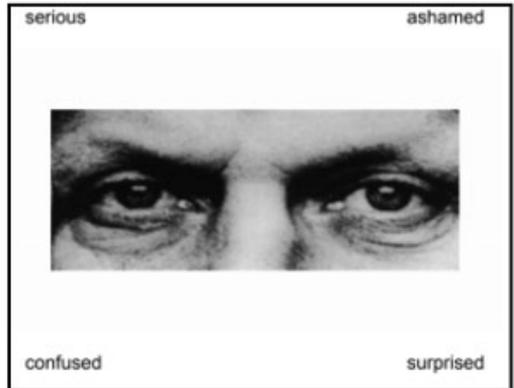
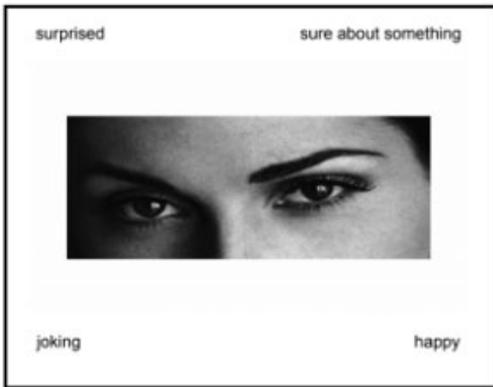
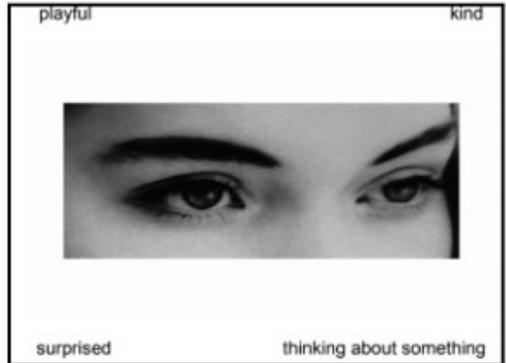
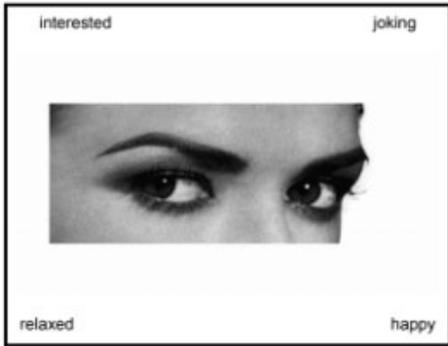


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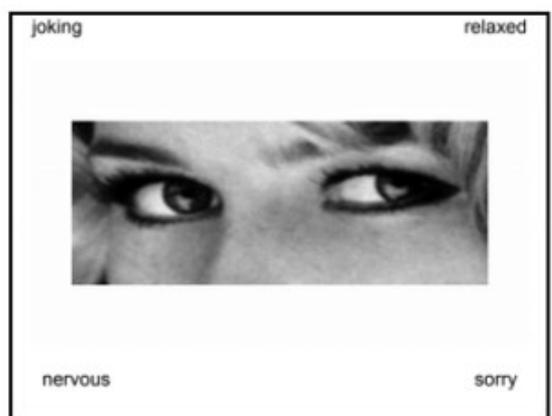
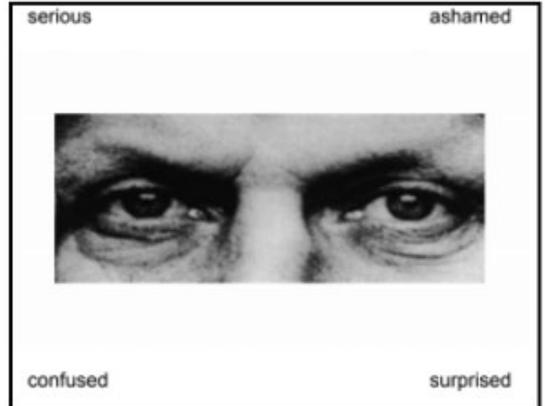
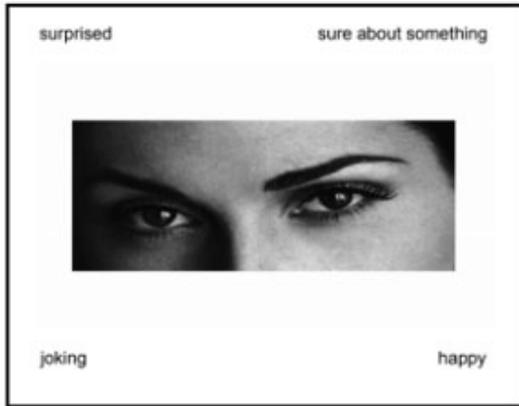
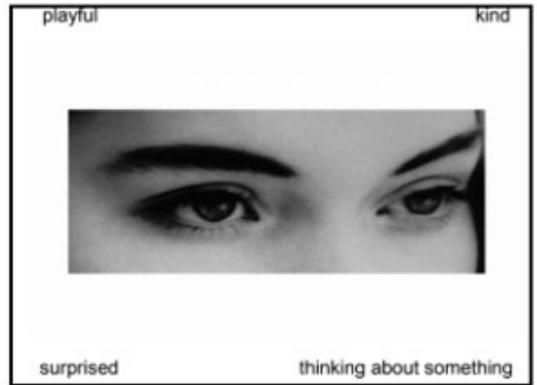
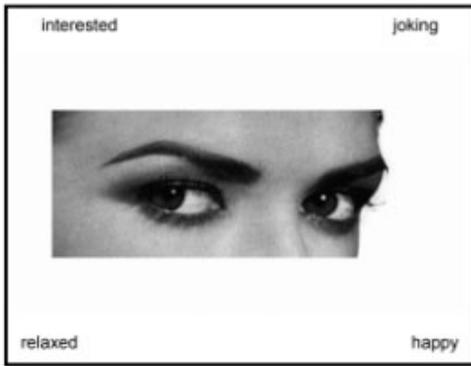
THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN



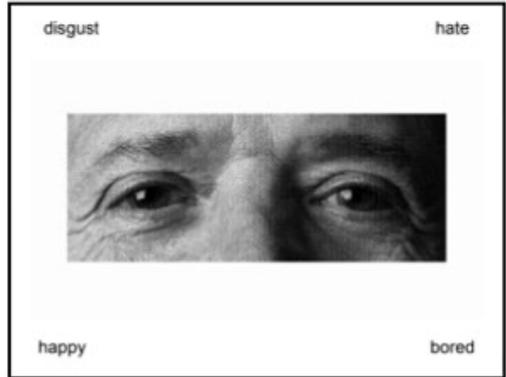
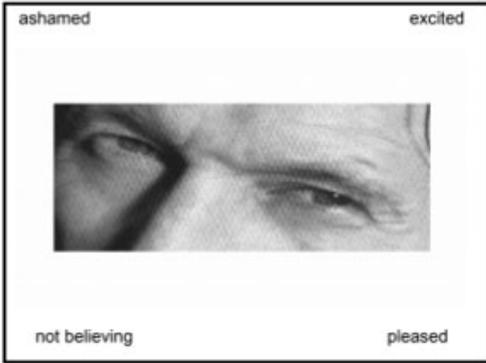
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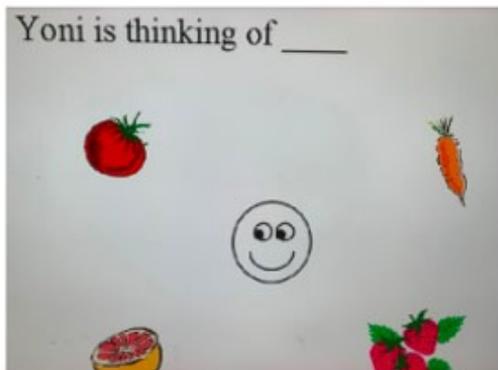
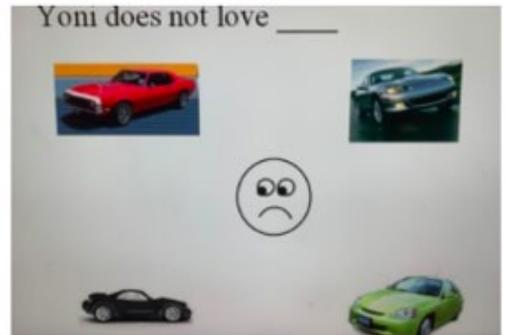


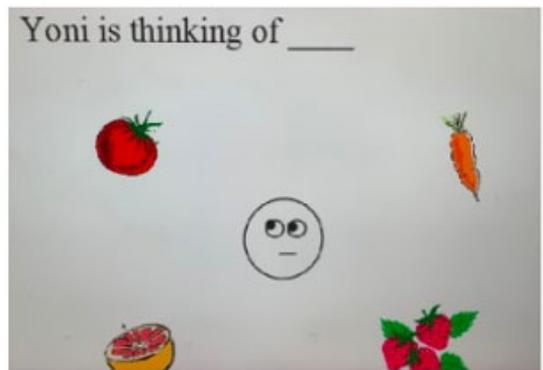
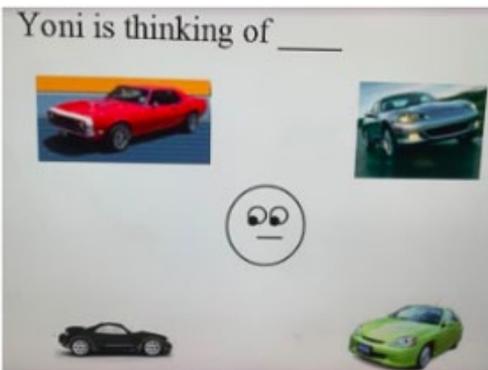
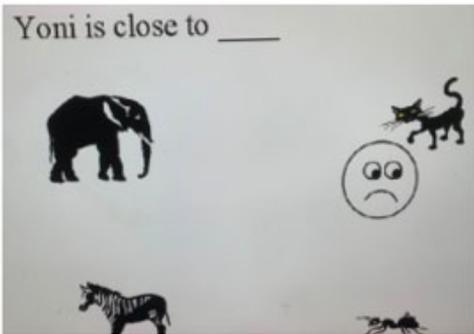
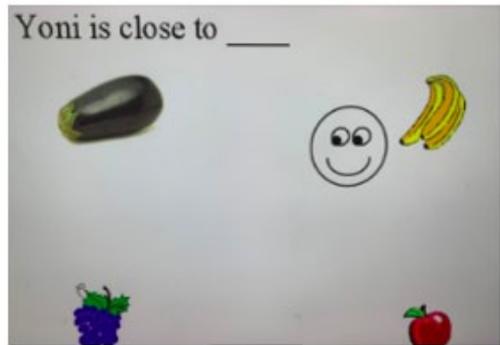
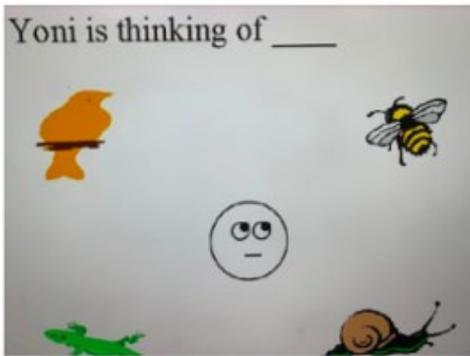
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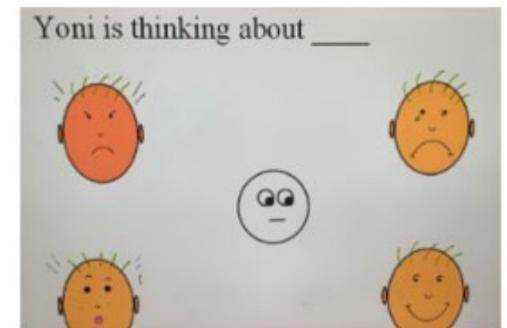
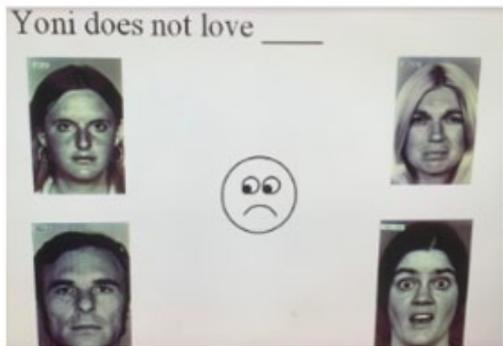
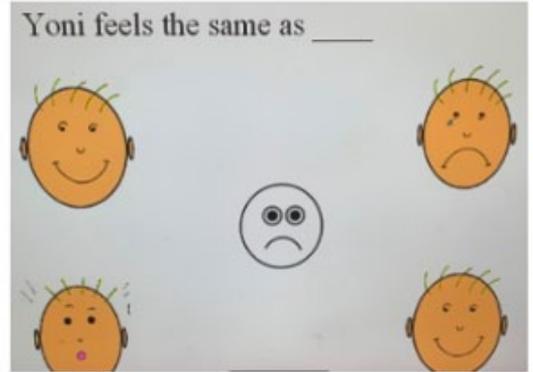
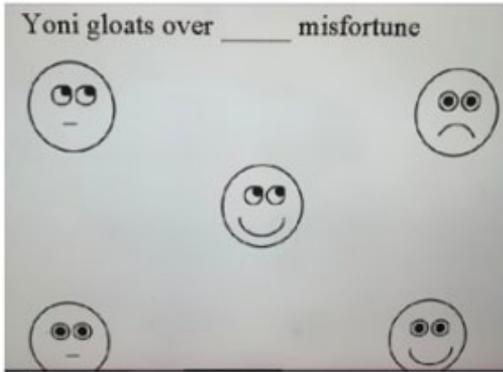


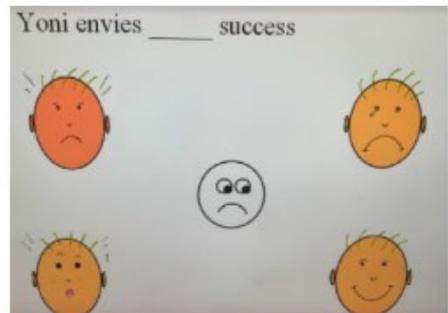
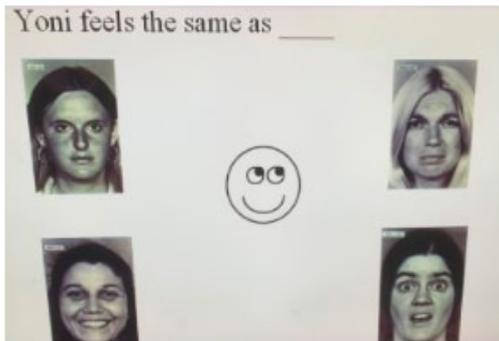
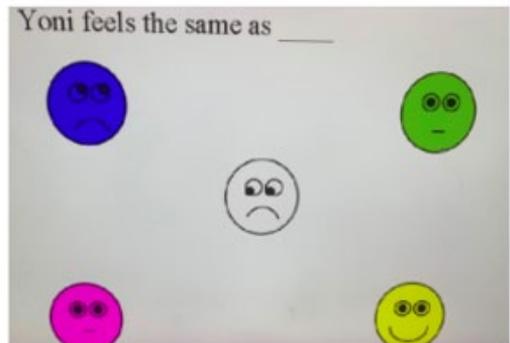
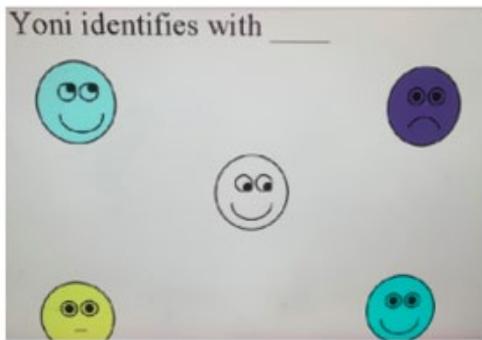
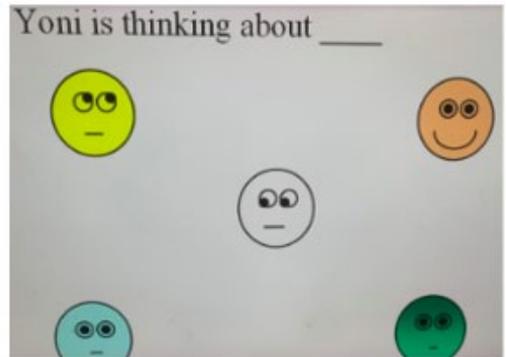
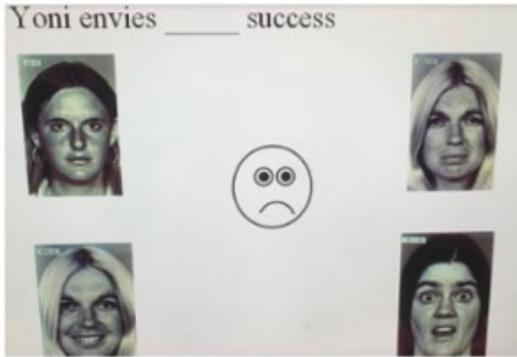
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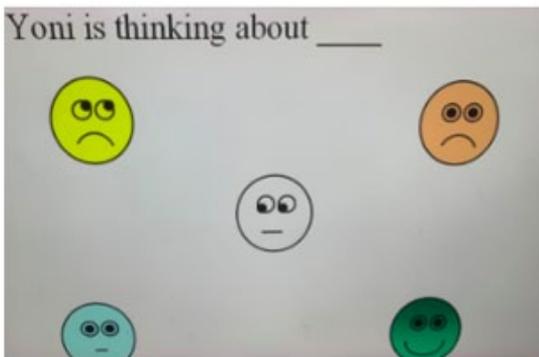
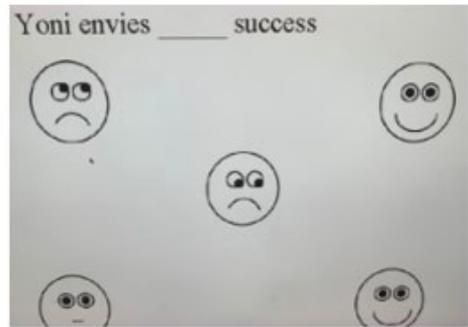
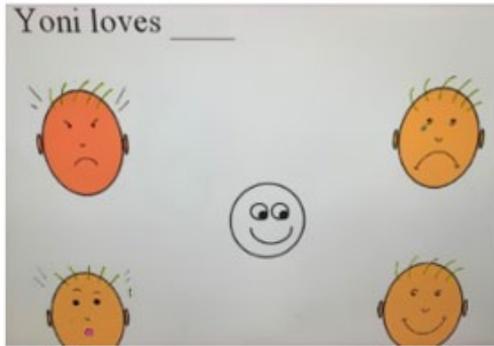




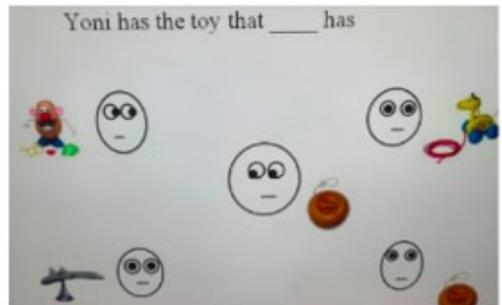
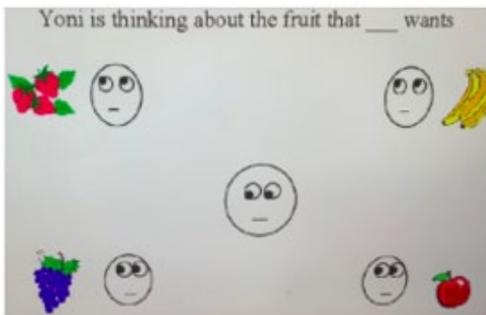




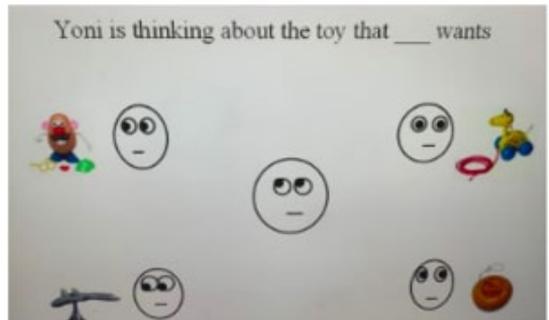
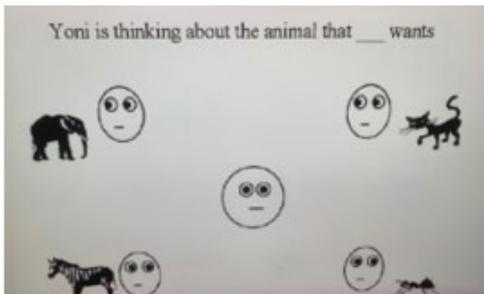
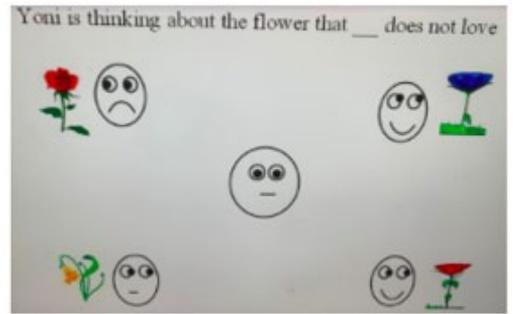
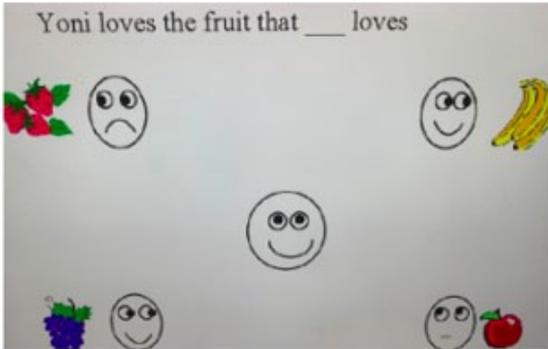


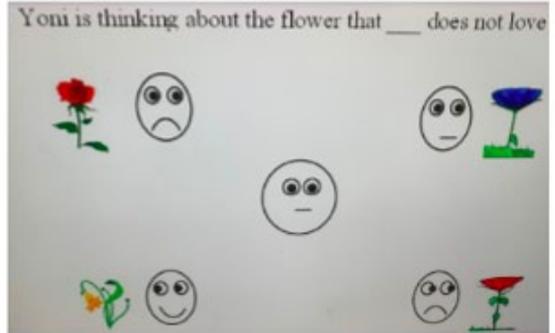
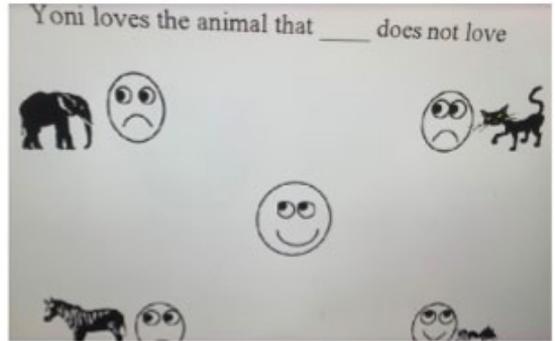
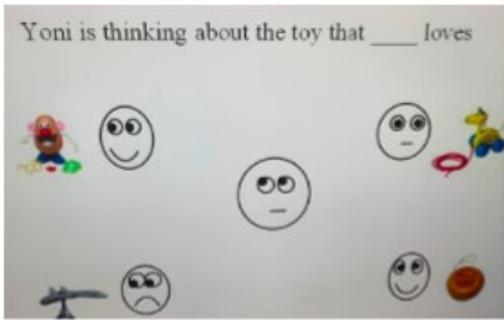


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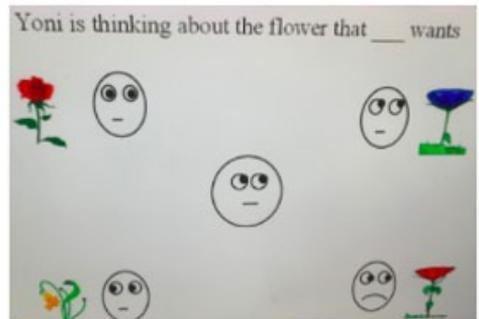
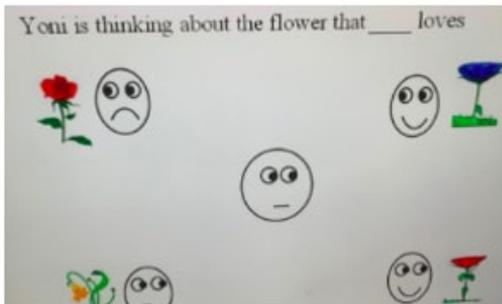
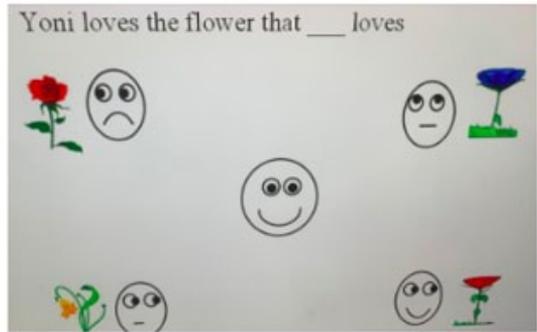
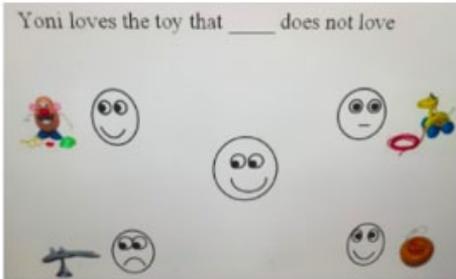
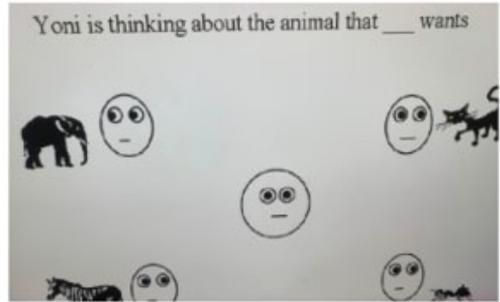
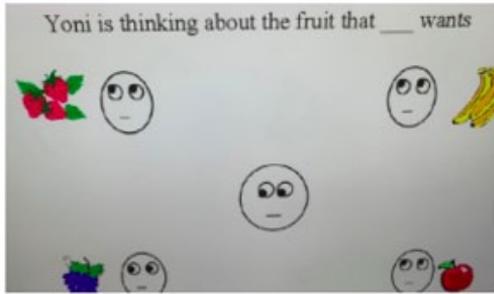


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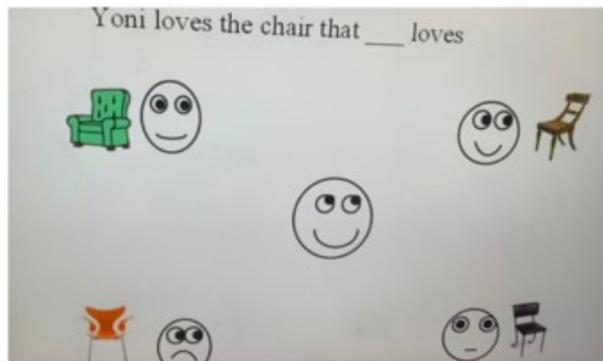
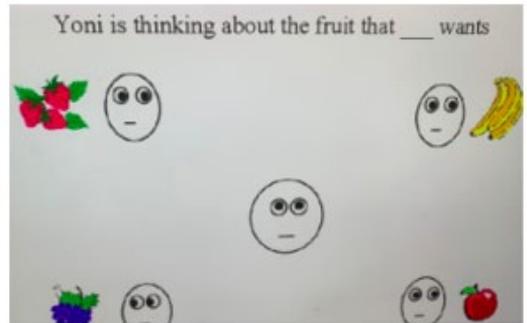
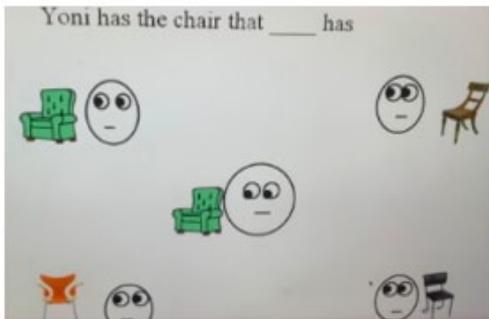
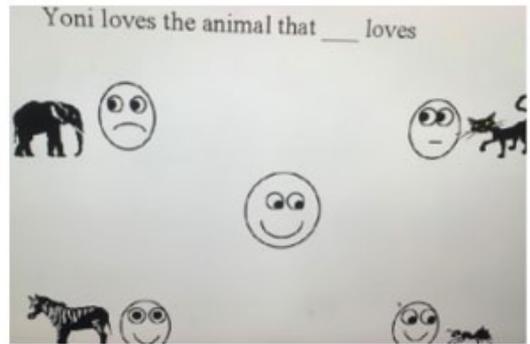
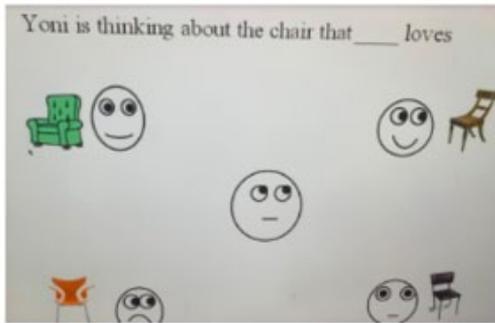




THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN



THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN



Appendix C

Children's Eyes Instructions

In this folder I've got lots of pictures of people's eyes. Each picture has four words round it. I want you to look carefully at the picture and then choose the word that best describes what the person in the picture is thinking or feeling. Let's have a go with this one (practice item). Look at this person. Do you think he is feeling jealous, scared, relaxed or hate (point to words as they are read)? Make sure child picks one of the options and give encouraging feedback without revealing whether they are right or wrong.

OK, let's have a go at the rest of them. You might find some of them quite easy and some of them quite hard, so don't worry if it's not always easy to choose the best word. I'll read all the words for you so you don't need to worry about that. If you really can't choose the best word, you can have a guess. Proceed with the test items in exactly the same way as the practice item.

Appendix D

Read the short story. Then answer each question.

Monster Learns Rules

One day, a monster came to our classroom. He didn't know any of the rules!

We had to show him how to sit on the carpet. We had to show him how to use a quiet voice. We had to show him how to use supplies.

We went to P.E. class. Monster tried to sit on the carpet. No, Monster! We don't have to sit on a carpet in the gym! Monster tried to use a quiet voice. No, Monster! We don't have to be quiet in the gym. Monster didn't know what to do with the supplies. We showed him how to throw a ball.

We went to the lunchroom. Monster sat at a table. Good job, Monster! Monster used a loud voice. No, Monster! We can't be too loud in the lunchroom. Monster tried to throw his food. No, Monster! We can't throw food. Monster was confused. Poor Monster.

We went to our classroom. We wrote the rules for the different places at school. Rules are different in different places. It is tricky but it keeps us safe!

Grade 1 Reading Comprehension Worksheet

Question:

1. Who is the main character?

2. Where is the monster sitting?

3. What is the problem?

4. How do they solve the problem?

5. What rules would you teach Monster if he came to your house?

Appendix E

Read the short story. Then answer each question.

Pen Pals

We are learning how to write friendly letters at school. I don't mind writing practice letters, but it would be more fun to write a real letter to someone. Just as I was thinking about it, our teacher, Mrs. Snow said that we really are going to write a letter to someone! We all started talking at once. Mrs. Snow asked us to quiet down again so that she could finish.

She said we are going to write to second graders in England to see what life is like in England. That sounds so cool! I couldn't wait to get started. Mrs. Snow handed out the names of our pen pals, and asked us to use what we learned about friendly letters to write to our pen pal. My pen pal's name was Oliver. The only things Mrs. Snow said we had to include in our letter were two questions:

1. Which holidays do you celebrate during the year? 2. What do you like to play?

We also had to answer those questions in our letters. She said we could add any other details about things we like to do, and what school is like here, if we wanted to.

It took a few weeks, but the day we got letters back from our pen pals was an exciting one! Oliver plays video games like we do over here. Their holidays are a lot of the same holidays we celebrate, like April Fool's Day! Oliver told me about a prank he was going to play on his dad. One holiday they celebrate that I don't is Boxing Day. It was interesting to see what is the same and what is different about living in different countries. I can't wait to learn more about my new pen pal!

Grade 2 Reading Comprehension Worksheet

Questions:

1. Who are the characters in the story?

2. What were the two questions the students had to include in their letters?

3. Why do you think it is important to talk to people who live differently than you?

4. How else could the main character communicate with his pen pal?

5. Who would you like to write a letter to? Why?

Grade 2 Reading Comprehension Worksheet

Appendix F

Human Informed Consent Form

Student Researcher:

Julia Werner

Title of Project:

The Effect of Reading Literary Fiction on Theory of Mind in Children versus Adults

I am asking for your voluntary participation in my science fair project. Please read the following information about the project. If you are willing to participate, please sign in the appropriate area below.

Purpose of the project:

To test to see if after reading a passage of literary fiction there is an increase in theory of mind test scores. Theory of mind is essentially the idea that other people have thoughts and feelings independent from one's own.

If you participate, you will be asked to:

Complete a theory of mind test and read passages

Time required for participation:

composite testing time will take no more than one hour

Potential Risks of Study: testing anxiety is the primary risk of the study; however, this should not exceed any feelings of anxiety resulting from already required standardized testing

Benefits:

Practice with reading and test taking skills

How confidentiality will be maintained:

All scores will be kept anonymous and no names will be collected or published

If you have any questions about this study, feel free to contact:

Adult Sponsor/QS/DS: Alesia Williams Phone/
email: alesia.williams@jefferson.kyschools.us

Voluntary Participation: Participation in this study is completely voluntary. If you decide not to participate there will not be negative consequences. Please be aware that if you decide to participate, you may stop participating at any time and you may decide not to answer any specific question.

By signing this form I am attesting that I have read and understand the information above and I freely give my consent/assent to participate or permission for my child to participate.

THE EFFECT OF READING LITERARY FICTION ON THEORY OF MIND IN CHILDREN

Adult Informed Consent or Minor Assent

Date Reviewed & Signed: _____
(mm/dd/yy)

- Research Participant Printed Name:
Signature:

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Signed: _____
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Glycovariants of ManC-Lectibody, a Novel Immunotherapeutic Drug, and their Effects on ADCC Activity

Sreevatsa Vemuri

Existing cancer treatments have detrimental side effects that stem from drugs' inability to distinguish between healthy and cancerous cells. Scientists have researched immunotherapy, an alternative treatment which essentially enhances the innate immune system to eliminate diseased cells. ManC-lectibody is a novel immunotherapeutic drug that imitates an antibody and performs a process known as antibody-dependent cell-mediated cytotoxicity or ADCC within the humoral immune system. Previous research proves that ManC-lectibody is highly selective to oligomannose glycans, or sugars which are expressed along the surface of a cancer cell. Additionally, ManC-lectibody has been known to induce ADCC but there is no information regarding modifications to the drug's structure and how those modifications can influence ADCC activity. This study aims to find what glycovariants of ManC-lectibody will increase ADCC activity. It was hypothesized that the GnGn glycovariant, a humanized Fc glycosylation modification, would increase ADCC activity. An ADCC reporter assay served as the primary method for the research and quantified ADCC activity. Three glycovariants of ManC-lectibody were created: GnGn, Wild type, and N200Q. A dose response curve was created to measure the efficacy and potency of the glycovariants of the drug. The GnGn glycovariant of ManC-lectibody was the most efficacious against lung cancer cells (LLC cell line) but was the most potent against melanoma cancer cells (B16F10 cell line). A two-way ANOVA statistical test proved that the GnGn glycovariant was statistically significant and produced a strong effect against the lung, melanoma, and ovarian cancer cells, therefore indicating that the GnGn glycovariant makes the ManC-lectibody a more effective drug.

Keywords: ManC-lectibody, antibody-dependent cell-mediated cytotoxicity (ADCC), fragmented crystallizable region (Fc region), Fc receptors, lung cancer, ovarian cancer, melanoma

Introduction

Pharmaceutical companies around the world are developing many drugs to combat and cure diseases. From changing the genetic makeup of bacteria to creating chemical derived drugs, scientists are able to reduce the number of disease-related deaths around the world. While this may seem like a plausible solution in decreasing diseases, pharmaceutical drugs are tedious in their manufacturing process. Currently, the production of pharmaceutical drugs is not feasible for

large scale application, thereby limiting drug quantities for patients¹. In addition, current pharmaceutical drugs only target select diseases, requiring further research to be conducted to resolve other deadly diseases². Most importantly, however, pharmaceutical drugs result in negative side effects, giving rise to severe implications to the human body³.

Immunotherapeutic drugs are a specific type of pharmaceutical drugs that can help mitigate diseases by using the immune system. Essentially, "immunotherapy aims to harness the host's adaptive and innate

immune system” to ultimately “[eliminate] diseased cells⁴.” While this approach is effective in “[eradicating] smallpox...typhoid, cholera, hepatitis, and more, it has been far less effective against cancer⁴.” This problem has negatively affected cancer patients as there are very few immunotherapeutic drugs that are capable of reducing side effects. Not only this, prolonged exposure to tumors without a treatment would place the patient in danger. Several drugs have been created to combat this issue of selectiveness, including the novel drug ManC-lectibody. This drug imitates the function of an antibody and is capable of selectively targeting cancer cells without causing harm to normal cells⁹. However, drug improvements still need to be made in order to improve ManC’s activity in decreasing cancer cells while still reducing detrimental side effects.

Brief Overview of the Humoral Immune System

The immune system is an essential human body system as it helps the “host eliminate toxic or allergenic substances” that can negatively affect the body⁸. An immune response is the reaction that takes place within the immune system to fight against foreign molecules⁷. There are several immune responses that contribute to the function of the immune system. However, when looking at the immune response associated with ManC-lectibody, the humoral immune response is the most prevalent due to the drug’s function. Within the humoral immune system, there are two main identities involved: antibodies and antigens. Antigens are molecules that stimulate an immune response. For example, carcinomas, bacteria, and viruses are all molecules that initiate an immune response, therefore making them antigens⁵. Antibodies are Y-shaped molecules that have two main regions: the fragment crystallizable region (Fc region) and the fragment antigen-binding region (Fab region). The Fc region is constant, meaning that the structure is relatively the same in all antibodies⁶. This is because the Fc region binds to the same immune cells, such as B cells or effector cells, that kill antigens. However, the Fab region is antigen-specific, meaning that it changes to target specific foreign substances⁶. Because of the antibody’s structure, the humoral immune system is antibody-mediated, meaning that the antibody serves

as the primary form of communication between the immune cells and the antigens⁵. To facilitate the understanding of this system, the antibody can be seen as a bridge connecting the immune cells to the antigens so that the immune cells can target the antigens.

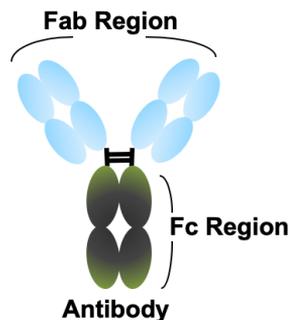


Figure 1. “Structure of an IgG1 antibody”.

An IgG1 antibody structure with two Fab regions and one Fc region (visual created by student researcher).

Literature Review of ManC-Lectibody

As noted by Dr. Nobuyuki Matoba, the creator of ManC-lectibody, the immunotherapeutic drug “simulates an antibody-cell interaction that attempts to decrease cancer cells by increasing antibody behavior⁹.” Dr. Matoba is a researcher at the University of Louisville and holds the current research regarding ManC-lectibody. The drug consists of two portions: an Fc region of an IgG1 antibody and two ManC portions. The ManC portions are derived from a lectin (plant protein) known as Actinohivin. Actinohivin has been known for its specificity in targeting glycoproteins, which are essentially sugars that surround the human immunodeficiency virus (HIV)¹⁰. By modifying this molecule, Dr. Matoba and his team were able to create a molecule capable of selectively targeting similar glycoproteins that surround cancer cells. These glycoproteins are expressed by some cancer cells and are known as oligomannose glycans or high mannose glycans (HMGs) and serve as biomarkers. Biomarkers are indicators that mark the presence of substances, in this case cancer cells¹¹.

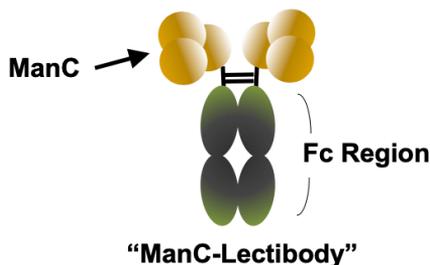


Figure 2. “Lectibody”.

This figure illustrates the structure of ManC-lectibody. Two ManC portions are combined to an Fc region of an IgG1 antibody by the process of dimerization (Seber Kasinger, Dent, Mahajan, Hamorsky, & Matoba, 2019).

Previous research from Dr. Matoba’s team shows that the drug can distinguish between cancer cells and healthy human cells mainly due to ManC-lectibody’s high affinity for high mannose glycans⁹. High mannose glycans are expressed in higher yields on cancer cells when compared to normal cells, thereby making the drug selective to only diseased cells⁹. As mentioned earlier, since the high mannose glycans mark the cancer cell, they serve as biomarkers¹¹. However, Dr. Matoba’s team refers to them as glycobiomarkers since the biomarkers are composed of sugars⁹. Dr. Matoba’s research was mainly concerned with determining whether the drug recognizes glycobiomarkers on the cancer cell’s surface and his team only examined ManC-lectibody’s effects on a specific ovarian cancer cell line⁹.

Similar approaches for the discovery of glycobiomarkers have been prominent in immunotherapy research. Muchena J. Kailemia, Dayoung Park, and Carlito B. Lebrilla, researchers from the Department of Chemistry at the University of California in Davis, California, found that the importance of glycobiomarkers is significant as it not only helps identify cancer in early stages, but it can also indicate the severity of the cancer¹². The varied intensity of the glycans found on the site of interaction between the antibody and the cancer cell indicate the sugar presence on the surface of the cell. Presumably, larger quantities of glycans may mean that there is severe carcinoma behavior while smaller quantities of glycans may show signs of a growing tumor. This coincides with Dr. Ma-

toba’s research on ManC-lectibody since it demonstrates how the intensity of high mannose glycans can stimulate ManC-lectibody to eliminate cancer cells faster due to the more recognition of sugars on the cell’s surface. Moreover, Kailemia and her team also discuss a glycosylation modification made to the Fc region on an antibody. Glycosylation is an enzymatic process that attaches glycans, or sugars, to the antibody¹². In Kailemia’s research, the modification to the glycosylation site on the antibody’s DNA terminated the enzymatic reaction. This modification resulted in a “GnGn glycovariant”, or a sugar variant of the drug, which is created when the glycosylation process is halted in the middle of the enzymatic pathway^{9, 12}. The GnGn glycovariant is not found in nature, therefore requiring the genetic modification¹². The Fc region has only one site for glycosylation and by modifying that site on a regular antibody, the researchers were able to find that there was a “enhanced recognition of glycans¹².” Given this, a GnGn glycovariant could improve ManC-lectibody’s effectiveness since it could increase glycan recognition, which would, in theory, increase the drug’s function.

Another aspect of the glycosylation process is that it can be reversed to cause severe changes to the Fc region’s function. A study done by Michael Kelliher and Ramiah Jacks, lead researchers in the Department of Chemistry at DePaul University in Chicago, shows that by removing essential sugars from the Fc region, the antibody reduces its signaling abilities with immune cells. Decreasing “the activity of the Fc region... enables[s] the receptors to attract antigens,” but it also stimulates less signaling between the Fc region and the effector cells¹³. With this, an “aglycosylation modification,” as defined by Kelliher and his team, could serve as a drawback to ManC-lectibody’s activity. This modification is specifically called a N200Q, or NQ, modification as it removes an amino acid at the two-hundred position and replaces it with a dysfunctional amino acid¹³. For the current research, however, the use of an aglycosylation modification or NQ glycovariant of ManC-lectibody may be beneficial since it could serve as a comparison trial to the GnGn glycovariant. Comparing the effects of both glycovariants will demonstrate how an Fc modification may improve the effectiveness of the drug. As mentioned before, ManC-lectibody has never been modified, thus contributing to existing research on the drug. This is

an important step in developing a drug as the most effective version of the drug is used in clinical trials.

Antibody-Dependent Cell-Mediated Cytotoxicity (ADCC)

The Fc region holds a cell interaction process known as antibody-dependent cell-mediated cytotoxicity, or ADCC. Maria Carmen Ochoa and her fellow researchers, in their immunology-based research publication, examined the process of antibody dependent cell-mediated cytotoxicity (ADCC) in depth. The authors contribute to the basis of knowledge about ADCC by contending that “antibodies attach to the surface of malignant cells, binding to proteins, which first stimulates the effector cell to enact on the malignant tumor¹⁴.” ADCC induction occurs when there is a transmission of signals from the Fc portion of an antibody to the immune cell (see Figure 3). ManC-lectibody has been known to induce ADCC but has yet to be tested with the proposed glycovariants; that is the glycosylated and aglycosylated versions of the drug⁹. In theory, fewer cells present should indicate more signaling due to the higher cell-death response from the effector cells. In this research study, the immune cell used will be a cell line known as the Jurkat T cell line due to its “intensive use in modeling an immune system environment” without the use of an animal¹⁵.

Brief Overview of Lung, Ovarian, & Melanoma Cancers

The glycovariants, or sugar versions, of ManC-lectibody will be tested on three types of mice-derived cancer cell lines: ovarian, lung, and melanoma cancer cell lines. The drug has been minimally tested on these cell lines and would contribute to the existing research on the drug if the glycovariants prove to be successful⁹. Additionally, the use of cell lines from immunocompetent mice will help simulate the immune system response while also allowing ADCC to occur. Starting with ovarian cancer, it is a type of cancer that begins in the female reproductive organ. It inhibits the ovaries and causes a tumor to arise. Ovarian cancer goes often undetected until it spreads to the rest of the body, specifically to the pelvis and abdomen¹⁶. Current research suggests that the cure rate for the fatal disease is around 30% and that preventing its spread is difficult due to the unnoticeability of it¹⁷.

Along with ovarian cancer, lung cancer is another detrimental disease that has become the leading cause of cancer deaths within the United States¹⁸. It first develops by affecting a lymph node and can cause fatalities as the carcinoma spreads throughout the rest of the lung¹⁸. Finally, melanoma is a type of skin cancer that develops when melanocytes grow rapidly and causes dysfunction to the cell. This disrupts melanin, the pigment that gives the skin its color¹⁹. Current research proves that ManC-lectibody does inhibit these three cancer cells to stop its successive reproduction, but there is no research that shows if certain modifications to the drug will either sustain or improve its effect in killing the cancer cells⁹.

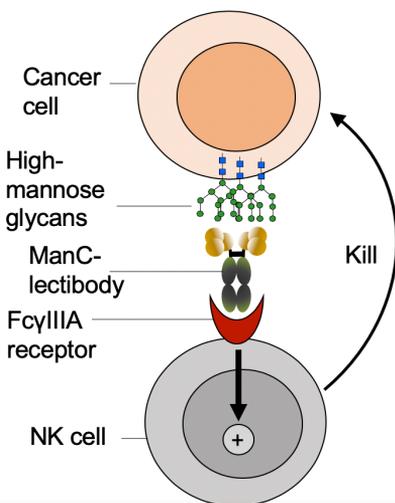


Figure 3. “ManC-lectibody in relation with ADCC”. The Fc region of ManC-lectibody sends a signal to the immune cell via the Fc gamma receptor and tells the immune cell to kill the cancer cell (Seber Kasinger, Dent, Mahajan, Hamorsky, & Matoba, 2019).

Gap, Value, Significance, & Research Goal

The research question has been centered around ManC-lectibody and the subsequent glycovariants of the drug while still playing a role in the larger context of cancer therapy. For this experimentation, the research question developed was: Which glycovariants of ManC-lectibody will increase ADCC activity? It has been hypothesized that the GnGn glycovariant of the drug will increase ADCC activity while still maintaining a high cell-death response. Although the drug has been known to selectively target cancer cells, it has never been modified, specifically with a glycosylation and aglycosylation modifications to create glycovariants⁹. Furthermore, an ADCC reporter assay has never been performed to quantify the effects of the glycovariants⁹. Finally, the drug has yet to be tested on different versions of ovarian, lung, and melanoma cancer cells⁹. While all these gaps are specific to the development of drug, ManC-lectibody is significant to cancer therapy since it will be the first-in-class immunotherapeutic drug to selectively target high mannose glycans. This will alleviate the issue of side effects that stem out from many cancer therapies. Additionally, the drug is “highly producible in a scalable plant-based system”, thus allowing for widespread manufacturing of the drug⁹. Due to the drug’s novel behavior and potential application, it is important to find the most effective version of the drug.

Method

A true experimental quantitative method was conducted to determine whether glycovariants of the drug would increase ADCC activity. ADCC activity was measured through an ADCC reporter assay, which quantified the signals between the effector cells (Jurkat T cell line) and the Fc region of the drug. Quantitative data was necessary as it aided in proving that each glycovariant increased ADCC activity and also helped determine the efficacy and potency of the glycovariant in terms of inducing ADCC. To employ this method, three main protocols were followed: cell splitting and plating, the addition of glycovariants, and the ADCC reporter assay.

Cell Splitting & Plating

Three cell lines were used: ID8, LLC, and B16F10 cell lines. These cell lines represent the specific version of ovarian (ID8), lung (LLC), and melanoma (B16F10) cell lines. The first protocol consisted of cell splitting and plating, which essentially means to culture, count, and plate cancer cells to ensure that the cells are in “optimal condition for the experiment”. This step is important because without healthy cells, the data may fluctuate and may have outliers, which could be detrimental to understanding the glycovariant’s effects. To initiate this protocol, all the cancer cells were pre-cultured and only had to be split and counted. The enzyme Trypsin was used to separate the cells from a flask to make the cells confluent. According to lab scientists Frauke Haenal and Norbert Garbow, making the cells confluent “are important quality control parameters in cell-based assays” as they “determine the health of [the] cells²⁰”. After adding Trypsin, the cells were split based on the number of cells in the flask. Cell splitting refers to separating the cells from one flask to another so that the cells are healthy and confluent for future experiments. A hemocytometer, or cell counting device, was placed under a microscope at 40x magnification and helped count the cells. This was important as it “[normalized] the number of cells²⁰”. Once counted, the cell quantity was used in calculations to find the volume of cells and medium needed in order to plate the cells. Cell medium is the basic growth factors needed for the cells to stay healthy²⁰. Cell plating refers to transferring the

cells into a ninety-six well plate. Ten-thousand cells were plated per well and the well plate was kept in an incubator at 37 degrees Celsius as this was the optimal temperature for cell growth⁹. This same process was done for the effector cells (Jurkat T cell line).

Addition of the Glycovariants

Through genome editing of ManC-lectibody, a DNA manufacturing company was able to create the glycovariants for the experiment. In order to achieve a true experimental method, the experiment needed a control. The wild type glycovariant served as the control and was essentially an unmodified version of the drug. After receiving the glycovariants in liquid form, they were added in different concentrations, through a serial dilution, to the well plate containing the cancer cells. A serial dilution splits the drug concentration by half, starting from an initial concentration of 50 nanomolar (nM). Nanomolar concentrations are used in many pharmacological experiments and help show the small amount of drug needed to produce a desirable effect¹⁷. A total of three trials were done for each cancer cell line as this helped with the statistical analysis.

ADCC Reporter Assay

The signaling between ManC-lectibody and the effector cells was measured using an ADCC reporter assay. According to Dr. Matoba and his team, “the assay measures ADCC not by cell death but rather by the expression of a reporter gene, known as luciferase⁹.” Luciferase is expressed by the effector cell when signals travel from ManC-lectibody to the effector cell. When these signals travel across the Fc receptor, they activate the receptor which then stimulates the effector cell to produce luciferase. Higher expression yields of luciferase indicate greater Fc receptor activation⁹. Essentially, if more luciferase is present, then there are higher levels of signaling between the drug and the effector cell. In order to find the reporter gene, a luciferase substrate was added to the well plates. When this substrate binds to luciferase, it catalyzes to produce light, which can be quantified by the luminescence value. Once this value was obtained, it was converted into a fold induction value. This value simply shows the increase of the glycovariant’s effects at differ-

ent concentrations, which, when graphed, shows the minimal concentration needed to produce a strong effect⁹. Both the fold induction and luminescence values have no units and are used to quantify the signaling between the modified drug and effector cells. As deriving the fold induction value using an equation is a tedious process, a mathematical software known as GraphPad was used to automatically calculate fold induction when given raw luminescence values.

A non-linear regression data plot was created to show the drug’s dose response for each glycovariant. This procedure is well known by researchers in the field of pharmacology²¹. When interpreting a dose response curve, there are two factors that determine the drug’s effect: the top value and the EC50 value. The top value represents the efficacy of the drug and the EC50 value expresses the drug’s potency. A drug’s efficacy refers to its maximum, attainable strength when introduced into a stimulating environment while potency is defined as the drug’s capability of producing an effect at a given concentration. Pharmacologists research drugs that are highly potent, meaning that the drug elicits the maximum effect at low concentrations²¹. In terms of the dose response curve, the efficacy of the drug would be the value at which the highest curve begins to level off while the EC50 is the concentration at which the drug gives half of its maximal response. For this experiment, the graphs will show the glycovariant’s efficacy and potency needed to induce ADCC at a given concentration.

GLYCOVARIANTS OF MANC-LECTIBODY AND THEIR EFFECTS ON ADCC ACTIVITY

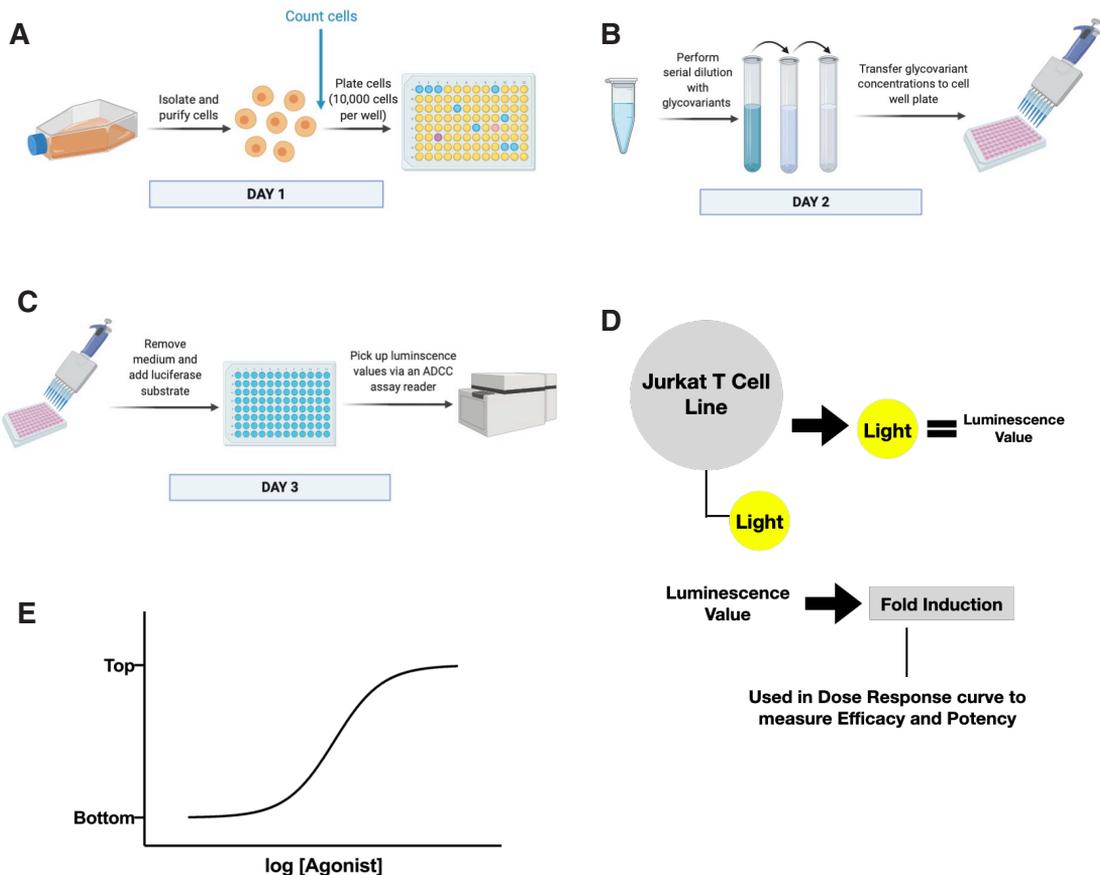


Figure 4. “Schematic Overview of the Methodology”.

(A) All cancer cells were isolated and purified through the use of trypsin and a centrifuge. Once cells were confluent, they were counted using a hemocytometer. The quantitative number of cells was used to calculate the volume of cells and medium needed to achieve 10,000 cells per well. (B) The glycovariants were obtained in liquid form and were kept in an Eppendorf tube until time for the serial dilution. The serial dilution was performed in a sterile and new well plate to minimize error. After the concentrations were achieved, the glycovariants were transferred to the well plate containing the cells. (C) The old medium was removed carefully from each well as the cells settled on the bottom of each well. The luciferase substrate, which was part of a BioAssay Kit for ADCC assays, was then added in microliter volumes. The well plate was placed in the ADCC assay which transcribed light into luminescence values. (D) This diagram shows a sample ADCC assay. The Jurkat T cell line is engineered to produce light when the Fc receptor is activated. This light is converted into luminescence values, which then is converted into fold induction values. Fold induction values are used in dose response curves to help measure the drug’s efficacy and potency in terms of inducing ADCC. (E) A sample dose response curve from GraphPad that displays the principles of top and EC50 values (Figures 4A-4D were created by the student while Figure 4E was obtained from GraphPad).

Results

Discussion & Analysis of Methods-Generated Data

To correctly determine whether a glycovariant had an effect on ADCC activity, the top and EC50

values were examined for all trials. A dose response curve was created for each trial along with a table that showed raw values. The GnGn glycovariant was examined closely as this was the hypothesized glycovariant. As mentioned before, the other glycovariants will be discussed as a comparison to the GnGn glycovariant to accurately depict the effects.

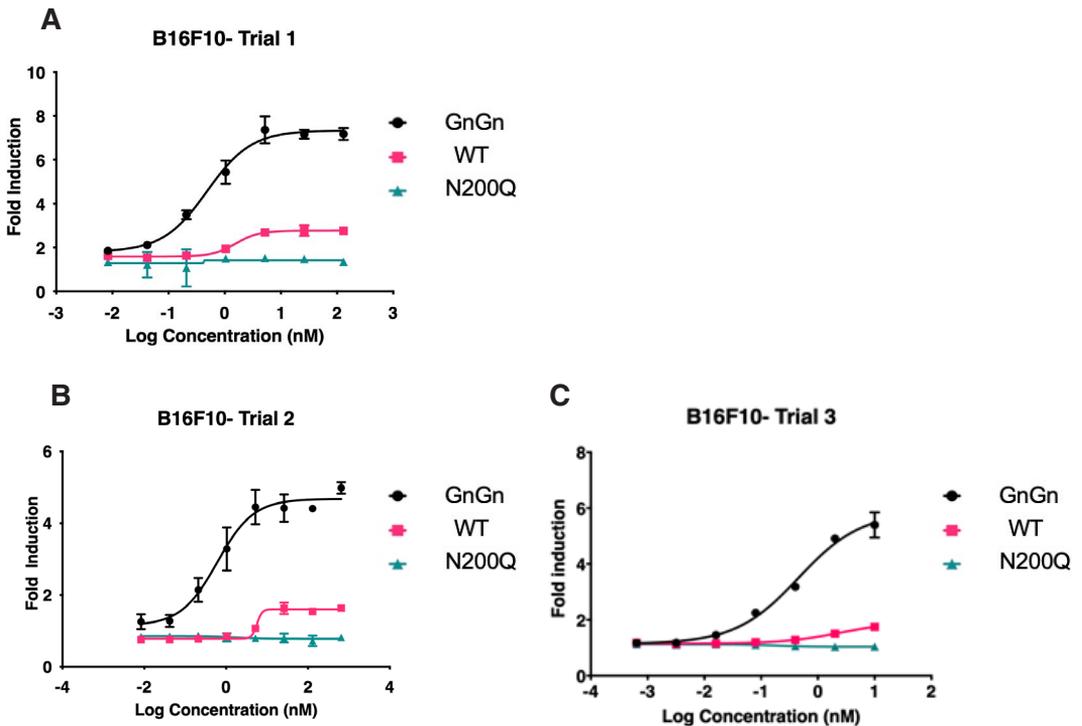


Figure 5. "Glycovariants of ManC-lectibody induce ADCC on B16F10 (melanoma) cancer cells."

(A) The GnGn glycovariant of ManC-lectibody reaches the highest peak for fold induction at a value of 7.335 for Trial 1. (B) Trial 2 indicates that the GnGn glycovariant has a higher Fc receptor activation as this version is able to induce ADCC with maximal effects at low concentrations. (C) Both the WT and N200Q (NQ) glycovariants fail to reach a fold induction peak beyond 4, depicting that they minimally activate the Fc receptor. *The NQ glycovariant did not elicit a strong enough effect; therefore, the EC50 value could not be calculated.

Table 1. Top Values of Glycovariants for B16F10 Cell Line (Melanoma cancer cells)

Trials	GnGn	WT	NQ
1	7.335	2.767	1.419
2	4.677	1.603	0.856
3	5.854	1.918	1.121

Figure 5 illustrates the dose response curve for each glycovariant on the B16F10 cell line, with Trial 1 showing the most efficacy. Although the GnGn glycovariant is the most efficacious in inducing ADCC on the B16F10 cell line, this does not mean the glycovariant is capable of mediating cell cytotoxicity by directly acting on carcinoma. However, it does provide insight that the GnGn glycovariant activates the Fc receptor, meaning that there is ADCC activity within the system. This supports the hypothesis that the GnGn glycovariant will increase ADCC activity by activating the Fc receptor. Collectively, the B16F10 cell line does prove that the glycovariants of ManC-lectibody can elicit Fc-mediated cytotoxicity via the effector cells but the drug is the most effective when it has a glycosylation modification.

The EC50 values of all glycovariants for the B16F10 cell line deviates significantly from the other cell lines. The cause of this behavior is unknown and would be a future topic of interest. For the GnGn glycovariant, the average EC50 value was 0.514. With regard to ADCC, this means that at a concentration of 0.514 nM, the glycovariant can produce half of the highest level of signaling. When compared to the other glycovariants, the GnGn version had a relatively low EC50 value, meaning that it was highly potent, since an EC50 value measures potency. This is important because many pharmaceutical drugs are highly potent, which make them effective at their function. While the WT glycovariant also has a relatively low EC50 value, it was not as strong as the GnGn glycovariant as indicated by the lower top value amount (Table 1).

Table 2. EC50 Values of Glycovariants for B16F10 Cell Line (Melanoma cancer cells)

Trials	GnGn	WT	NQ
1	0.485	1.550	N/A*
2	0.605	5.683	N/A
3	0.453	2.412	N/A

The data above suggests that the LLC cell line had a slight increase in the top values and a significant increase in the EC50 values when compared to the B16F10 cell line. This could be taken under the assumption that the glycovariants have different effects when in contact with different cell lines. This could possibly be because of the varied expression of HMGs on each cancer cell or different glycans being produced from the cell. Stowell, Ju, and Cummings found that “protein glycosylation varied from cell line to cell line” and that one specific sugar alteration marked each cell line²². Additionally, they mentioned that diseased cells rarely produce other glycans, implying that the drug enacts differently on different cell lines²². Given this, glycovariants of the drug should specifically target one cell line that expresses HMGs consistently and makes the drug highly potent. The GnGn glycovariant had the highest efficacy in Trial 2 (see Figure 6B and Table 3) but was highly potent in Trial 1. The EC50 value did deviate from Trials 2 and 3, indicating that it could be a data outlier. But the findings stay consistent with the research question and prove again that the GnGn glycovariant increased ADCC activity. Dr. Matoba’s team has tested an existing lung cancer drug known as Cetuximab and compared its ADCC activity to the WT version of the drug. Though the data is unpublished, they concluded that the WT version of the drug induces ADCC with a higher efficacy and potency compared to Cetuximab. Since the GnGn glycovariant is more effective than the WT version, the GnGn glycovariant could easily serve as a better targeted therapy.

GLYCOVARIANTS OF MANC-LECTIBODY AND THEIR EFFECTS ON ADCC ACTIVITY

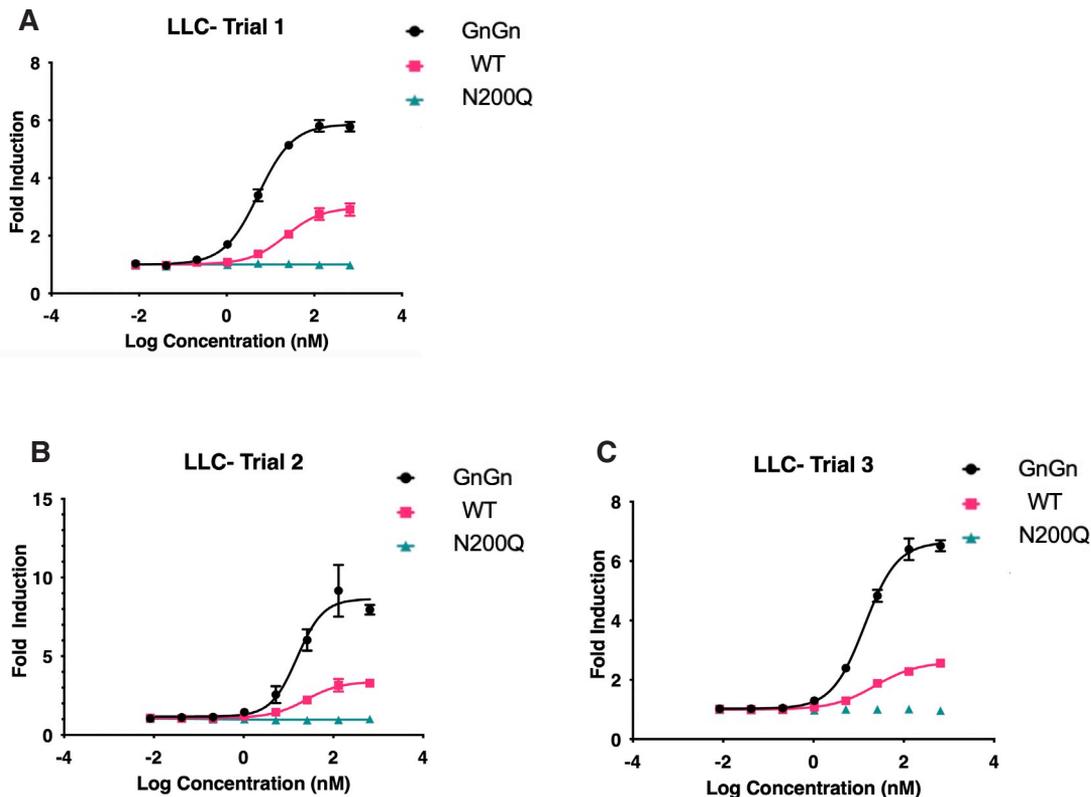


Figure 6. “Glycovariants of ManC-lectibody induce ADCC on LLC (lung) cancer cells.”

(A) The GnGn glycovariant when introduced to the LLC cell line shows a similar dose response when compared to the GnGn glycovariant from the B16F10 cell line. (B) Trial 2 shows the GnGn glycovariant when it is the most efficacious at inducing ADCC via Fc receptor activation. (C) The WT does not show any potency or efficacy, implying how the removal of an essential sugar negatively affects the immune-mediated mechanism of the drug.

Table 3. Top Values of Glycovariants for LLC Cell Line (Lung cancer cells)

Trials	GnGn	WT	NQ
1	5.865	2.978	1.003
2	8.640	3.384	1.035
3	6.644	2.606	1.000

Table 4. EC50 Values of Glycovariants for LLC Cell Line (Lung cancer cells)

Trials	GnGn	WT	NQ
1	5.301	22.310	0
2	15.480	24.650	0
3	15.590	23.410	0

GLYCOVARIANTS OF MANC-LECTIBODY AND THEIR EFFECTS ON ADCC ACTIVITY

Table 5. Top Values of Glycovariants for ID8 Cell Line (Ovarian cancer cells)

Trials	GnGn	WT	NQ
1	4.876	2.878	0.984
2	5.208	2.801	1.064
3	4.940	1.665	1.091

Table 6. EC50 Values of Glycovariants for ID8 Cell Line (Ovarian cancer cells)

Trials	GnGn	WT	NQ
1	8.266	28.000	0
2	6.412	32.640	0
3	16.000	21.580	0

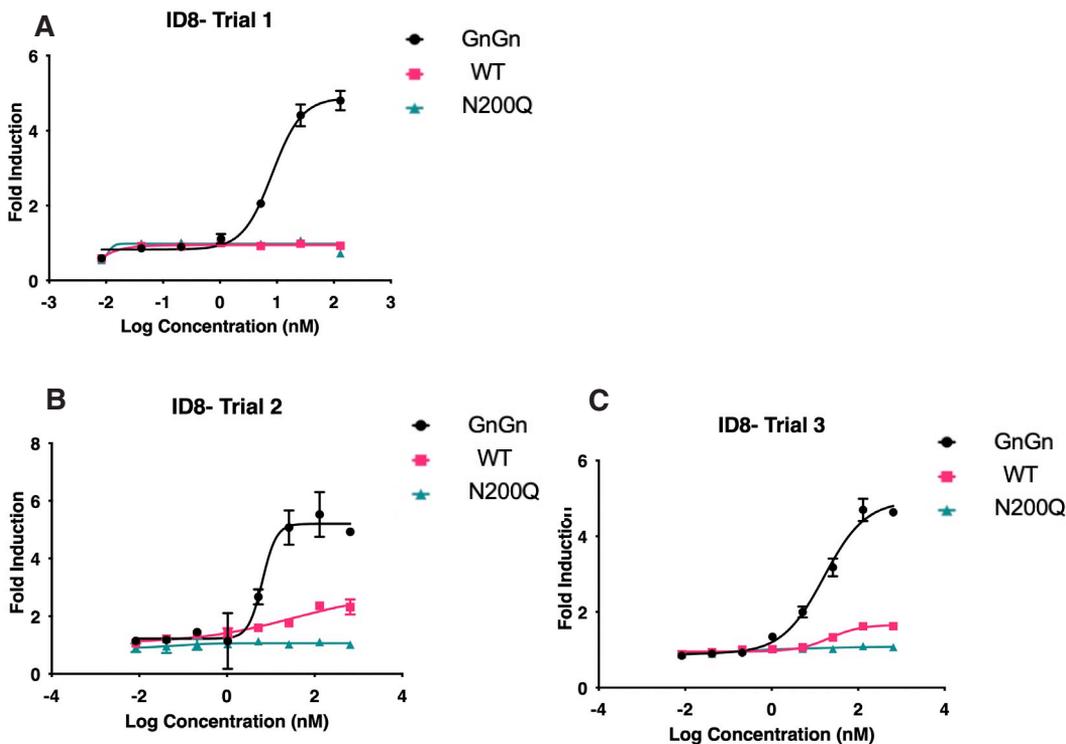


Figure 7. “Glycovariants of ManC-lectibody induce ADCC on ID8 (ovarian) cancer cells.

(A) Trial 1 shows no ADCC induction from the WT and NQ glycovariant as well as a relatively low ADCC induction for the GnGn glycovariant. (B) The WT glycovariant produces no curve to accurately portray the dose response. (C) There is a strong variation of EC50 values for the ID8 cell line, with Trial 3 having an EC50 value of 16.00. This may mean that the drug functions differently when in contact with ovarian cancer cells.

Table 7. Two-way ANOVA Test for Top Values

Source of Variation	% of Total Variation	P value	Significant?
Interaction	3.124	0.1542	No
Cell Line	2.678	0.0620	No
Treatment	86.80	<0.0001	Yes

Table 8. Two-way ANOVA Test for EC50 Values

Source of Variation	% of Total Variation	P value	Significant?
Interaction	8.415	0.0229	Yes
Cell Line	55.48	<0.0001	Yes
Treatment	26.49	<0.0001	Yes

As shown in Table 5, the highest top value recorded for the ID8 cell line was 5.208. This value is slightly less than both the LLC and B16F10 cell lines, indicating that the GnGn glycovariant minimally induced ADCC activity in ovarian cancer. However, this seems to be a data error because in Dr. Matoba’s research, they found that ovarian tissue is overly expressed with HMGS⁹. In theory, the drug should display the highest ADCC activity when in an environment of ovarian cancer cells. However, this was not the case as it had the lowest efficacy among the three cell lines. Human error when pipetting and transferring could account for this difference. It is possible that the type of ovarian cell line used could have altered the data. Furthermore, the EC50 value slightly increased but was not consistent among the three trials. These trends can be attributed to the glycovariants as they could have affected the transmittance of signals. They could also be a result of effector cell dysfunction, meaning that the Jurkat T cell line could not kill the carcinoma. When objectively looking at the data, there seems to be increased ADCC activity with the GnGn glycovariant, which supports the hypothesis. However, this behavior of the glycovariant will be an aspect of future research.

Statistical Analysis

A two-way ANOVA test was done to statistically compare the effects of each glycovariant across all cell lines. The ANOVA test consisted of two variables: the glycovariant and the cell line. Using a two-way ANOVA test, one can determine the source of variation in the experiment to establish where the effects may come from. A P value was calculated for each glycovariant and this P value was compared to the biological P value of 0.05. This helped determine whether or not the glycovariant had a significant effect. An ANOVA test was done for both the top value and the EC50 value. The GnGn glycovariant was specifically examined as this was the hypothesized glycovariant. The ANOVA results for the top values of each glycovariant are shown in Table 7 and display four main components: percent of total variation, P value, P value summary (compares calculated P value to 0.05), and significance. If the calculated P value is less than 0.05, then the glycovariant’s effect is significant. As listed in Table 7, there was about 2.7% variation from the cell line and about 87% variation from the glycovariant, indicating that each glycovariant causes the varying effects rather than the cell line. This was expected as the glycovariants should induce an effect on the various cell lines. The calculated P value for the cell line part of the ANOVA test was 0.062, which

makes this variable not significant whereas the calculated P value for the glycovariant part was less than 0.0001. This means that the different glycovariants are significant and show statistical difference, which was also expected. Furthermore, a multiple comparisons table was created to show all the possible combinations of glycovariants and lists their mean difference, P value, and whether or not they were statistically different. All GnGn glycovariants, when compared to the WT and NQ glycovariants, had P values less than 0.05, therefore meaning that the GnGn glycovariant was statistically different and had achieved in increasing ADCC activity.

When examining the EC50 ANOVA test, only the GnGn and WT glycovariants were compared as the NQ was not potent enough to produce an EC50 value. The percent of total variation for the cell line was about 55.5% while the glycovariant percentage was about 26.5%, which differed from the previous ANOVA test (see Table 8). Given this, the source of variation for the EC50 values could be dependent on the cell line rather than the treatment as seen in the top values ANOVA test. It was assumed that the EC50 value of each treatment should be similar across any cell line; however, the EC50 value recorded in the first trial of the B16F10 cell line shows deviation. Both the cell line and treatment variables resulted in P values that were significantly less than 0.05, showing that the EC50 values were statistically significant. The GnGn treatment was statistically significant against the WT treatment in all cell lines except the B16F10 cell line, implying that the GnGn treatment induces a different effect in melanoma cancer cells.

Conclusion

ManC-lectibody is an engineered molecule capable of selectively targeting diseased cells. This form of targeted therapy mitigates detrimental side effects to the human body while also enhancing the immune system to fight against foreign molecules. Dr. Matoba and his team have proved that ManC-lectibody induces ADCC and that the “mechanism of action of ManC-lectibody is mostly immune-mediated.” Dr. Matoba’s research surrounded the standard version of the drug, which had no alterations. This research serves to fill a gap in the existing body of knowledge by modify-

ing ManC-lectibody to potentially enhance its function of inducing ADCC. Earlier research suggested that altering the glycosylation site in the Fc region of an antibody changes the structure of the antibody, thereby changing its function⁸. Based on this information, three glycovariants of the drug were created that specifically changed the Fc region of ManC-lectibody: the GnGn, WT, and N200Q. It was hypothesized that the GnGn glycovariant would increase Fc receptor activation which would simultaneously increase ADCC activity. Using an ADCC reporter assay, this research was able to prove that the GnGn glycovariant of the drug increases ADCC activity when in contact with melanoma, lung, and ovarian mouse cancer cell lines.

Since the drug is still in testing phases, it is important to understand the data accurately. Though the GnGn glycovariant increases ADCC activity, it varies across cell lines. Additionally, the data shows inconsistencies with the EC50 values, suggesting further testing on certain cell lines. Despite these technical issues, the glycovariants add to the gap in the existing knowledge about ManC-lectibody and serve as the first modifications made to the drug.

The novelty of this study is that it is the first to enhance ManC-lectibody’s function as an immunotherapeutic drug. Although the gap in the research is specific to improving ManC-lectibody’s function, it can be applied to a bigger gap of finding a way to facilitate the production and implementation of pharmaceutical drugs. Many drugs are not applicable for large-scale manufacturing. However, the production of the drug is “rapid and scalable [through a] plant-based transient overexpression system⁹.” Perhaps the most notable gap that ManC-lectibody fills is the fact that if approved by the Federal Drug Administration (FDA), it will serve as the first-in-class immunotherapeutic drug to selectively target HMGs. Because of this, it is vital that the most effective version of the drug is created. With this research, the GnGn glycovariant surpasses the standard drug and has an enhanced function in inducing ADCC, serving as the primary contender for approval.

Limitations

Since ManC-lectibody is still in testing phases, it is important to consistently get accurate results. In

this research, there was some human error as well as data outliers that negatively impacted the data. Additionally, the glycovariants produced different trends among the data, which sparked new understandings about the behavior and function of the modified drug. Another concern is that the drug may perform differently during in vivo tests. Although the primary use of mouse-derived cancer cell lines was to mitigate this, the in vivo tests could have some error that would impact the current knowledge about the drug. Finally, this study only examined the glycovariants effects on ID8, LLC, and B16F10 mouse cell lines and not human cell lines. The glycovariants could induce a different effect on human cancer cells, which could either hinder or improve ManC-lectibody's function.

Future Directions

The glycovariants of ManC-lectibody will be tested on immunocompetent mice through an in vivo study to better simulate an immune system environment. Furthermore, the EC50 variation that occurred would be further studied to see if the cause of this variation is the glycovariants or human error. This is specific to the B16F10 cell line as the GnGn glycovariant had the most EC50 deviation on melanoma cancer cells. In addition, other types of ADCC assays will be performed on the glycovariant to examine other aspects of the modified drug. Most importantly, however,

ManC-lectibody will be researched on its ability to selectively target Covid-19 as this virus has HMG-type glycans that coat its shell[23]. ManC-lectibody has been tested on the SARS-CoV virus, which is similar to the novel Covid-19 virus, and Dr. Matoba's team have found that it is unable to neutralize the virus, meaning that ManC-lectibody cannot prevent the virus from spreading. However, no research exists on ManC-lectibody's ability to induce ADCC on infected cells to possibly kill the cells before the virus reproduces and spreads (See Figure 8).

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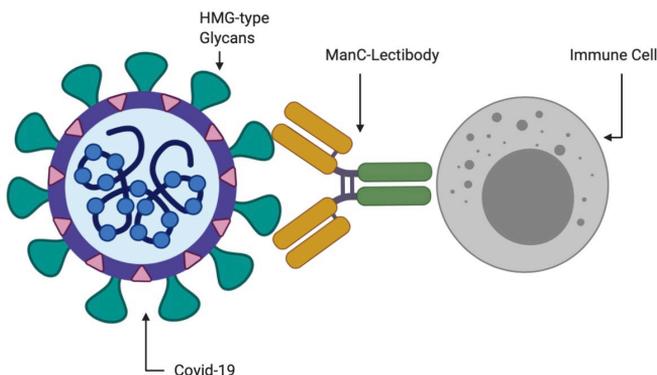


Figure 8. “Glycovariants of ManC-lectibody against Covid-19 using ADCC”

ManC-lectibody has the potential to induce ADCC on infected cells. The spike proteins that stem out of the Covid-19 virus are glycoproteins that contain oligomannose-type glycans, or HMG-type glycans. Since ManC-lectibody is selective to HMGs, it could possibly target the virus and act as an immune-mediated drug to kill infected cells.

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Seasonality in Equities Traded on the Toronto Stock Exchange Between 1980 and 2019

Nick Woollcombe

This study investigates the day-of-the-week and month-of-the-year effects for equities traded on the Toronto Stock Exchange (TSX) between January 1, 1980, and December 31, 2019. As a conduit for the average price of stocks traded on the exchange, the S&P/TSX Composite Index (INDEXTSI:OSPTX) is used. The findings show that for the day-of-the-week effect, Mondays have underperformed while Fridays have overperformed. It is found that the day-of-the-week effect is present on the Toronto Stock Exchange at the 95th confidence level. Conversely, month-of-the-year effects are inconclusive; only one of three tests support the existence of the anomaly. Historical analysis shows that a \$100.00 investment in the S&P/TSX Composite Index would have grown to \$888.69 from January 1, 1980, to December 31, 2019, in a simple buy-and-hold strategy. However, if an investor had adopted this paper's findings, they would have turned that same \$100.00 investment into \$3,444.49.

Keywords: Market anomalies, Toronto Stock Exchange, Day-of-the-week effect, Month-of-the-year effect, Market efficiency

Introduction

Security exchanges are based on the premise that they will efficiently facilitate capital formation and distribution. For transactions to occur, academics have hypothesized that the efficient market hypothesis (EMH) means security prices will reflect only and all relevant information so that assets will reside at their intrinsic, or true, value (Dzhabarov & Ziemba, 2010.) Anomalies are predictable fluctuations that affect this hypothesis. Recently, seasonal anomalies have gained attention for playing a significant role in how security prices are determined. Seasonality is a time series characteristic in which asset prices follow a predictable pattern of movement; these fluctuations can oc-

cur over a variety of periods, from hours to years.

Historically, researchers have directed their studies at examining the January and day-of-the-week effects. In the United States of America, Aggarwal and Rivoli (1989), Cross (1973), and Keim and Stambaugh (1984) found evidence to support the theory that returns vary according to the day-of-the-week. However, the effect is not limited to US equities; researchers have documented the pattern in numerous foreign exchanges (Kuria & Riro, 2013; Kamstra, Kramer, & Levi, 2001; Jaffe & Westerfield, 1985). Additionally, seasonality patterns have been found in different types of financial securities, including bonds and Treasury bills (Cornell, 1985; Dyl & Maberly, 1986).

Compared to the rest of the world, there has been very little recent research on seasonality in Canada's

largest financial market, the Toronto Stock Exchange (TSX). Cadsby (1989) found the turn-of-the-year, turn-of-the-month, and October effects to be present in Canadian markets; however, he only studied data until December 31, 1987. Athanassakos and Robinson (2004) found evidence to support the adage “sell in May and go away; come back on St. Leger’s day,” but he only studied months that coincided with the proverb, at data until 2003, and did not examine the market for the day-of-the-week effect.

There are countless types of assets that investors can buy to maximize returns, ranging from bonds to livestock. Still, this study examines seasonality patterns in the market for stocks, also known as equities – a type of security that represents fractional ownership in a company. The research methodology is based on the numerous previous studies of seasonality in equity markets. Specifically, the research methodology is derived from that of Kuria and Riro (2013), who studied seasonal anomalies in the Nairobi Security Exchange, and Rahman (2009), who studied the day-of-the-week effect in the Dhaka Stock Exchange. The S&P/TSX Composite Index (INDEXTSI: OSPTX) is used to represent the price of equities traded on the Toronto Stock Exchange. Made up of around 250 of the 1,500 companies listed on the exchange, the S&P/TSX Composite Index represents over 70% of the market capitalization. Using t-tests and analysis of variance (ANOVA) models, data is analyzed from Yahoo! Finance from January 1, 1980, until December 31, 2019, in search of

- a day-of-the-week effect. This effect would see a certain day(s) over- or underperform; or
- a month-of-the-year effect. This effect would see a certain month(s) over- or underperform.

Every investor’s goal is to outperform the stock market; to accomplish this, they need to select assets that will give them a higher return than the exchange. When investors fail to beat the market, they have underperformed. This study aims to gain a greater insight into the effect that seasonal anomalies play in the pricing of equities in the Toronto Stock Exchange. Additionally, this paper seeks to comprehend the impact of these patterns and, consequently, evaluate the TSX’s efficiency. Investment professionals can use the findings of the study as they attempt to maximize economic gains.

Literature Review

Seasonality in financial markets was first proposed by Wachtel (1942) when he found that stock market gains in January were above the monthly average. Since then, researchers have uncovered numerous different types of seasonality in financial markets, including correlations between stock price returns and the day-of-the-month, proximity to holidays, and time of day (Aly, Mehdian, & Perry, 2004; Kuria & Riro, 2013; Dzhabarov and Ziemba, 2010). Nevertheless, this paper will focus on day-of-the-week and month-of-the-year anomalies.

Day-of-the-Week Effect

While anomalies relating to a specific day(s) of the week have not been studied as carefully as monthly anomalies, researchers have repeatedly found a relationship between the day-of-the-week and market returns. In a study of seasonality across eighteen countries, Agrawal and Tandon (1994) found evidence of the weekend effect – a sequence that sees Friday overperform and Monday underperform – in nine of the regions. In a study of developing country’s markets, Chan, Hui, and Wong (1992) found negative mean returns on Monday and Thursday, but strong positive returns on Friday. In non-Westernized countries, researchers have also studied markets for evidence of day-of-the-week effect irregularities. In Saudi Arabia, Abalala and Sollis (2015) found the opposite of the typical North American and European conclusion – they discovered that Saturday, the first day of the week, usually overperforms. However, not all studies have found conclusive evidence of the pattern; Keef and Roush (2007), when researching the S&P 500 Index, found no evidence of the weekend effect.

Month-of-the-Year Effect

Generally, previous research on month-of-the-year anomalies focused on either the January effect or the “sell in May and go away” hypothesis.

Investors commonly use the phrase “sell in May and go away,” originating from the English saying, “sell in May and go away, and come on back on St.

Leger's Day," to describe seasonal investment returns. The adage would see investors sell their investments in May and hold cash during the summer months before reinvesting on St. Leger's Day, a horse race in England during September (Dzhubarov & Ziemba, 2016). When Dzhubarov & Ziemba (2016) tested the theory on the S&P 500 Index (INDEXSP: .INX), they found that a strategy based on the proverb returned close to twice the average gains compared to a full year buy-and-hold strategy. Specifically, Dzhubarov and Ziemba (2016) found that between 1993 and 2015, a full year buy-and-hold strategy would have turned \$1.00 into \$3.05, while an investor who held cash from May until September would have turned the same investment into \$5.77, an 89% difference. Likewise, Jacobsen and Bouman (1998), in a global study of 37 countries, found that investors who follow the maxim outperformed the benchmark index.

However, the "sell in May and go away" adage is not the only set of monthly anomalies; researchers have consistently found that certain months outperform others. Bentzen (2009), in a cross-section study of the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ), found January returns to be significantly higher than other months. Aptly named the January effect, Dzhubarov and Ziemba (2010), Watchel (1942), and Heston and Sadka (2008) confirmed the result of Bentzen (2009) with differing methods. The January effect is also found in international markets, but with varying degrees of certainty. Lucey and Whelan (2002), when studying the Irish stock market, documented the January irregularity and evidence of peak returns in April. In Japan, Kato and Schallheim (1985) found that the market peaked in January, while in China, Mookerjee and Yu (1999) found that maximum returns took place one month later, in February.

Canada

Compared to the rest of the world, there has been very little recent research on seasonal anomalies on the Toronto Stock Exchange. When researching month-of-the-year patterns, Tinic, Barone-Adesi, and West (1987) found the January effect to be present in Canadian markets, but only studied data up to 1985. As for

the day-of-the-week effect, Cadsby (1989) found there to be turn-of-the-year, turn-of-the-month, and October effects in the market, but only studied data up to 1982. Similarly, Athanassakos and Robinson (2004), when examining data from 1975 to 1989, found that returns on Monday overperformed the rest of the week. Overall, there has been inadequate research on seasonality in the Toronto Stock Exchange – all of the past studies have focused on Canada as a whole, used outdated data, or found inconclusive results.

Methods

This study aims to determine if there is a day-of-the-week or month-of-the-year effect in equities traded on the Toronto Stock Exchange between January 1, 1980, and December 31, 2019. The methodology is adopted from the work of Rahman (2009), who studied the day-of-the-week effect on the Dhaka Stock Exchange, and Kuria and Riro (2013), who studied seasonal anomalies on the Nairobi Security Exchange. Similar to Rahman (2009) and Kuria and Riro (2013), an index is used as a conduit for the average market price. Closing price data is collected on the S&P/TSX Composite Index from January 1, 1990, to December 31, 2019, using Yahoo! Finance. The S&P/TSX Composite Index is made up of around 250 of the 1,500 companies listed on the exchange and represents over 70% of the market capitalization of the Toronto Stock Exchange.

The daily return of the index is calculated using the following formula for each day over the 39 years:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$

Where R_t represents the return of the index on day t , P_t refers to the price of the index on day t , and $P_{(t-1)}$ refers to the price of the index on the previous day.

To begin to determine whether the day-of-the-week and month-of-the-year effects are present in the market, each weekday is tested to determine whether the performance is statistically significant. Essentially, this one-sample t-test establishes whether each day/month will reliably deliver positive or negative re-

SEASONALITY IN EQUITIES TRADED ON THE TSX

turns. For this analysis, the following hypotheses are formulated:

$$H_0: \mu = 0$$

$$H_a: \mu \neq 0$$

Where μ represents the population mean return of the index on each weekday/month. To find the t-statistic, the following formula is used:

$$t = \frac{\bar{x} - \mu}{s_{\bar{x}}}$$

Where \bar{x} represents the mean return of the index on each weekday/month, μ refers to the hypothesized mean (in this case, 0), and $s_{\bar{x}}$ refers to the sample's standard error. The standard error ($s_{\bar{x}}$) is found with the following formula:

$$s_{\bar{x}} = \frac{s}{\sqrt{n}}$$

Where s refers to the sample's standard deviation and n refers to the sample size.

Next, a two-sample t-test is used to test whether the average return between two sequential days/months is statistically significant. This test determines if two consecutive days'/months' returns have unequal means and are statistically dependent. For this analysis, the following hypotheses are formulated:

$$H_0: \mu_1 - \mu_2 = 0$$

$$H_a: \mu_1 - \mu_2 \neq 0$$

Where μ_1 represents the population mean return of the index on a day/month and μ_2 represents the population mean return of the index on the following day/month. For instance, when testing for the day-of-the-week effect, if μ_1 represents Monday, μ_2 would represent Tuesday. When testing for the month-of-the-year

effect, if μ_1 represents January, μ_2 would represent February. To find the t-statistic, the following formula is used:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{SD_1^2}{n_1} + \frac{SD_2^2}{n_2}}}$$

Where \bar{x}_1 refers to the mean return of the index on day/month one, \bar{x}_2 refers to the mean return of the index on day/month two, SD_1^2 refers to the standard deviation of day/month one's performance, SD_2^2 refers to the standard deviation of day/month two's performance, n_1 refers to the sample size of day/month one, and n_2 refers to the sample size of day/month two.

Then, a single-factor analysis of variance is used to test whether the mean return of each of the days/months is statistically equal. Essentially, this test determines whether any days/months will reliably underperform or overperform. When testing for the day-of-the-week effect, the following hypotheses are formulated:

$$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$$

$$H_a: \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5$$

Alternatively, when testing for the month-of-the-year effect, the following hypotheses are formulated:

$$H_0: \mu_1 = \mu_2 = \mu_3 = \dots = \mu_{10} = \mu_{11} = \mu_{12}$$

$$H_a: \mu_1 \neq \mu_2 \neq \mu_3 \neq \dots \neq \mu_{10} \neq \mu_{11} \neq \mu_{12}$$

Where $\mu_1, \mu_2, \mu_3 \dots \mu_n$ represents the mean return of the index on each day/month. For instance, when testing for the day-of-the-week effect, μ_1 represents Monday, μ_2 represents Tuesday, and μ_3 represents Wednesday. When testing for the month-of-the-year effect, μ_1 represents January, μ_2 represents February, and μ_3 represents March.

To calculate the F-statistic, the following formula is used:

$$F = \frac{\frac{BSS}{df_B}}{\frac{WSS}{df_W}}$$

Where *BSS* refers to the sum of standard deviations between groups, *WSS* refers to the sum of standard deviations within groups, *df_B* refers to the degrees of freedom between groups, and *df_W* refers to the degrees of freedom within groups. *BSS* is calculated with the following formula:

$$BSS = n_1(\bar{x}_1 - \bar{x})^2 + n_2(\bar{x}_2 - \bar{x})^2 + n_3(\bar{x}_3 - \bar{x})^2 + \dots + n_n(\bar{x}_n - \bar{x})^2$$

Where *n₁*, *n₂*, *n₃* ... *n_n* refers to sample size of each day/month, $\bar{x}_1, \bar{x}_2, \bar{x}_3, \dots, \bar{x}_n$ refers to the average return of each day/month, and \bar{x} refers to the sample mean. *WSS* is calculated with the following formula:

$$WSS = (n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2 + (n_3 - 1)SD_3^2 + \dots + (n_n - 1)SD_n^2$$

Where *n₁*, *n₂*, *n₃* ... *n_n* refers to sample size of each day/month and *SD₁²*, *SD₂²*, *SD₃²* ... *SD_n²* refers to the standard deviation in returns for each day/month.

Findings

Day-of-the-Week Effect

Table I shows the result of the one-sample t-test for the day-of-the-week effect and summary statistics for each day. Across the 39 years, Friday overperformed the most with a mean return of 0.063% per day, while Monday underperformed the most with a mean return of -0.047%. The one-sample t-test determines that the mean return of each day is statistically significant; if a day is significant, the null hypothesis is rejected, and it can be inferred that the variance in return is not random. The p-value for each of the days is calculated, such that Monday (0.045), Wednesday (0.020), and Friday (0.001) are significant at the 95th confidence interval. Therefore, for these three days, the null hypothesis is rejected. This result provides evidence for the existence of the day-of-the-week effect, as some days repeatedly over- or underperform.

Table II shows the result of the two-sample t-test for the day-of-the-week effect. The test aims to determine if the mean return of two consecutive days is statistically significant; if a set of days are significant, the null hypothesis is rejected, and the variance in return is not random. The p-value for each of the pairs is such that Monday-Tuesday (0.007) and Friday-Monday (0.0003) are significant at the 95th confidence interval. Therefore, for these two pairs, the null hypothesis is rejected. This result provides further evidence for the existence of the day-of-the-week effect, as Monday to Tuesday, and Friday to Monday have unequal means and are statistically dependent.

Table I: One-Sample t-Test for the Day-of-the-Week Effect

	Summary Statistics			Results	
	Obs. (#)	Avg. Return (%)	SD (%)	t-value	p-value
Monday	1909	(0.04703)	1.02295	2.00879	0.04470
Tuesday	2016	0.03731	0.94406	1.77460	0.07611
Wednesday	2062	0.04797	0.93245	2.33591	0.01959
Thursday	2055	0.02735	0.92528	1.33977	0.18047
Friday	2012	0.06267	0.85429	3.29038	0.00102

SEASONALITY IN EQUITIES TRADED ON THE TSX

Table II: Two-Sample t-Test of Sequential Days for the Day-of-the-Week Effect

	Summary Statistics			Results	
	Obs. (#)	Avg. Return (%)	SD (%)	t-value	p-value
Monday	1909	(0.04703)	1.02295	2.68603	0.00726
Tuesday	2016	0.03731	0.94406		
Tuesday	2016	0.03731	0.94406	0.36276	0.71680
Wednesday	2062	0.04797	0.93245		
Wednesday	2062	0.04797	0.93245	0.71218	0.47639
Thursday	2055	0.02735	0.92528		
Thursday	2055	0.02735	0.92528	1.26413	0.20626
Friday	2012	0.06267	0.85429		
Friday	2012	0.06267	0.85429	3.65182	0.00026
Monday	1909	(0.04703)	1.02295		

Table III shows the result of the analysis of variance for the day-of-the-week effect. As the F value (4.032) is higher than the F critical value (2.373), the null hypothesis is rejected, and it is concluded that the months deliver statistically different returns. The test provides even more evidence for the existence of the day-of-the-week effect.

Month-of-the-Year Effect

Table IV shows the result of the one-sample t-test for the month-of-the-year effect, as well as summary statistics for each month. Across the 39 years, May outperformed the most with a mean return of 0.054% per day, while September underperformed the most with a mean return of -0.071% per day. Next, a one-sample t-test is run to determine if the mean return of

each month is statistically significant; if a month is significant, the null hypothesis is rejected, and it can be inferred that the variance in return was not random. The p-value for each of the months is calculated, such that May (0.047), September (0.039), and December (0.020) are significant at the 95th confidence interval. Therefore, for these three months, the null hypothesis is rejected. This result provides evidence for the existence of the month-of-the-year effect, as some months repeatedly over- or underperform.

Table III: ANOVA for the Day-of-the-Week Effect

Source of Variation	SS	df	MS	F	p-value	F crit
Between Groups	0.00141	4	0.00035	4.03211	0.00287	2.37282
Within Groups	0.88106	10049	0.00009			
Total	0.88248	10053				

SEASONALITY IN EQUITIES TRADED ON THE TSX

Table IV: One-Sample t-Test for the Month-of-the-Year Effect

	Summary Statistics			Results	
	Obs. (#)	Avg. Return (%)	SD (%)	t-value	p-value
January	828	0.05103	0.94811	1.54871	0.12184
February	785	0.04664	0.85332	1.53137	0.12608
March	872	0.02570	0.93120	0.81508	0.41525
April	807	0.04752	0.81278	1.66100	0.09710
May	861	0.05449	0.80312	1.99070	0.04683
June	856	(0.01598)	0.78029	0.59930	0.54913
July	873	0.03785	0.76743	1.45727	0.14540
August	871	0.01620	0.85419	0.55981	0.57575
September	790	(0.07127)	0.97011	2.06489	0.03926
October	873	0.00060	1.41607	0.01258	0.98997
November	839	0.05020	0.99172	1.46625	0.14296
December	811	0.07471	0.90931	2.33978	0.01954

Table V shows the result of the two-sample t-test for the month-of-the-year effect. The test aims to determine if the mean return of two consecutive months is statistically significant; if a set of months are significant, the null hypothesis is rejected, and the variance in return is not random. The p-value for each of the pairs is calculated, but although there are some close pairs, at the 95th confidence interval, none are significant. Therefore, for all of the sets, the null hypothesis was not rejected. This result provides evidence that there is no month-of-the-year effect in the market, weakening the findings found in Table IV.

SEASONALITY IN EQUITIES TRADED ON THE TSX

Table V: Two-Sample t-Test of Sequential Months for the Month-of-the-Year Effect

	Summary Statistics			Results	
	Obs. (#)	Avg. Return (%)	SD (%)	t-value	p-value
January	828	0.05103	0.94811	0.09753	0.92232
February	785	0.04664	0.85332		
February	785	0.04664	0.85332	0.47539	0.63457
March	872	0.02570	0.93120	0.50978	0.61027
March	872	0.02570	0.93120		
April	807	0.04752	0.81278	0.17590	0.86039
April	807	0.04752	0.81278		
May	861	0.05449	0.80312	1.84384	0.06538
May	861	0.05449	0.80312		
June	856	(0.01598)	0.78029	1.44630	0.14828
June	856	(0.01598)	0.78029		
July	873	0.03785	0.76743	0.55673	0.57778
July	873	0.03785	0.76743		
August	871	0.01620	0.85419	1.95395	0.05088
August	871	0.01620	0.85419		
September	790	(0.07127)	0.97011	1.19515	0.23220
September	790	(0.07127)	0.97011		
October	873	0.00060	1.41607	0.83638	0.40306
October	873	0.00060	1.41607		
November	839	0.05020	0.99172	0.52272	0.60124
November	839	0.05020	0.99172		
December	811	0.07471	0.90931	0.51590	0.60599
December	811	0.07471	0.90931		
January	828	0.05103	0.94811		

SEASONALITY IN EQUITIES TRADED ON THE TSX

Table VI: ANOVA for the Month-of-the-Year Effect

Source of Variation	SS	df	MS	F	p-value	F crit
Between Groups	0.00141	11	0.00013	1.46179	0.13841	1.7896
Within Groups	0.88107	10054	0.00009			
Total	0.88248	10065				

Table VI shows the result of the analysis of variance run on the month-of-the-year effect. As the F value (1.462) is less than the critical F value (1.790), the null hypothesis is not rejected, and it is concluded that the months deliver statistically equal returns. The test provides further evidence against the month-of-the-year anomaly, additionally weakening the conclusion found in Table IV.

Discussion

Throughout this study, there are two main conclusions drawn about the day-of-the-week and month-of-the-year effects.

Day-of-the-Week Effect

The most significant conclusion drawn is the existence of the day-of-the-week effect. The one-sample t-test, two-sample t-test, and analysis of variance all reject the null hypothesis, establishing evidence for the existence of the day-of-the-week effect. Friday overperforms the most with a mean return of 0.063% per day, while Monday underperforms the most with

a mean return of -0.047%. This result is in line with other researchers' findings on different exchanges; almost all studies in the Western world have found that Monday underperforms while Friday overperforms the weekly average (Theobald & Prince, 1984; Board & Sutcliffe, 1988; Tang and Kwok, 1997; Smirlock & Starks, 1986).

Month-of-the-Year Effect

In examining data for the month-of-the-year effect, three different tests are run. First, a one-sample t-test is conducted to determine if any days' returns consistently over- or underperform the market. This test rejects the null hypothesis – it found that at the 95th confidence interval, May, September, and December are statistically significant. However, the two-sample t-test and analysis of variance both did not reject the null hypothesis. In both of these cases, the null hypothesis would indicate that the month-of-the-year effect does not exist on the Toronto Stock Exchange. Therefore, this study draws inconclusive results about the existence of the month-of-the-year effect and requires further investigation.

Table VII: Investments in the S&P/TSX Composite Index with this Study's Findings

	Returns	
	01-Jan-80	31-Dec-19
Index Benchmark	\$100.00	\$888.69
Month-of-the-Year Principles	\$100.00	\$1,983.59
Day-of-the-Week Principles	\$100.00	\$2,513.71
Month-of-the-Year and Day-of-the-Week Principles	\$100.00	\$3,444.49

SEASONALITY IN EQUITIES TRADED ON THE TSX

Figure I: \$100 Investment with Month-of-the-Year Findings



Figure II: \$100 Investment with Day-of-the-Week Findings



Implications

Investors can use this paper's findings to bet-

ter their investment strategies in the hope of greater monetary gains. Table VII shows the results of \$100.00 invested in the S&P/TSX Composite Index (INDEXTSI: OSPTX) index from January 1, 1980, to

SEASONALITY IN EQUITIES TRADED ON THE TSX

Figure III: \$100 Investment with Month-of-the-Year and Day-of-the-Week Findings



December 31, 2019, with various investment strategies. It is calculated that if an investor had adopted a simple buy-and-hold strategy, \$100.00 would have turned into \$888.69. However, if an investor had applied the principles of this paper, they could have significantly increased their gains; \$100.00 invested but not held during every Monday, June, and September interval would have turned the same investment into \$3,444.49 – a 3,876% increase.

Figure I, Figure II, and Figure III show the results of \$100.00 invested on January 1, 1980, to December 31, 2019. The day-of-the-week principles see investors not hold assets on Mondays, while the month-of-the-year principles see investors not hold investments in June and September.

Possible Explanations

Researchers have proposed numerous explanations for why these anomalies may exist in markets, but

there are two prevailing theories; the SAD and settlement date theories. Usually, when financial securities are bought in exchanges, the asset and payment are exchanged at the same time. However, a deal is occasionally structured such that the trade and payment do not take place on the same day. Depending on the day that the exchange happens, the length of time before the payment is made can vary; for instance, because the market is closed on the weekend, an exchange taking place on Friday may have to wait longer than an exchange on Monday. This gap may leave investors with more time to invest their funds in alternative markets before the original payment, affecting the supply-demand balance and, therefore, price.

The second leading theory proposed to explain the seasonal anomalies is seasonal affective disorder (SAD). SAD proposes that the number of sunlight hours that a person receives affects their happiness. Studies have linked happiness to risk aversion, so the number of sunlight hours a person receives may affect their willingness to purchase securities. Throughout

the year, people receive varying amounts of sunlight, so this effect could explain the month-of-the-year anomaly (Kamstra, Kramer, & Levi, 2003).

Limitations

This study finds that Monday underperforms compared to the rest of the week, so if an investor were to try to leverage the full power of this effect, they would hold securities for every day other than Monday. Notably, this result does not consider the trading cost of purchasing and then selling the security once a week, which could get costly quickly. Therefore, depending on the trading fees attached to the investment account, it could be inefficient to leverage this finding fully.

Additionally, this study only considered data from the Toronto Stock Exchange, and as such, the findings may only apply to that market. Among other factors, cultural differences may invalidate the result if transferred to a different region.

Lastly, this study only considers the price of the S&P/TSX Composite Index (INDEXTSI: OSPTX) and uses it as a conduit for market pricing. While the index represents over 70% of the exchange's market capitalization, it only consists of around 250 of the largest companies traded on the market. Consequently, this study does not consider how the effect may interact with the share prices of lower-market capitalization companies, potentially complicating the result.

Conclusion

This study aims to examine the day-of-the-week and month-of-the-year effects on the Toronto Stock Exchange (TSX) from January 1, 1980, to December 31, 2019. As measuring each stock on the exchange is too complicated and out of scope for this study, the S&P/TSX Composite Index is used to measure the market's general price level. For each of the investigated anomalies, a one-sample t-test, two-sample t-test, and analysis of variance are considered. This study finds that the day-of-the-week effect is prevalent in the market, with Monday and Friday acting as outliers, which is in line with past researchers' conclusions. However, the study draws inconclusive results about

the status of the month-of-the-year effect on the Toronto Stock Exchange.

Future researchers could examine seasonal anomalies in the Canadian bond, commodity, and housing markets to further the knowledge of irregularities in Canada's financial systems. Alternatively, scholars could further research this paper's topic, examining all companies traded on the Toronto Stock Exchange rather than using an index. Compared to the other First World nations, there has been an inadequate amount of research on seasonality patterns in Canada's markets – this must be fixed.

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The Effect of Animal-Assisted Therapy on Fine Motor Skill Development

Madeline McWatters

This study investigated the effect of weekly animal assisted activities utilizing guinea pigs on the fine motor development of children in grades kindergarten through third while also aiming to find more engaging and effective methods of occupational therapy for children in particular. An experimental research method was used to obtain quantitative data measuring fine motor ability through three different baseline data tests before and after a four week period. These baseline tests were implemented on both a control group and an experimental group. However, the experimental group had weekly interaction with guinea pigs between the two baseline data tests while the control group made no change to their daily routine. Ultimately, it was found through correlational research methods that animal assisted activities can be beneficial for fine motor development as the experimental group, on average, showed a much greater improvement in the tests over four weeks than the control group.

Keywords: occupational therapy, animal assisted activities, animal assisted therapy, fine motor skills

Introduction

The term motor skill incorporates both gross and fine motor (FM) skills. As a whole, motor skills “are actions that involve movement of muscles in the body” (Fine Motor Skills, para. 2). While gross motor skills encompass larger movements in body parts such as the arms, legs, and feet; FM skills encompass smaller movements found in the hands, wrists, fingers, and toes (Fine Motor Skills, para. 2). The development of FM skills starts at a very young age and has lasting effects. Losse et al. (1991) affirmed the fact that children who struggle with developing their FM skills have difficulty performing basic tasks such as dressing and feeding themselves. As a result, these children are more dependent on others, more open to peer ridicule, and less likely to meet the expectations of school. In addition, establishing poor FM skills at the

beginning of childhood can have lasting effects as it is hard for children to outgrow bad habits if they did not develop good habits from the start (as cited in Rule, 2002, p. 9). Therefore, the development of FM skills is very important for children, notably in preschool and elementary school.

Unfortunately, many children have difficulty developing their FM skills or have a disability that puts them at a disadvantage in this regard. Therefore, many families use occupational therapy (OT) as an outlet to improve FM function. Rule (2002) revealed in his study that “occupational therapists work with individuals and communities in order to enhance their participation in occupations they currently have or want to have by improving their skills or by modifying their environment or their activities” (p. 10). While OT can be very effective, little innovation in treatment methodology has occurred over the past couple of years.

Specifically, the field of OT has not yet adopted animal-assisted therapy (AAT) techniques that are present in psychological, physical and speech therapy.

Literature Review

Fine (2011) defined AAT as “a form of therapy that involves using an animal as a fundamental part of the person’s treatment” (p. xv) and revealed that it is primarily used for patients coping with stress and emotional distress. According to Ernst (2014), “the therapeutic potential of animals was first recognized in the late 1800s, when Florence Nightingale, considered the founder of modern nursing, made substantial discoveries regarding AAT” (para. 2) and its ability to mitigate anxiety for those living in psychiatric institutions. However, AAT did not become popular until the early 1960’s when Boris Levinson, a respected psychotherapist also known as the “father of AAT”, realized that the presence of his dog during therapy treatments improved patient outcomes (para. 4). Today, the effectiveness of ATT is up for debate. While many studies have found ATT to be very beneficial, other studies have concluded that ATT is not actually as effective as the general public believes. This is due to the fact that people are more prone to have a bias towards companion animals. In other words, people’s love for animals tends to yield greater reviews for AAT than might actually be present (Crossman and Kazdin, 2018).

As mentioned earlier, AAT is primarily used for psychological, physical, and speech therapy purposes. Therefore, there is a need to apply it to OT contexts as similar benefits could be seen in this field of therapy. In the psychological therapy field, AAT has been used for improving social anxiety, stress, and behavior. To illustrate, Dilts, Trompisch, and Bergquist (2011) found in their study done on a variety of children with special needs that dolphin-assisted therapy can be beneficial in improving socialization, anxiety and attitudes towards therapy (p. 63). In addition, Jones, Rice, and Cotton (2019) explain in their study surrounding canine-assisted psychotherapy, or using canines in the treatment of mental disorders by psychological means, that canine-assisted therapy can be beneficial in easing PTSD, depression, anxiety, and disruptive behavior in adolescents. Furthermore, secondary

factors of canine-assisted psychotherapy included increased participation and socialization even though those outcomes were not the intended results of the study (p. 18).

More recently, AAT has shown to be beneficial in the physical and speech therapy fields as well. Neagu and Zsuzsanna (2017) explained that hippotherapy, or AAT utilizing horses and horseback riding, can be very beneficial in improving posture, muscle tone, and balance in children with disabilities (p. 402). Furthermore, Machová et al. (2018) concluded that for children with developmental dysphasia, a language disorder that develops in children, speech therapy utilizing canines significantly improved the children’s ability with “narrowing and shutting of the eyes, as well as filling up the cheeks with air and smiling” (para. 1).

As far as the types of animals used in ATT, Fine (2011) revealed that the most common animals used are dogs, followed by cats (p. xv). Therefore, there is a need to do more extensive research on the role that “pocket pets” or small, pocket-sized mammals, as defined by Kršková, Talarovičová, and Olexová (2010), can have within AAT (p. 141). While smaller animals have been used in AAT before, they are primarily used for psychological therapies when they are used. An example of this would be the study done by Kršková (2010) which examined the psychological effects of AAT utilizing guinea pigs and concluded that guinea pigs can be beneficial in improving socialization for children with autism (p. 148). In addition, more extensive research is also revealing some of the unique benefits that working with small animals makes possible. For example, Law & et al. (1995), revealed that “pocket pets” are unique in that their small size actually increases a sense of responsibility within the child interacting with them (as cited in Kršková, 2010, p. 141).

In addition to AAT, animal-assisted activities (AAA’s) are also a very common therapeutic and educational tool. Ernst (2014) explains that AAA’s use animals in order to enhance the quality of life much like AAT. However, unlike AAT, treatment goals are not planned out for each AAA visit and a credentialed therapist is not necessary to perform the AAA (para. 20). For example, Daly and Suggs (2010) concluded that doing informal activities with class pets in elementary school classrooms significantly fosters moral development particularly in regards to empathy. In

addition, Kirnan, Siminerio, and Wong (2016) found that dog-assisted reading programs that allow children to read to dogs boost enthusiasm, self-esteem, and reduce disruptive behaviors as compared to traditional reading programs. Similarly to those 2010 and 2016 studies, this study will utilize AAA's as opposed to AAT because a credentialed therapist and set treatment goals were not feasible for this particular study.

Ultimately, this research project is designed to address the research gaps in OT and AAT previously mentioned in order to pioneer new treatment methods within OT. This is important because animals are rarely used in OT but doing so could pave the way for more engaging methods of treatment which is very important for children as they have shorter attention spans and need more interactive treatment. This study will also help fill in the gap of research surrounding pocket-pets as it will be specifically focusing on the guinea pig. Ultimately, this study poses the question of to what extent can weekly interaction with guinea pigs over a four week period improve the FM skills of children in grades kindergarten through third? These interactions will most likely prove beneficial for developing fine-motor skills in some way, however, it is unclear as to whether the AAA's will be just as effective as traditional OT methods.

Methods

In order to obtain the most accurate results, quantitative data was used to determine the change in FM skills. As a result, any changes in FM skills were supported by concrete data and evidence. In addition to this, quantitative data was also used to see if there were any secondary results of the study related to levels of engagement and enthusiasm when the animals were introduced as compared to the baseline data tests representative of traditional OT therapy methods. The previously mentioned study done by Jones et al (2019) serves as a good example for a study with both a primary and secondary result as they found that canine-assisted psychotherapy was beneficial for primary factors of the study including anger-management and anxiety as well as secondary factors similar to the study including increased engagement and activity. This quantitative approach is supported by many studies such as the one done by Kakebeeke and

others (2019) which measured changes in gross motor skills resulting from physical therapy with quantitative methods similar to the study at hand. The children in this study were timed while doing a variety of different tasks including standing on one leg, walking in a straight line, and hopping on one leg. These quantitative results then allowed researchers to be able to objectively see whether or not the physical therapy was effective.

An experimental research method was primarily used in order to note changes in FM skills for both an experimental group and a control group. Both groups utilized in this study were similar in age, gender, and background, however, the control group carried on with their daily routine while the experimental group interacted with the guinea pigs over the course of the research study. Then, a correlational research method was used to see if there was actually a correlation between any FM development and the AAA's. Finally, a survey research method was used to note secondary factors such as increased enthusiasm and engagement that also resulted from the study. An experimental research method was the most effective for this study as it ensured that other outside factors were not the cause for development in FM skills. An example of an experimental study being done utilizing AAA's was conducted by Kirnan and others (2016) mentioned earlier. This study measured the effects of dog-assisted reading programs on the reading skills and attitudes towards reading for children. The study incorporated a control group that followed a traditional reading program and an experimental group that participated in the dog-assisted reading program. While the experimental group showed stronger reading skills than the control group, both groups improved significantly. Thus, a control group is needed to see the true extent of the improvement due to a child's natural development.

As far as subject selection, five students were chosen for the control group and five students were chosen for the experimental group. There were no notable differences between the students chosen for each group so they were divided simply by availability. While a larger test group would have been favorable, time and availability limitations made two groups of five ideal. These two groups were similar in gender ratio with the experimental group consisting of five males and zero females and the control group con-

sisting of four males and one female. In addition, the groups were relatively similar in age distribution with two five-year-olds, one six-year-old, and two seven-year-olds in the control group as well as one five-year-old, one six-year-old, two seven-year-olds, and one eight-year-old in the experimental group. Finally, it is important to note that as all of these students attended the same school; they have completed similar curriculums and in theory have a relatively similar rate of FM development.

As far as the students that did end up being chosen, sampling procedure was non-random and a sample of convenience. It was not favorable for students to be taken out of class to participate in the study; therefore, it was necessary to rely on students who would be able to participate in the study before the start of school. Thus, a sampling procedure based on convenience was necessary for the feasibility of the study and everyone that was interested was allowed to participate. This sampling procedure can also be seen in a 2010 study done by Krscova et al. which utilized all willing participants found in a special education class to see how interaction with guinea pigs improved anxiety and anger.

Internal validity was maintained throughout the experiment through the experimental research method as it helped ensure that other outside factors were not causing changes in FM skills. In addition, the students did not alter their behavior or react to the experiment as they were unaware of the study and thought of the baseline data tests as games rather than as a research study. As far as external validity, the real-life setting with elementary students in their actual classrooms made the study replicable in other classrooms.

Data Collection

In order to collect data, both the control group and the experimental group participated in three baseline data tests to measure their FM abilities at the start of the study. Two of these tests, the Box and Blocks Test as well as the Nine-Hole Peg Test, were recreations of real tests commonly used by occupational therapists to improve FM skills. The Box and Blocks test times a patient to see how long it takes them to remove 20 large blocks (20 in this particular study) one at a time from a box and then place them back into the box one at a time after they are all removed (see

appendix A). The Nine-Hole Peg Test times children to see how quickly they can individually remove 14 small pegs (14 for this particular study) from a peg board and then place them all back into the pegboard after taking them out (see appendix B). For the third test, the children were tasked with screwing four large plastic nuts onto large plastic bolts and then unscrewing them all afterwards (see appendix C). These tests encompassed muscles in the fingers, palms, and wrists of the hand. For the Blocks and Box Test and Nine-Hole Peg Test, students were instructed to switch the hand that they were using halfway through in order to make sure that both hands were being incorporated.

After the first three baseline tests were recorded, the control group was told to make no change to their daily routine while the experimental group interacted with two guinea pigs every week for 45 minutes over the course of four weeks. The use of the guinea pigs and elementary students was approved by the school's internal review board beforehand. Students directly interacted with the guinea pigs by petting them, holding them, and picking them up. In addition, students indirectly interacted with the guinea pigs by filling up water bowls, rearranging the cages, ripping up vegetables for them, and making mazes out of blocks for the guinea pigs to run through. After four weeks, the three baseline data tests were repeated for both the control and the experimental group and the data was recorded to note any changes between the pre and post assessment.

The results were obtained by calculating the average time difference between the pre and posttests of all three activities for both the experimental and control group. This made it possible to see which group showed the most improvement, if any, for each of the three tests. It was then possible to analyze these results in order to determine whether or not animal-assisted interactions are indeed beneficial for FM skills.

The primary limitation of the study thus far was the small test sample due to time and availability limitations as a larger test sample would have made the data a better representation of elementary students in general. In addition, time limitations also restricted the study to a time span of four weeks while more sessions interacting with the guinea pigs would have been ideal. Finally, due to the timid nature of most guinea pigs, precautions had to be taken to ensure that the guinea pigs were not distressed or anxious. Therefore, it was not

ANIMAL-ASSISTED THERAPY & FINE MOTOR SKILL DEVELOPMENT

Table 1
Pre and post baseline data test results for experimental group

	Box & Blocks Test		9 Hole Peg Test		Nut & bolt test	
	Pre	Post	Pre	Post	Pre	Post
Participant 1	:46	:33	1:00	:44	:38	:30
Participant 2	:45	:40	1:00	:43	1:02	:57
Participant 3	:58	:52	:53	:57	1:19	1:17
Participant 4	:48	:44	1:11	:57	1:09	:56
Participant 5	:40	:35	:47	:49	:42	:36

possible to have hands-on interaction with the guinea pigs throughout the entire 45 minute time span which is why the indirect interaction was so important.

Results

To reiterate, this study posed the question “to what extent does weekly interaction with guinea pigs over the course of four weeks improve the FM skills of children grades kindergarten through third?” with the purpose of finding out whether or not animal assisted activities utilizing guinea pigs are beneficial for FM skills. If so, this study could then be used to see whether or not AAAs can compare to traditional methods of OT. In the end, the experimental group showed a much more significant improvement as compared to the control group, and all students in the experimental group preferred the AAAs over the traditional baseline data tests. As seen below, these results were rounded to the nearest second. Table 1 shows the pre and post test data for all three tests of the experimental group that interacted with the guinea pigs while table 2 shows the pre and post test data for the control group which made no change to their daily routine over the course of the four weeks.

The original predictions of this study were that both groups would show improvement in their FM skills due to a child’s natural development; however, the experimental group would show greater improvement over the course of the four weeks. The results

ultimately supported this hypothesis. While some students actually performed some of the posttests slower than the pretests, the overwhelming majority of trials showed improvement between the pre and post-tests. However, the experimental group showed greater improvement than the control group. Figure 1 shows the average time increase (shown as a positive value) or decrease (shown as a negative value) for all three tests of both the experimental and control group. A decrease in time showed improvement while an increase in time showed deterioration. In addition, it shows the average time difference for all three tests combined.

Therefore, it can be seen that the experimental group had an average 7.2 second decrease in time over the three baseline tests while the control group only had a 2.4 second decrease in time over the three baseline tests.

In addition to this data, a short survey question was posed to each student in the experimental group after the entire study. The question asked whether the students preferred doing activities in which they were interacting with the guinea pigs or the baseline test activities that were representative of typical activities that one may do in traditional OT sessions. The students had the options of picking the guinea pigs, the baseline data tests, or no preference. In the end, all five of the students said that they preferred doing activities with the guinea pigs over the baseline tests. Therefore, this data helps answer the secondary question regarding whether or not animal assisted activities are more engaging and enjoyable. This secondary

Table 2
Pre and post baseline data test results for control group

	Box & Blocks Test		9 Hole Peg Test		Nut & bolt test	
	Pre	Post	Pre	Post	Pre	Post
Participant 6	:37	:40	:50	:54	1:00	1:00
Participant 7	:51	:46	1:00	1:12	1:15	1:06
Participant 8	:41	:38	:44	:47	:49	:38
Participant 9	:42	:46	1:02	:53	1:08	:50
Participant 10	:47	:43	:52	:48	:59	:59

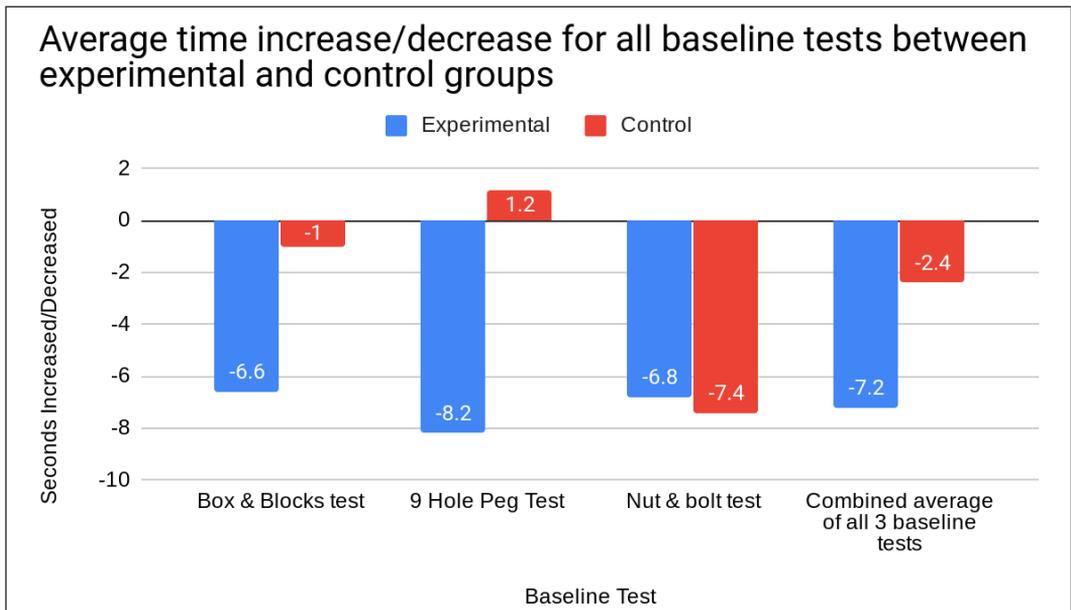
question could serve as rationale for why AAAs could stand up to traditional methods of OT.

Discussion

Ultimately, after conducting three different baseline tests with both an experimental group and a control

group, the results inferred that AAAs can indeed be beneficial for FM development. This inference is due to the 7.2 average second decrease in time between the pre and post baseline tests for the experimental group as compared to the 2.4 average second decrease in time for the control group. To put into context the significance of these numbers, the time taken to complete the baseline tests took between 30 seconds (the

Figure 1: Average time increase/decrease for all baseline tests between both experimental and control groups



ANIMAL-ASSISTED THERAPY & FINE MOTOR SKILL DEVELOPMENT

fastest time out of all trials) and 79 seconds (the slowest time out of all trials).

Therefore, due to the 4.8 average second difference in time improvement between the experimental group and control group, it can be inferred that AAA's with guinea pigs including petting, holding, caring for, and playing with them do indeed have an impact on a child's FM development as compared to not making any change. To answer the research question posed, weekly interaction with guinea pigs over the course of four weeks for 45 minutes each week can have a significant impact on FM development according to the data collected in this study.

These results also mirror the results of many similar studies mentioned in the literature review. To illustrate, the study done by Neagu and Zsuzsanna (2017) found a connection between hippotherapy and posture as well as balance. In addition, the study done by Dilts, Trompisch, and Bergquist (2011) reported a connection between dolphin assisted therapy and the behavior of special needs children. Similarly to the results at hand, these studies found AAT to have positive benefits, however, the researchers of these studies did not conclude the results to be sufficient enough to stand alone and recommended that they be used as complementary methods to traditional therapy programs. With future research, the results of this study will most likely mirror these results and be deemed a good complementary method to traditional OT rather than a stand-alone method of therapy.

While these results do not show how AAA's compare to traditional methods of OT, the results of the survey question posed could serve as rationale for why they may be able to stand up to traditional methods. 100% of the students in the experimental group stated that they preferred the sessions where they interacted with the guinea pigs as opposed to the sessions where they were completing the baseline data tests. This means that the guinea pig interaction was very engaging and enjoyable for children, making them much more willing to unknowingly improve their FM skills.

Another factor of the data worth mentioning is the difference in time between all three tests for both groups. The experimental group had very consistent averages of decrease between all three tests with a 1.6 second difference between the test with the most improvement and the test with the least improvement. On the other hand, the control group saw a 8.4 second

difference in time between the test with the most improvement and the test with the least improvement. This 8.4 second difference is because while the nut and bolt test recorded a 7.4 second decrease in time for the control group, the 9 hole peg test saw a 1.2 second increase in time. Some rationale to explain this data could be that students were doing activities in school during the month of January, the month that the study was conducted, that primarily strengthened the wrist muscles in their hand, which the nut and bolt test was meant to target, whereas the experimental group got to improve on a wide variety of hand muscles throughout interacting with the guinea pigs.

This data is significant for the field of study as it could serve as rationale for why it might be beneficial to incorporate AAA's and specifically pocket-sized pets into OT programs. The large gap in research regarding this makes it especially important in paving the way for more innovative methods of treatment that not only improve motor skills but do it in a fun and engaging way which is very important for children with short attention spans and tendencies to get distracted. However, before incorporating the results of this study into OT programs, it is important to do more research surrounding AAT

To elaborate, as most OT patients are individuals with a specific medical condition or developmental issue, it is important that this research is also applied to this demographic of children as all children used in this study had no known medical condition pertaining to their FM abilities. In addition, while this study was geared towards children as they have a particular affinity towards animals and a low attention span, this same research can be applied to an older audience whether it be middle schoolers, high schoolers, or adults. Finally, it would be beneficial for future studies to address the limitations mentioned in the methods section such as the small sample size, short time span, and amount of direct exposure that the children actually had with the guinea pigs, as well as the limitations that will be mentioned in the next paragraph.

Additional limitations of this study include the fact that while a significant amount of FM development does occur between kindergarten and third grade, much more happens in the first few years of one's life before they even start school. Therefore, to see an even greater impact on FM skills, it would have been beneficial to use an even younger demographic

of students that were not feasible for this study. Another limitation of this study was the inconsistency of working with elementary aged children. No matter how many times the rules of the baseline data tests were explained to the children, there were often times where the children would not do exactly what they were told because they were between the ages of five and eight. These included things like picking up two blocks at a time or forgetting to switch which hands they were using right away. If the errors could be fixed with a quick reminder, the child would be permitted to continue the test; however, if the error took more than a second or two to resolve, the child would be asked to restart the test.

Alternative explanations for the results of this study could include that the students in the experimental group were more comfortable in the setting as they actively participated in the study over the four week period. Due to this, there was also an increase in competition in the experimental group as the children wanted to beat the times of the other children that they knew in the experimental group. On the other hand, the control group did not know who else was in the control group and thus did not have the same competitive motivation.

Conclusion

To conclude, this study found that AAT has the potential to be very beneficial for FM development and with further research may improve the field of OT. This conclusion was made due to an experimental study that found a 4.8 second difference between an experimental group that interacted with guinea pigs over the course of four weeks and a control group that made no change to their daily routines. The 4.8 second difference was between pre and post baseline data tests that were designed to be a good representative of the student's FM skills. In addition, the survey responses found that AAT was much more engaging than traditional methods of therapy.

Thus, this study is significant for the field of OT as well as AAT research. Specifically, it is significant as it fills in a gap of knowledge surrounding the use of smaller animals, such as guinea pigs, in AAT as well as the potential of AAT within OT. This new information with further research could improve OT treatments to make them more engaging and interactive especially for children.

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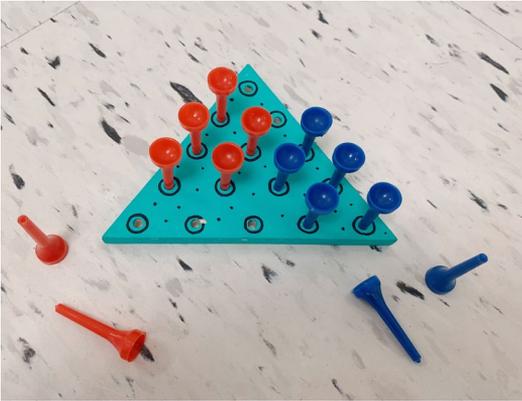
Appendix A

Box & Blocks Test



Appendix B

9 Hole Peg Test



Appendix C

Nut & Bolt Test



Influential Factors for Young Entrepreneurial Success: A Delphi Study on High School Entrepreneurs

Nanyi Jiang

While previous literature has shown how certain internal and external factors have contributed to the accomplishments of adult entrepreneurs, there is little research that focuses on young entrepreneurs. Along with a growing entrepreneurial interest among adolescents, this study examines what factors have contributed to the success of high school entrepreneurs in Ontario, Canada. Employing a Delphi study, experts and non-experts in the field were invited to participate in this study. Three categories of experts include current high school entrepreneurs, high school teachers of entrepreneurship, and successful adult entrepreneurs. One category of non-experts consists of seven students who aim to become future entrepreneurs while in high school. In the first stage, a contextual survey was used to collect subjects' information about personality, family background, and financial support in terms of their entrepreneurship. In the second stage, a three-round Delphi study was conducted among the group of experts. In the third stage, an interview was constructed among the group of non-experts. Then, their responses were compared with the experts'. As a result, the identifiable factors influencing the success of high school entrepreneurship were summarized as the PITF model – Personality, Institutional support, Timing perception, and Family background (ranked by the subjects in the order of importance). Notably, two results stand out from the previous studies: 1) it is found that Open to Experience defined by the “Big-5 model” is the most dominant personality trait that determines entrepreneurial success. 2) Significant differences of perceptions were shown between experts and non-experts in terms of the amount of timing and financial support needed for establishing a business.

Keywords: youth entrepreneurship, high school students, Big-5 model, Delphi Study

1. Introduction

With increased globalization and market fragmentation, entrepreneurship has been more crucial for economic growth in modern economies than it has ever been before (Mueller, 2007). Along with the growing demand for new types of businesses, interest in entrepreneurship has also arisen, especially among high school students across America, as 72% intend to start a business someday (Schawbel, 2014). Despite their optimistic attitudes towards start-ups, the number of adolescents engaged in the entrepreneurial landscape remains low. A survey by Junior Achieve-

ment and Ernst & Young LLP (EY) shows that only 13% of American entrepreneurs today started their first business at the age of 18 or younger (Grocholski, 2018). The gap between the percentage of adolescents having entrepreneurial objectives and the percentage of those who took actions emphasizes the significance of the exploration of youth entrepreneurship.

This study defines entrepreneurs as individuals who establish and manage new businesses and addresses “successful business as one which creates profit” and sustains profitability for at least one year (Merriam-Webster, n.d.; Mongan, 2017). The purpose of this mainly qualitative research is to determine the criti-

cal factors that might contribute to high school students' (14 to 18 years old) entrepreneurial successes in Ontario, Canada. By analyzing the personality, family, funding, and timing factors with entrepreneurial success, this study provides valuable insight for high school students who are considering starting a business and venture capitalists who hope to promote the new generation's entrepreneurship for an innovative and inclusive economy.

2. Literature Review

With the idea of youth entrepreneurship being a relatively new focus of academic research, it is essential to review and synthesize research findings from a wide range of credible sources, including academic studies, internal company-specific research, psychological theories, and regional studies. According to Robert H. Brockhaus, the Coleman Chairholder in Entrepreneurship at Saint Louis University, in determining the traits of successful entrepreneurs, there are two main categories: one focuses on the psychological factors (internal indicators), and the other focuses on the environmental "push" factors (external indicators) (Brockhaus, 1980; Wyld, 2011). This section explains both perspectives yet shows little communication between the two and the lack of similar research in the context of youth entrepreneurship, which lead to the reason why a model that evaluates both internal and external factors towards adolescent entrepreneurs' success is developed.

2.1 Internal Factors

In the mid-twentieth century, sociologists started to focus on psychological factors of being an entrepreneur to answer three major questions: "Who is an entrepreneur? What drives them? What traits define them?" (Kerr et al., 2017). However, with the lack of a consensus, some researchers concluded that the approaches towards personality traits and characteristics "have been unfruitful and that behavioral approaches will be a more productive perspective for future research in entrepreneurship" (Gartner, 1989;

Brockhaus, 1982).

A few decades later, driven by growing attention to the start-up culture¹, research about the entrepreneurial personality resurged with "an increasingly consistent set of theoretical frameworks" (Kerr et al., 2017, p.7). Amy Boren, Assistant Professor at Texas Tech University, suggests that traits of emotional intelligence (EI), "the ability to monitor one's own and other's feelings," is related to the entrepreneur's success and growth (Boren, 2010, p.57). Moreover, several studies have reached a consensus of categorizing the "Big-5 model," five dominant EI traits of successful entrepreneurs: 1. *Neuroticism*, 2. *Extraversion*, 3. *Openness to Experience*, 4. *Agreeableness*, and 5. *Conscientiousness* (Antoncic et al., 2013; Judge et al., 2002, p.766). According to Scott E. Seibert, Professor of Human Resource Management at Rutgers University, the Big Five traits are defined as below:

- **Neuroticism:** "individual differences in adjustment [of uncertainty] and emotional stability."
- **Extraversion:** "the extent to which people are assertive, dominant, energetic, active, talkative, and enthusiastic."
- **Openness to Experience:** "a personality dimension that characterizes someone who is intellectually curious and tends to seek new experiences and explore novel ideas."
- **Agreeableness:** "one's interpersonal orientation. Individuals high on Agreeableness [are] trusting, forgiving, caring, [generous], and gullible."
- **Conscientiousness:** "an individual's degree of organization, persistence, hard work, and motivation in the pursuit of goal accomplishment" (Zhao & Seibert, 2006, p. 260).

The consistency in which these studies hypothesize certain personality traits of successful entrepreneurs has laid the cornerstones of predicting success in business ventures. Hence, applying these psychological theories in the context of high school entrepreneurs is relevant for this study.

While there has been a general focus of entrepreneurial study on personal determinants, controversies exist as to whether the identification of only the Big

1 Startup culture: a business environment that values creativity, clear vision, open communication, and flat hierarchy.

Five traits presents a comprehensive analysis of what personality traits make entrepreneurs successful. In agreement, David Wyld, Professor of Management at Southeastern Louisiana University, illustrates the “importance of studying entrepreneurship by focusing on the development of the person as a whole, rather than on personality traits in isolation” (p. 101). This study addresses Wyld’s concern by not only asking experts to rank the importance of the Big Five traits on their success, but also their supporting arguments based on their entire entrepreneurial career.

2.2 External Factors

Although the assessment of psychological factors shows relevancy to entrepreneurial success, it does not confirm an absolute cause-and-effect relationship. Aspiring adolescent entrepreneurs may have dreams of being the next Bill Gates or Mark Zuckerberg, but they cannot get there without a supportive environment and financing (Schwartz, 2014, p. 521). Consequently, there exists another body of thought regarding nature versus nurture. The researchers from the latter perspective believe that nurturing plays a more dominant role as a predictor of success (Bergmann et al., 2016; Politis et al., 2011, p.17; Luthje & Franke, 2003, p. 143). Dr. Bergmann, Professor of Entrepreneurship at the University of St. Gallen, questions the growing literature that has so far primarily ignored contextual influences and examines personality-wise determinants solely. Especially in the context of students who typically “have no or little industry experience, the university and regional context and their family background can be assumed to be more important for their entrepreneurial propensity than

for people at a later stage of their professional career” (p. 6). Similarly, based on Vroom’s expectancy theory (See Figure 1), Professor Renko (2012) conducted a study on young entrepreneurs, concluding that their “motivation is largely based on financial reasons” (external factors) regardless of “whether they believe that their hard work will lead to establishing a [business]” (internal factors) (Renko et al., 2012, p. 681). Hence, the consideration of external factors is equally important for this research.

2.3 Gap Analysis

Previous studies that identify elements that contribute to start-ups’ success rates are primarily centered around adult entrepreneurship, including university entrepreneurship as one of the youngest sample groups (Luthje & Franke, 2003). In terms of adult entrepreneurship, studies analyze the external (Sarasvathy et al., 2013), gender-based (Sirec & Mocnik, 2012), industry-specific, i.e., engineering (Luthje & Franke, 2003), and psychological factors contributing to the success of some adult entrepreneurs (Khosla & Gupta, 2017; Boren, 2010). In terms of university entrepreneurship, studies connect the political (Schwartz, 2014), identity-building (Nielsen & Garner, 2017), resourcing (Politis et al., 2011), and environmental (Wright et al., 2017) factors regarding the success of multiple entrepreneurs who are university students. However, high school entrepreneurship (fourteen to eighteen-years-old) has been a subject of little theoretical and empirical research. The results obtained from youth entrepreneurship can be differentiated from adult entrepreneurship because (1) high school students have a dual identity of operating

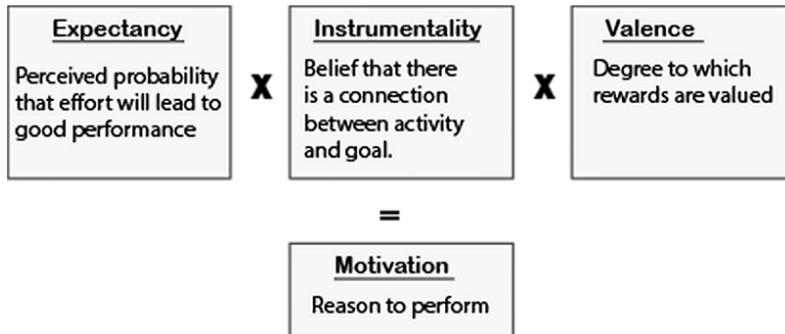


Figure 1: Expectancy Theory Model

INFLUENTIAL FACTORS FOR YOUNG ENTREPRENEURIAL SUCCESS

a business alongside studying at school; both demand time, effort, and commitment, and (2) a student entrepreneur with no prior knowledge in the field is different from an adult entrepreneur who might have extensive education and experience in other businesses before establishing his/her own.

Furthermore, while there is much research devoted to the internal and external traits of successful entrepreneurs, it is apparent that the communication between these sources has been minimal, as most studies assess either the internal or the external factors. Thus, using the Delphi Method, this study explores the perspectives and experiences of various experts to examine the contribution of both internal and external factors (personality and timing perception, family background, and institutional support) in the field of youth entrepreneurship and the model is developed below.

3. Methodology

This study uses a qualitative Delphi study approach to explore the extent to which there exists a correlation between the four factors introduced in the gap analysis and high school entrepreneurial success in Ontario, Canada. In previous literature, several groups of

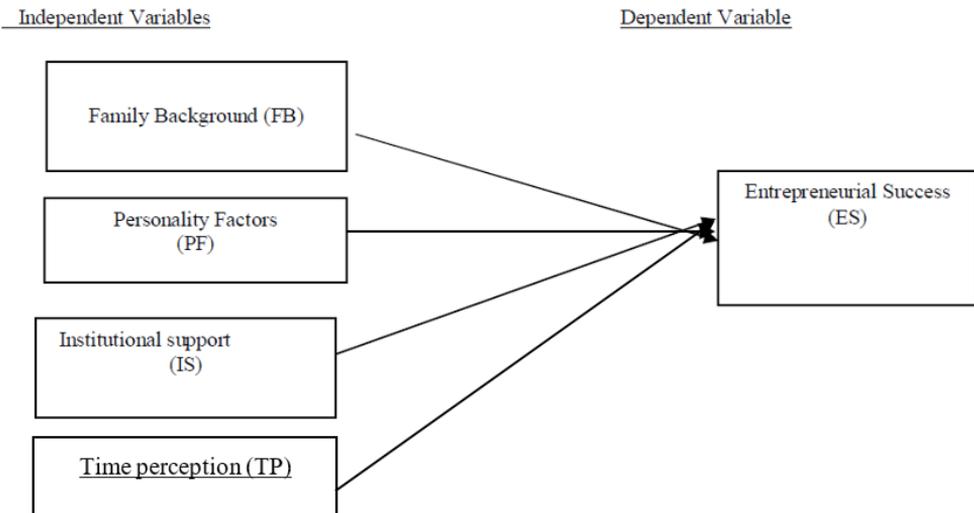
researchers have tried to analyze this question within distinct contexts. Dr. S. Gunapalan, the Head of the Management Department at the South Eastern University of Sri Lanka, for example, conducted a study on factors that influence entrepreneurial success for women in Sri Lanka. Referring to Dr. S. Gunapalan's design, the following shows a conceptual model (See Figure 2) of this study which exhibits the general hypothesis that high school entrepreneurial success is determined by particular internal factors (personality and timing perception) and external factors (family background and institutional support):

In adapting parts of Dr. S. Gunapalan's methodology in the context of high school entrepreneurs while adding the new factor Time perception, a four-factor model PITF is established, which stands for: Personality, Institutional support, Timing perception, and Family background. In this study, it is hypothesized that PIT factors are required more so than I factor to guarantee high school entrepreneurial success (Ummah & Gunapalan, 2012).

3.1 Approach

The Delphi study approach, developed by Dalkey and Helmer (1963), tries to "obtain the most reliable consensus of a group of experts ... by a series of

Figure 2: Conceptual Model adapted from Ummah & Gunapalan (2012)



questionnaires interspersed with controlled opinion feedback” (Dalkey & Helmer, 1963, p. 5). The Delphi study is well-suited for social and economic research where “only little well-established knowledge is available” and “such knowledge is dispersed across a wide range of experts whose subjective evaluation[s] can enrich the understanding and [analyses] of the research subject” (Jandl et al., 2009, p. 66). In this study, the Delphi method is appropriate because (1) there is limited well-established research about this topic, and (2) reaching a consensus among a group of current experts with both practical experience and theoretical knowledge can help explore the complexity of youth entrepreneurship.

According to Clinical Psychologist Dr. Linda Carr, most quantitative methodologies “test theory deductively from existing knowledge, though developing hypothesized relationships and proposed outcomes for study” (Carr, 1994, p. 718). Thus, it might appear well-matched for this research to employ a quantitative experimental design, for example, primarily focusing on comparison between entrepreneurs and high school students. However, the experimental design often fails to determine nuanced relationships, meanings, and explanations in research that consist of cognitive, affective, behavioral factors, which is needed for this study (Amaratunga et al., 2002, p. 17). Moreover, with little pre-knowledge of high school entrepreneurs’ sample, the statistical results from an experimental design might “lead to conclusions that are of questionable value” (Cliff, 1983). On the contrary, with “flexibility,” a “holistic focus,” and a “deeper understanding of social phenomena,” a primarily qualitative methodology yields more valid data with context (Haq, 2014, p. 4; Carr, 1994, p. 718).

Lastly, according to Dr. Brian Sandford, Professor of Construction at Pittsburg State University, the unique characteristic of the Delphi study is its “ability to provide anonymity [of] respondents, a controlled feedback process, and the suitability of a variety of statistical [analyses’] techniques to interpret the data” (Hsu & Sandford, 2007, p. 2). This provides two advantages: first, it counters the disadvantages of “conventional means of pooling opinions obtained from a group interaction (i.e., influences of dominant individuals, noise, and group pressure for conformity)” (p. 2). To derive a consensus from different lenses and perspectives about the correlation between PITF and

successful youth entrepreneurship, this particular strength of the Delphi method has crucial applications for this project’s data collection. Second, many statistical techniques apply to this Delphi study, such as mean value, standard deviation, bar graphs, etc.

3.2 Sampling and recruitment

In terms of sampling, a panel of experts from different fields and backgrounds can produce credible results, notably including participants who might provide a different or minority point of view (Iqbal & Pison-Young, 2009, p. 599; Turoff, 2002, p. 96). Thus, after receiving approval from my school’s Internal Ethics Review Board, three categories of experts were recruited to represent different perspectives about the field of young entrepreneurship: four current high school entrepreneurs from the LaunchX program, two high school teachers of business education from Ontario, Canada, and one previous high school entrepreneur who has eight years of experience in establishing and operating start-ups (see Table 1). Moreover, there is one category of non-experts, namely potential high school entrepreneurs. The participants were contacted through emails, social media accounts, and start-ups’ websites.

The first category of experts consists of four high school entrepreneurs from LaunchX, a Young Entrepreneurs Program that has more than 1000 high school entrepreneurs, including more than 250 participants who have launched their start-ups across North America (Kilkeel). Three participants from this category have been operating their businesses for one to twelve months, while one has been running her business for one to five years. They were purposely chosen to represent high school students who are currently operating a business at the infant stage of entrepreneurial success.

The second category of experts consists of two teachers who have over fifteen years of experience teaching high school courses in business, economics, and management in Ontario, Canada. Particularly, they each ran a special International Business program which led students to create their student-oriented businesses at school for several years. Hence, they can provide insightful knowledge and experience concerning entrepreneurship as they have experiences with the challenges and successes of youth entrepreneurs.

Table 1: Business Information of the Subjects

Subject #	Profession	Business (pseudonyms)	Description	Years of Experience
Subject 1	Student	S	Sell snacks to fundraise for boarding yearbook	2 – 5 years
Subject 2	Student	Q	Make wearable bands that records melodies	1 – 2 years
Subject 3	Student	P	Connect immigrants to the services they need	1 – 2 years
Subject 4	Student	W	Medical communications device alerting caregivers instantly of senior health emergencies	1 – 2 years
Subject 5	Teacher	/	/	30 years
Subject 6	Teacher	/	/	15 years
Subject 7	CEO	T	simplify fan engagement with a tool that's built for the social era of marketing.	1 – 5 years
Subject 8 - 14	Ontario high school students who intend to become entrepreneurs			

The third category consists of one extraordinary entrepreneur, subject 7. His entrepreneurial career started at the age of 13 when he created his first business and became the youngest social entrepreneur to receive venture capital funding from CBC’s Dragons’ Den² at the age of 15. Today, he is the co-founder of a data analytics company with annual revenue of more than one million CAD. With abundant experience, subject 7 can present valuable knowledge regarding factors that have contributed to his success at such a young age.

The last category, subjects 8 – 14, are seven high school students from Ontario, Canada, who are potential high school entrepreneurs. They represent high

school students who aim to become entrepreneurs yet have zero expertise in the field. To explore the reasons why there is only a small group of adolescent entrepreneurs in the society, the non-experts’ perceptions toward PITF are crucial while comparing with the experts’ perceptions.

3.3 Data collection methods

A survey with five distinct sections was used. Sections one to four were contextual questions, while the fifth section was the Delphi survey with questions reoccurring throughout three rounds. With a survey that included both closed-ended and open-ended

2 Dragons’ Den: a reality tv show where aspiring entrepreneurs pitch their business concepts and products to a panel of Canadian venture capitalists in the hope of securing investment finance from them (CBC, 2020).

questions, quantitative probability and purposeful qualitative sampling are combined to produce more generalizable results (Creswell, 2009).

3.3.1 Contextual survey

The first section of the survey includes questions about the students and their businesses (see Appendix A). The second section of the survey involved a pre-Delphi personality test for each participant in which the questions that are centered around the Big Five traits: 1. *Neuroticism*, 2. *Extraversion*, 3. *Openness to Experience*, 4. *Agreeableness*, 5. *Conscientiousness* (Zhao & Seibert, 2006, p. 260) (see Appendix B for the survey and how the test is structured). A Likert scale was used for the statements collected ranging from 1 (strongly disagree) to 5 (strongly agree). The purpose of the third part of the survey was to gain a general understanding of each respondent’s family background: 1) family of entrepreneurs and 2) attitude and support of entrepreneurship (see Appendix C). In the fourth section, the information on whether they have used any funding resources was collected (see Appendix D).

3.3.2 Three-Rounds Delphi study

The Delphi study was constructed in the fifth section of the survey (see Appendix E). By combining closed questions (i.e., multiple-choice) and open questions (i.e., short answers) relating to PITF, the Delphi method produced both quantitative and qualitative results. Theoretically, this section, the Delphi study, can be continuously repeated until consensus has been achieved, but three rounds are often enough to reach a consensus (Hsu & Sandford, 2007, p.2).

In the first round (see Appendixes A to E), the participants completed all five sections of the survey. After responses were collected, a summary of the results was compiled and sent back to the participants (see Appendix F). In the second round (see Appendix E), participants received the second survey consisting of the same questions from the fifth section: the Delphi method in the first survey. They were asked to review and assess the summarized results (see Appendix G) from the first round before completing the new survey, which led to responses closer to a consensus (Hsu & Sandford, 2007, p.2). After the second round, the third round again invited participants to “consider their scores in light of the group response and decide whether they want to change any of their responses” (Iqbal & Pipon-Young, 2009, p. 600).

Table 2: Statements of Characteristics

Rank	Statement	f ¹	M ²	SD ³	Big-5 Category
1	I find myself thinking about ways to improve products to meet the changes in our culture.	7	4.71	0.49	Openness to Experience
2	When I need to concentrate, I can tune out my environment.	7	4.71	0.49	Extraversion
3	I offer quick responses to my employees and my customers.	7	4.57	0.53	Extraversion
4	I am willing to fail for the sake of innovation.	7	4.43	0.79	Neuroticism
6	I have detailed short-term plans for my company.	7	3.57	1.27	Conscientiousness
7	I have a vision of my company five years from now.	7	3.00	1.00	Conscientiousness
8	Most of the time, I would instead delegate than be entirely responsible for all aspects of the task.	7	2.57	1.27	Agreeableness
9	I feel uncomfortable making decisions with uncertainty.	7	2.14	0.90	Neuroticism

INFLUENTIAL FACTORS FOR YOUNG ENTREPRENEURIAL SUCCESS

Table 3: Personality Factor Comparison Prior and After the Delphi Study

Rank	Category	Pre-Delphi personality test (M)	Round 3 Delphi Ranking: Most Important Characteristics (%)
1	Openness to Experience (1)	4.71	50.0
2	Extraversion (2)	4.64	16.7
3	Neuroticism (2)	3.64	16.7
4	Conscientiousness (2)	3.29	16.7
5	Agreeableness (1)	2.57	16.7

Table 4: Questions Around Family Background

Statements	Yes (%)	No (%)
I have family members who are entrepreneurs.	57.1	42.9
My family highly supports my entrepreneurial endeavors, along with my education.	100.0	0.0
My family financed the grassroots of my business.	72.4	28.6
My parents pay for my education (elementary school, high school, university).	100.0	0.0
I have a part-time job alongside my business.	66.7	33.3

3.3.3 Comparative analysis

After the Delphi study, seven high school students (subjects 8 - 14) from Ontario, Canada, were interviewed about their perception in terms of entrepreneurial budget, timing, and whether that affects their action of becoming entrepreneurs. This was a new and essential part of this Delphi design as comparing their perceptions with the experts' perceptions (subjects 1 - 7) would provide insights about obstacles and misconceptions that hindered them from becoming adolescent entrepreneurs.

3.4 Ethics Memorandum:

This study was approved by my institution's Internal Ethics Review Board (see Appendix H).

4. Findings

4.1 Personality Traits

The responses to the Delphi study demonstrated that all subjects strongly believed personality traits

play the most dominant role as a predictor of success in entrepreneurship.

During the fifth section of the survey, the Delphi study, subjects were asked to choose the most critical characteristics in becoming an entrepreneur. At the end of the third round, the most prevalent one to be selected was *Openness to Experience* among the five characteristics in the "Big-5 model" (see Table 3). This result is consistent with the Pre-Delphi personality test (see Table 2), which identified that *Openness to Experience* as the most outstanding characteristic that most subjects possess to a high extent ($M = 4.71$).

4.2 Family Background

Overall, it was an unexpected finding that family background was considered by the subjects to play an insignificant role in promoting their ventures. Most subjects' businesses were not directly financed by their families (71.4%). However, the subjects acknowledged that they had 100% emotional support from their family in the form of encouraging them to be creative, take responsibilities and risks, and improve their communication skills. Indirect financial

3 ³Statistics highlighted in blue: round 3 Delphi study results with subjects 1-7 (experts in the field of high school entrepreneurship).

INFLUENTIAL FACTORS FOR YOUNG ENTREPRENEURIAL SUCCESS

Table 5: Funding Estimation for High School Entrepreneurs (CAD)

	Round I	Rationale	Round II	Rationale	Round III	Rationale
subject 1	\$1000	N/A	\$500	it depends on the type of business	\$500	same reason as last round
subject 2	\$2000	N/A		N/A		N/A
subject 3	\$100	all you need is a website or an app. In high school, we are dependents, so we do not have to worry about food on the table.	\$100	just server costs, realistically no money is needed to get a business off the ground	\$100	same reason as last round
subject 4	\$3000	high school students most likely will not need salaries. If it is a hardware company, then funding would depend	\$0	income not needed (unless it is a hardware company that needs funding for production)	\$0	same reason as last round
subject 5	\$250	N/A	\$250	studies show that "bootstrapping" is just as important as the product or service.	\$250	The shoestring approach is always the best approach to establish whether your product or service is viable.
subject 6	\$150	\$10 cost per unit x 10 units should get you started on sales; use the profit to purchase more product	\$300	the product should not retail for more than \$20, so per unit cost of the product should be 50% of \$20, which is \$10. Estimate that one purchases 20 units, totals \$200 + shipping, some marketing materials = \$300 approx.	\$200	allows for the purchase of enough product + several months online presence to build resources
subject 7	\$0	so many amazing tools out there for free that can help you make a reliable product	\$0	same reason as last round	\$500	same reason as last round
Range	0-2000		0-500		0-500	
M	\$928.6		\$191.7		\$258.3	
SD	1159.0		196.0		206.0	

assistance through the fact that the subjects are not paying rent, utilities, and other expenses, made them more likely to take financial risks in entrepreneurship due to their financial safety blankets. Furthermore, it is essential to note that 100% of the subjects' families will pay for their education, and most of the subjects do not have a part-time job along with their businesses (see Table 4).

4.3 Institutional support

During the three rounds, the subjects were asked to estimate how much funding does a high school student need to open a new business and why (see Table 5).

In the first round, the calculation of funding to open a new business was a range of 0 to 2000 CAD with high variation. The general rationale is that if entrepreneurship is computer-based, it requires less funding. At the same time, if it is a hardware company, then a higher budget is needed because of the additional costs required for land, manufacturing, other assets, etc. However, after the subjects re-evaluated their answers based on the Round 1 summary (see Appendix F), the range narrowed to 0 to 500 CAD. Furthermore, in Round 3, the subjects maintained the same scale, yet there were more subjects than previously that expressed 200 to 300 CAD to be the norm (M=258.3).

INFLUENTIAL FACTORS FOR YOUNG ENTREPRENEURIAL SUCCESS

Table 6: Preparation Time Perception for High School Entrepreneurs (Days)

	Round I	Rationale	Round II	Rationale	Round III	Rationale
subject 1	30.0	for market research and producing the MVP	30.0	same reason	30.0	same reason
subject 2	60.0	N/A		N/A		N/A
subject 3	0.8	it is less about the idea and more about the execution and how much time you put into it.	0.8	time is needed to talk with people and understand the problem that you are trying to solve.	0.8	same reason as last round
subject 4	5.0	market research, planning	180.0	same reason as last round	180.0	same reason as last round
subject 5	1.0		7.0	A week at most with proper support.	0.4	idea/concept, discussion, simple prototype, market research, early cost projections, execution.
subject 6	0.8	4-5 hours devising Business Plan, 10 hours to research and source product, 5+ hours marketing strategy	0.8	5 hours researching product/market/environment; 5 hours sourcing suppliers; 5 hours marketing strategy; 5 hours designing a business plan	0.8	same reasons as before! (research, sourcing product, strategic plan, marketing)
subject 7		A lot or a little depending on the industry.		Lots of time at the start to make sure you are on the right path	30.0	One month to get it right with solid MVP
Range	20h - 2 months		20 h - half-year		10 h - half-year	
M	16.3		43.7		40.3	
SD	24.2		77.1		69.9	

4.4 Timing

During the three rounds, the subjects were asked to estimate how much preparation time does a high school student need to open a new business and why (see Table 6).

In the first round, the subjects’ estimations ranged from 20 hours to 2 months in terms of a business’ preparation time. For example, the subject who answered 20 hours stated that the high school entrepreneur needs “4 to 5 hours devising a business plan, 10 hours to research and source the product, 5 or more hours marketing strategy.” While the purpose of a Delphi study is to reach a consensus, after reviewing the others’ responses, it was surprising that the range had expanded from 10 hours to half a year in the third round, while the means have decreased to 40.3 days.

To synthesize the implications of the collected data, it is essential first to determine whether there are different perceptions between successful high school en-

trepreneurs (subjects 1 - 7) and potential high school entrepreneurs (subjects 8 - 14). After interviewing seven high school students who have the aim to become entrepreneurs, the results have shown that the perceptions gaps between the two groups are surprisingly large (see Table 7).

5. Discussion

The implications of the findings contribute to young entrepreneurial research in two significant ways. Firstly, personality is argued to be the most critical factor of the PITF model. The study identified some consistent Big-5 characteristics of successful high school entrepreneurs, especially *Openness to Experience*, which has reached a consensus with the “Big-5 model” theories (Zhao & Seibert, 2006, p. 260; Antoncic et al., 2013; Judge et al., 2002, p.766). Secondly, this study exhibits valuable qualitative insights

INFLUENTIAL FACTORS FOR YOUNG ENTREPRENEURIAL SUCCESS

Table 7: Comparison of Perspectives between Entrepreneurs and Non-entrepreneurs

subject #	Please estimate how much funding does a high school student need to open a new business (CAD):	The amount of funding is a crucial determinant of why I did not open my business. (1: Strongly Disagree 5: Strongly Agree)	Please estimate how much preparation time does a high school student need to open a new business (days):	The amount of preparation time is a crucial determinant of why I did not open my business. (1: Strongly Disagree 5: Strongly Agree)
subject 8	\$30,000	5	240	5
subject 9	\$1,000,000	3	730	4
subject 10	\$100,000	4	365	3
subject 11	\$1,000	3	150	2
subject 12	\$10,000	4	1460	3
subject 13	\$15,000	5	1825	5
subject 14	\$1,000	4	730	5
Range	\$1000-1,000,000 \$0 - 500 ¹		Half-year - 5 years 10 h – half-year	
Mean	\$165,286 \$258.3	4.0	785.7 40.3	3.86
SD	369682.6 206.0	0.8	635.1 69.9	1.2

Statistics highlighted in blue: round 3 Delphi study results with subjects 1-7 (experts in the field of high school entrepreneurship).

on funding and timing of start-ups, which can be used to guide potential high school entrepreneurs and venture capitalists. This section consists of the explanation of the results relating to the subjects' perceptions of the importance of Personality Traits, Institutional Support, and Timing about entrepreneurial success. The order of PTI is organized according to the ranking of priority by the subjects.

5.1 Personality Traits

Over three rounds of the Delphi surveys, 100% of the subjects reached the consensus that the personality factor is the most crucial predictor of entrepreneurial success. This finding supports theories that argue personality is an influential factor of entrepreneurial success as it appears that young entrepreneurs inherently possess personality traits that promote innovative business ventures (Bergmann et al., 2016;

Politis et al., 2011, p.17; Luthje & Franke, 2003, p. 143). Of the five characteristics included within the Delphi study, the subjects prior and past administration of the posed questions identified *Openness to Experience*: flexibility in response to market needs to be rated the highest in terms of significance. Before the Delphi study, the results of the personality test (Table 2) showed that *Openness to Experience* is a required trait. At the same time, the consensus of the Delphi Study rated *Openness to Experience* to be the most valued trait out of the “Big-5 model”. In the context of adolescents, this finding indicates the importance of emphasizing flexible thinking and decision making in young entrepreneurial education. Business-related education programs, simulation exercises (e.g., Cap-sim), exposure to business practices, and comparative analysis of businesses would prove to be beneficial in fostering this trait (Bedawy, 2017).

On the contrary, there are also traits in the “Big-5

INFLUENTIAL FACTORS FOR YOUNG ENTREPRENEURIAL SUCCESS

model” that are least identifiable as predictors of success in the context of high school entrepreneurs. An evident example is *Agreeableness: people management with the right balance of delegation*, which has the lowest means and highest standard deviation ($M= 2.57$, $SD=1.27$). With expertise and success in the field, subjects 1 – 7 suggested that there is not an ideal type of leadership. Different types of leadership can become useful in various industries. For example, while autocratic leadership often has a negative connotation as the leader controls all significant decision makings. Subject 7, an “authority-obedience manager,” believed “this type of leadership trait can be quite effective for the success of [his] business products which requires time efficiency and quick execution.” Thus, it is essential for high school entrepreneurial educators understand that they do not have to reinforce the knowledge of one type of leadership on students, but explain to them the advantages and disadvantages of each type of leadership and support them to find the type of leadership that best suits their personalities and their businesses.

5.2 Institutional Support

The results of the findings demonstrate that the business practices of young entrepreneurs are highly interdependent upon technology, i.e., social media platforms; therefore, the start-up funding from the subjects’ perspective was remarkably less than expected. Later, seven high school students with zero entrepreneurial experience (subjects 8 - 14) were interviewed about start-up funding estimation. Their perception of the minimal amount of funding was significantly higher than the experts’ (subjects 1-7) in the study (see Figure 3).

Furthermore, the potential entrepreneurs strongly agree ($M=4$) that the amount of funding is a crucial determinant of why they did not open their business while not acknowledging that their forecast could be wrong due to the accessibility of “free apps and online tools” mentioned by subject seven whose company has an annual revenue of more than one million CAD and believed a \$0 budget is required to start a business. Hence, if venture capitalists assign more budget into campaigns that teach the use of inexpensive tools to students to build up their businesses via the internet, then it is hypothesized that more young individu-

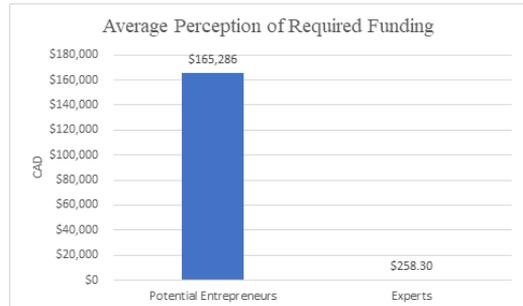


Figure 3: Average Perception of Required Funding (CAD)

als may consider embarking upon developing their business pursuits. For example, the LaunchX campaign in the U.S. is an educational business program that teaches students how to create their businesses primarily through the use of technology as most of the students from the LaunchX campaign set up their businesses online (Kilkeel).

5.3 Timing

The range of time that is required to develop and implement business practices varied throughout the three rounds of the Delphi study with no agreement which serves as an indicator that there is not a specific amount of time that is required to open a business; whereas the actual entrepreneurship is more focus oriented as entrepreneurs set goals and achieve them.

Despite the variation of opinions among the first category of subjects (1 – 7), their estimation of required preparation time is still significantly lower than what the second category of subjects (8 – 14) have predicted (5% of their prediction) (see Figure 4). Again, this implies that potential high school entrepreneurs might not have conducted extensive research or obtained accurate information about preparation time for opening a business in high school. Although their predictions could be valid in a professional business setting, they lack the hands-on experience to plan and operate a business at their age, which caused this perception gap. Thus, this finding inspires potential entrepreneurs not to be intimidated by the stereotypes of expensive funding and long preparation time for start-ups as these might be incorrect perceptions, according to experts who have experience in the field. While timing perception is not proven to be an out-

INFLUENTIAL FACTORS FOR YOUNG ENTREPRENEURIAL SUCCESS

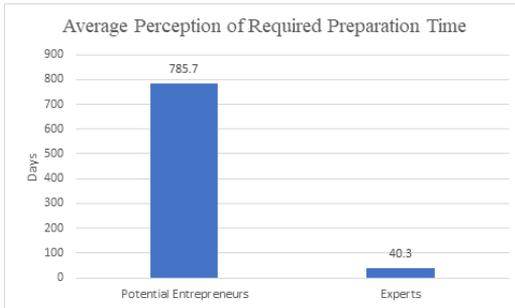


Figure 4: Average Perception of Required Preparation Time (days)

standing factor contributing to entrepreneurial success, the implication of the responses shows having a more optimistic attitude of financial support and preparation time might encourage more adolescents to become potential entrepreneurs.

6. Limitations

First, because this is not a longitudinal, multi-year study, several students' businesses may be profitable and thriving in the status quo, but the sustainability of future success cannot be predicted. To counter this, subjects other than current high school entrepreneurs, such as teachers and university entrepreneurs whose businesses have been operating for a few years, were recruited to produce a more reliable consensus. Moreover, the definition of success for this research, to reach and sustain profitability for at least one year, could be too generalizable as different models of entrepreneurship may rely on different factors for their success (e.g., userbase, ability to attract investors, social impact, etc.). Future researches could also use the PITF model – Personality, Institutional support, Timing perception, and Family background (in the order of importance) – to explore further factors that support youth entrepreneurial success with the focus of a specific type of entrepreneurship.

Second, after reviewing the summary of each Delphi round, it is a limitation that subjects might abandon their initial responses to conform to popular opinions. Thus, the study protects the anonymity of all subjects and encourages them only to change their

responses if they are genuinely convinced by others' rationales.

Another limitation is that all the subjects are from the same geographical area: Ontario, Canada, where individuals have an annual middle-to-high average income of \$49,000 in 2018 (Statistics Canada). Thus, the conclusion from this study is limited to a narrow socioeconomic demographic. This leaves the opportunity for future researchers to explore the direct and indirect financial factors that contribute to high school entrepreneurial success, with greater emphasis.

7. Conclusion

Through this Delphi study, the influential factors that might contribute to adolescent entrepreneurial success were examined, and the PITF model was evaluated. It was found that Personality is the most important factor, while Family background is deemed to be the least important factor. After comparing the responses between the experts (subjects 1-7) and non-experts (subject 8-14), results have shown apparent differences between their perceptions. Non-experts responded significantly higher in terms of cash (Institutional support) and Time needed to establish a start-up due to the lack of acknowledgment of inexpensive technical tools for entrepreneurship and experience in business operation. However, the opinions of the experts and non-experts provide a narrow representation of all adolescents. In the future, there are two types of studies that can enhance the validity of this study's results: 1) quantitative studies on PITF that is generalizable to a larger population and 2) case studies that show a more extended time of the growth of the adolescent entrepreneurs and their business development.

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Appendix A: Basic Information

1. Your name: _____
2. Your company's name (answer "/" if you are/were not a high school entrepreneur):

3. Describe your business in 5-10 words (answer "/" if you are/were not a high school entrepreneur):

4. How long have you been operating your business?
 - less than a month
 - 1 - 12 months
 - 1 - 5 years
 - more than five years
 - I am/was not a high school entrepreneur
5. Annual revenue (CAD) (answer "/" if you are/were not a high school entrepreneur):

Appendix B: Personality Factors

Questions		1 = strongly disagree	2	3	4	5 = strongly agree
1.	I am willing to fail for the sake of innovation.					
2.	I feel uncomfortable making decisions with uncertainty.					
3.	When I need to concentrate, I can tune out my environment.					
4.	I offer quick responses to my employees and my customers.					
5.	I find myself thinking about ways to improve products to meet the changes in our culture.					
6.	I have a vision of my company five years from now.					
7.	I have detailed short-term plans for my company.					
8.	Most of the time, I would instead delegate than be entirely responsible for all aspects of the task.					

Personality Test Explanation

Questions	Big-5 Category	Explanation	
1.	I am willing to fail for the sake of innovation.	Neuroticism: emotional stability and comfort with uncertainty	
	The two statements test whether subjects are willing to take innovative risks with potential failure and comfortable with uncertainty.		
2.	I feel uncomfortable making decisions with uncertainty.		
3.	When I need to concentrate, I can tune out my environment.	Extraversion: confidence and laser-like execution	The two statements test whether subjects are focused, quick-to-act, and confident with decision-making.
4.	I offer quick responses to my employees and my customers.		
5.	I find myself thinking about ways to improve products to meet the changes in our culture.	Openness to Experience: flexibility in response to market needs	The statement test whether subjects plan to improve/renovate their products aligning with the changes in market needs.
6.	I have a vision of my company five years from now.	Conscientiousness: big picture focus coupled with detail orientation	The two statements test whether subjects have long-term and short-term plans for their company.
7.	I have detailed short-term plans for my company.		
8.	Most of the time, I would instead delegate than be entirely responsible for all aspects of the task.	Agreeableness: people management with the right balance of delegation	The statement tests the extent of how much the subjects delegate their responsibilities.

Appendix C: Family Background

1. I have family members who are entrepreneurs.
oYes
oNo
2. My family highly supports my entrepreneurial endeavors, along with my education.
oYes
oNo
3. My family financed the grassroots of my business.
oYes
oNo
4. Did your parents pay for your education (elementary school, high school, university)?
oYes
oNo
5. Do you have a part-time job alongside your business?
oYes
oNo

Appendix D: Institutional Support

1. What support have you used for your business' initial funding?
oFamily
oGovernment funding
oAngel Investors
oVenture Capitalist
oCrowdfunding
oOther: _____ (please indicate)
oI am/was not a high school entrepreneur

Appendix E: the Delphi Method

1. If you must choose, what do you think is the most important personality to be a high school entrepreneur?
oNeuroticism: emotional stability and comfort with uncertainty
oExtraversion: confidence and laser-like execution
oOpenness to Experience: flexibility in response to market needs
oConscientiousness: big picture focus coupled with detail orientation
oAgreeableness: people management with the right balance of delegation
2. If you must choose, which one – personality factors, family background, or institutional support – is most important for becoming a successful high school entrepreneur?
o personality factors
o family background
o institutional support

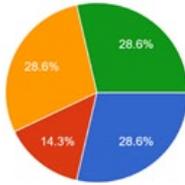
3. Please estimate how much funding does a high school student need to open a new business (CAD) and why:

4. Please estimate how much preparation time does a high school student need to open a new business and why:

INFLUENTIAL FACTORS FOR YOUNG ENTREPRENEURIAL SUCCESS

If you must choose, what do you think is the most important personality to be a high school entrepreneur?

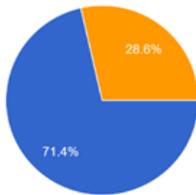
7 responses



- Comfort with uncertainty
- Laser-like focus and execution
- Flexibility in response to market needs
- Big picture focus coupled with detail orientation
- People management with the right balance of delegation

If you must choose, which one – personality factors, family background, or institutional support – is most important for becoming a successful high school entrepreneur?

7 responses



- personality factors
- family background
- institutional support

Appendix F: Summary of Round 1 Results

Summary: the Delphi Study (First Round)

Hi participants, thank you so much for participating in the first round of the Delphi Study! Your participation means a lot for this research as you are one of the seven participants who came from various backgrounds with expertise in young entrepreneurship.

In the second round, participants receive the second survey consisting of the same questions from the fifth section: the Delphi method in the first survey. You are asked to review and assess the following results from the first round, and you will, most likely, revise your answers based on what others have responded in the second survey.

Please estimate how much funding does a high school student need to open a new business (CAD) and why:

7 responses

\$250.00

1000

2k

\$100, all you need is a website or an app. In high school, we are dependants so we don't have to worry about food on the table.

None, so many amazing tools out there for free that can help you make a solid product

3000; high school students most likely won't need salaries, if it's a hardware company then funding would depend

\$100-200 - \$10 cost per unit x 10 units should get you started on sales; use profit to purchase more product

Please estimate how much preparation time does a high school student need to open a new business and why:

7 responses

One Day

At least one month - for market research and producing the MVP

Two months

20 hours, it is less about the idea and more about the execution and how much time you put into it.

A lot or a little depending on the industry.

5; market research, planning

20 hours - 4-5 hours devising Business Plan, 10 hours to research and source product, 5+ hours marketing strategy

Appendix G: Summary of Round 2 Results

If you must choose, which one – personality factors, family background, or institutional support – is most important for becoming a successful high school entrepreneur?

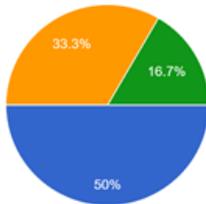
6 responses



- personality factors
- family background
- institutional support

If you must choose, what do you think is the most important personality to be a high school entrepreneur?

6 responses



- Neuroticism: emotional stability and comfort with uncertainty
- Extraversion: confidence and laser-like execution
- Openness to Experience: flexibility in response to market needs
- Conscientiousness: big picture focus coupled with detail orientation
- Agreeableness: people management with the right balance of delegation

Please estimate how much funding does a high school student need to open a new business (CAD) and why:

6 responses

\$100, just server costs, realistically no money is needed to get a business off the ground

\$300; product should not retail for more than \$20, so per unit cost of product should be 50% of \$20, which is \$10. Estimate that one purchases 20 units, totals \$200 + shipping, some marketing materials = \$300 approx.

0 - same as before. So many tools

\$250 - studies show that "bootstrapping" is just as important as the product or service.

\$500; it really depends on the type of business

0; income not needed (unless it's a hardware company that needs funding for production)

Please estimate how much preparation time does a high school student need to open a new business and why:

6 responses

20 hours, time is needed to talk with people and understand the problem that you are trying to solve.

15-20 hours; 5 hours researching product/market/environment; 5 hrs sourcing suppliers; 5 hours marketing strategy; 5 hours designing business plan

Lots of time at the start to make sure you're on the right path

A week at most with proper support.

At least one month - for market research, planning, producing the MVP..

half year

Appendix H: Consent to Participate Form

Informed Consent

AP Capstone Research Study

Appleby College | Oakville, ON, Canada L6K 3P1

Introduction

- You are being asked to be in this research study for the AP Capstone Research course.
- You were selected through LinkedIn or personal connections as you are/was a young entrepreneur.
- Please read this form before providing your consent.

Description of the Study Procedures

- If you agree to be in this study, you will be asked to do the following things:
 1. Fill in a personal survey
 2. You might be asked to participate in a follow-up interview

Risks/Discomforts of Being in this Study

- There are no reasonably foreseeable (or expected) risks. There may be unknown risks.

Benefits of Being in the Study

- The benefits of participation are:
 1. A background understanding of my selected topic of research
 2. A reflection and a better understanding of yourself from the personal survey

Confidentiality

- The records of this study will be kept strictly confidential. My teacher and I will be the only ones looking at the data.
- Your identity will be disclosed in the material that is submitted. However, you will be given the opportunity to review and approve any content that is provided about you.

Right to Refuse or Withdraw

- The decision to participate in this study is entirely up to you. You may refuse to take part in the study at any time without affecting your relationship with the investigators of this study or Appleby College. Your decision will not result in any loss of benefits to which

you are otherwise entitled. You have the right not to answer any single question, as well as to withdraw entirely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material.

Right to Ask Questions and Report Concerns

- You have the right to ask questions about this research study and to have those questions answered by me before, during, or after the research. If you have any further questions about the study at any time, feel free to contact me. If you like, a summary of the results of the survey will be sent to you.
- If you have any problems or concerns that occur as a result of your participation, you can report them to guidance and/or myself.

Consent

- Your signature below indicates that you have decided to volunteer as a research participant for this study and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigators.

Subject's Name (print):

Subject's Signature:

Date:

Investigator's Signature:

Date:

The Cus Efflux System and *E. coli* Resistance to Green-Synthesized Silver Nanoparticles

Pragyat Khanal

This study aimed to determine how the deletion of the *cusC* gene influences *E. coli* growth in a medium containing silver nanoparticles. Two strains of *E. coli* were ordered, one of which had a deletion of the *cusC* gene, and were placed into four culture tubes each, which all contained nanoparticles. A quantitative approach and a posttest-only control group design were executed to compare the growth of the two strains by measuring the tubes' optical densities (ODs) every hour while in school. A smooth line curve showed that the strain without the *cusC* gene ceased growth after some time while the parent strain continued to grow, and inferential statistics showed that a manipulated factor caused the difference in the final OD values of the strains. Thus, the deletion of the *cusC* gene appeared to reduce bacterial resistance when exposed to nanoparticles. This information can be used in the development of future therapeutics.

Keywords: Cus efflux system, silver nanoparticles, *E. coli*, *cusC*, bacterial resistance, optical density

Introduction

In the field of microbiology, bacterial diseases have become increasingly prevalent. While antibiotic treatments have been administered to those who fall ill, various bacterial strains have evolved and developed resistance to combat the toxic nature of these antibiotics. Such is the case when resistant bacteria survive and pass their genes to their offspring while the non-resistant bacteria die off and do not reproduce. The overall bacterial resistance to antibiotics has been significant enough for Alanis (2005, p. 704) to claim that "the era where acute or chronic bacterial infections used to be treated with 'antibiotics-only' appears

to have come to an abrupt end." Therefore, with the seemingly ineffective nature of antibiotic treatments, an alternative antimicrobial agent and its impacts on bacterial resistance should be studied extensively.

Literature Review

Bacterial Antibiotic Resistance

There has been ample research regarding methods of bacterial resistance to antibiotics, one of which are through efflux pumps, which are mechanisms incorporated within the bacterial cell membrane that are responsible for expelling antimicrobial, or harmful,

agents, such as antibiotics. Tenover (2006) called attention to the various resistance mechanisms and described that these efflux pumps work quickly to ensure the antimicrobial agents do not collect within the cell before traveling to an active site to trigger their effects. Additionally, Marquez (2005) pointed out that MDR, or multi-drug resistant, efflux pumps are the most responsible for overall bacterial resistance to antibiotics and other antimicrobial agents due to their ability to expunge a wide variety of therapeutics. Delmar et al. (2013) gave a description of one such efflux pump, the Cus efflux system, which opens up to initiate the discarding process in the presence of heavy metals. More specifically, the CusC pump in this system is responsible for discarding copper and silver ions. Therefore, manipulating the gene expression of these pumps could be related to bacterial resistance. To add on, Blair (2015) presented a clear evaluation of how well efflux pumps function and established that they correspond to increased bacterial resistance when the genes coding for the pumps were overexpressed. In other words, influencing the genes that code for efflux pump structure will affect their efficiency in discarding antimicrobial agents. Overall, resistance mechanisms can be controlled; however, research regarding how methods of resistance can be manipulated has been lacking.

Silver Nanoparticles

Silver nanoparticles (AgNPs) are small pieces of silver that have shown various cytotoxic effects on bacterial strains. Shrivastava et al. (2007, p. 8) identified and reported that “once inside the cell, nanoparticles would interfere with the bacterial growth signaling pathway by modulating tyrosine phosphorylation of putative peptide substrates critical for cell viability and division.” By inhibiting cell division, nanoparticles jeopardize the survival of bacteria. Additionally, Morones et al. (2005, p. 2352) examined the effect of these nanoparticles, which “attach to the surface of the cell membrane and drastically disturb its proper function, like permeability and respiration”. Disrupting the function of the cell membrane creates easy openings to allow other harmful substances to enter and affect bacterial cells. Salopek and Salopek-Sondi (2004) corroborated with Morones et al. as they gave cognizance to the charge of silver nanoparticles, which disrupts

the structure of the cell membrane and eventually makes the cell vulnerable to additional antimicrobial agents. Moreover, nanoparticles can affect protein synthesis and inhibit the progression of the cell cycle. Liu et al. (2010) observed that nanoparticles arrested human cells in the S, or synthesis, phase of interphase in the cell cycle. DNA strands are replicated to prepare for cell division, or mitosis, during the S phase. Since silver nanoparticles have the effect of trapping bacteria in the S phase and not letting them progress, cell growth stagnates. Based on all of these studies, silver nanoparticles seem to be an effective alternative antimicrobial agent to antibiotics.

With the growing popularity of silver nanoparticles in the biology and medical fields, new methods of nanoparticle synthesis have emerged. Yakout and Mastoga (2015, p. 3538) performed and discussed one such method, green synthesis, in which they used nontoxic chemicals, such as starch, due to “simplicity, cost effectiveness, [and] compatibility for biomedical and pharmaceutical application”. Research involving green synthesis of silver nanoparticles has been lacking since it is a fairly new concept, so an experiment focusing on their influence would establish a new understanding of them.

Research on Efflux Pumps

Current research on changes in efflux pump structure have shed light on mechanisms that affect the antimicrobial resistance of bacteria. Ni et al. (2016) presented evidence that colistin-resistant bacteria could be susceptible to colistin, an antibiotic, if efflux pump inhibitors (EPIs) were introduced to the bacterial strains, ultimately inhibiting bacterial growth within the medium. If efflux pump functions are disturbed by an outside force, bacterial resistance to certain antimicrobial agents will decrease, opening doors for studies on other inhibition methods. Furthermore, Anes et al. (2015) presented a clear evaluation of the EPIs when used in combination with antibiotics, which can undo the resistance that the bacteria have developed for ages. Anes et al. also claim that using EPIs with antibiotics would be an effective measure to treat bacterial diseases. Whereas inhibitors limit the function of efflux pumps, these efflux pumps can also be manipulated to increase their function. Sun et al. (2014, p. 263) focused on this overexpression, which “has

been frequently found in clinical isolates that have increased MICs to antibiotics.” The MIC, or minimum inhibitory concentration, is the lowest concentration of antibiotics that will hinder bacterial growth. The increase in MIC means the bacteria are able to tolerate antimicrobial agents at higher concentrations. Thus, the efflux pump function has increased. All in all, changes to efflux pump functions have shown to influence bacterial resistance to antimicrobial agents, but testing alternative methods of efflux pump manipulation would provide a better picture of this cause and effect relationship.

Gap in Knowledge

With all the information surrounding silver nanoparticle cytotoxic effects and efflux pump function, the genes that code for these efflux pumps have not been touched upon often. Krishnamurthi et al. (2019) arrived at a conclusion in their study that population growth of *E. coli* staggered when grown in a medium containing silver ions. They hypothesized that mutations of the Cus efflux system conferring to overexpression causes increased bacterial resistance; however, they stressed that the Cus efflux system has not been directly mutated to test for *E. coli* resistance to silver nanoparticles. This gap in knowledge, along with the emerging use of green-synthesized silver nanoparticles, leads to the following research question: to what extent does the deletion of the *cusC* gene, which codes for the CusC efflux pump, influence *E. coli* resistance to green-synthesized silver nanoparticles within the growth medium? Based on previous research, overexpression of the *cusCFBA* operon, a section of bacterial DNA containing genes (including *cusC*) that code for Cus efflux pumps, should result in greater antimicrobial resistance and nanoparticle extrusion, and underexpression of this operon should produce the opposite effect. The purpose of this research is to explore another method of inhibiting efflux pumps and testing the effectiveness of this method by measuring bacterial resistance to silver nanoparticles. The execution of this study is significant in an age of medical research while also providing information useful in developing future therapeutics that can treat bacterial diseases.

Methods

Research Approach

This study attempted to investigate how the deletion of the *cusC* gene, which codes for the Cus efflux system, affects *E. coli* resistance to silver nanoparticles via a quantitative approach. A quantitative approach best fit this experiment because the main measuring instrument used, a nanodrop, allowed for the collection of numerical data that would objectively describe the growth of *E. coli* in their respective culture tubes and would provide an explanation of the effect of Cus efflux pump mutations on bacterial survival. Previous studies have used the quantitative approach to explain cell behavior when exposed to silver nanoparticles. Krishnamurthi et al. (2019) utilized time-lapse microscopy and discovered that cell lengths of *E. coli* bacteria oscillated when exposed to silver ions by measuring their lengths over a period of time. They used this numerical data to determine how silver ions affect bacterial length. Thus, a quantitative approach would allow for the formulation of reasonable conclusions via the collection of numerical data.

Methodologies

A posttest only control-group experimental design, in which the control group and experimental group are only tested after a treatment is imposed on the experimental group, best fit this research study. The experimental group of *E. coli* was mutated before testing resistance to nanoparticles as they had to be ordered beforehand. Therefore, growth in both groups was observed at even intervals only after the experimental group was treated. The control group had the parent, or original, *E. coli* strain in culture tubes, while the experimental group had the mutant *E. coli* strain without the *cusC* gene in culture tubes. This experimental design allowed for the reduction of confounding variables from influencing the study. Changes in bacterial population were measured by recording the optical density (OD) of the culture tubes in a nanodrop at even intervals, and a growth curve was created based on the data collected. Various studies have conducted a similar experimental design for similar experiments. Salopek and Salopek-Sondi (2004) tested how silver nanoparticles affect bacterial growth. *E. coli* bacte-

THE CUS EFFLUX SYSTEM AND RESISTANCE TO NANOPARTICLES

ria were separated into two groups: one group was placed in media containing silver nanoparticles, and the other group was placed in media lacking nanoparticles. Then, the bacterial population was measured in even intervals. As for the method of measurement, the optical density of the culture tubes was recorded in a spectrophotometer every 30 minutes to measure bacterial population, as this is the most reliable and efficient way to quantify bacterial population.

Subject Selection

E. coli is one of the most common bacteria used in scientific research in the biology and biotechnology fields. Su et al. (2010) worked with *E. coli* to determine how different proteins in the cell membrane work together when exposed to copper or silver ions. Additionally, Delmar et al. (2013) determined that the Cus efflux pump opens up when *E. coli* are exposed to ionic copper or silver. Thus, *E. coli* is popular in the biology community because of its ease of accessibility and use. Furthermore, the rapid reproduction rate of *E. coli* allowed for data collection to take place within the limited given time frame. Therefore, *E. coli* was used to determine the relationship between *cusC* deletion and resistance to silver nanoparticles.

Data Collection

Before the experiment ran, the parent strain (designation number: BW25113) and the mutant strain (designation number: JW0561-1), which were both obtained from the Coli Genetic Stock Center at Yale University, were cultured onto an agar plate for two days. After culturing, data was obtained via frequent testing on the eight culture tubes used. These tubes were divided into two groups of four each; each tube in the control group received a colony of the parent strain, while each tube in the experimental group received a colony of the mutant strain. All tubes contained 5 mL of an LB (lysogeny broth) medium and 30 μL of a silver nanoparticle solution, which were synthesized via a redox reaction between soluble starch and silver nitrate (AgNO_3). The green-synthesis procedure by Yakout and Mostaga (2015) was mirrored in which 10 mL of 1% soluble starch was mixed with 50 mL of 1 mM AgNO_3 on a hot plate for 3 hours until the solution turned a brownish-yellow color. After

the bacteria were placed in their respective tubes, they were placed in an incubator at a temperature of 37° . Their OD values were recorded by extracting 2 μL of each culture onto a nanodrop, with the wavelength set at 600 nm. In this experiment, an OD value of 1 is equivalent to approximately 10^8 bacterial cells. The nanodrop was blanked, or reset to an OD of 0, with the original LB each time. The OD of all eight tubes were measured every hour while in school over the span of two days before they were discarded.

Analysis

After two weeks of testing and obtaining results, the data for all eight tubes were used to construct a smooth line graph in which the x-axis was time elapsed and the y-axis was the OD of the test tubes. The graphs between the two groups were then compared to each other and to an ideal bacteria growth curve (see Appendix A). Abnormalities in the graphs, such as premature stagnation or dips, were taken into account and recorded. In addition, inferential statistics was used to determine whether the difference between the mean bacterial populations of the two groups was a chance variation or a variation due to the deletion of the *cusC* gene in the mutant strain of *E. coli*.

Validity

Construct validity was established by only using the optical density of the culture tubes for its intended purpose of measuring bacteria population and then analyzing these results. In addition, internal validity was ensured by conducting this experiment in a classroom laboratory setting in order to reduce the effects of confounding variables. The protocol was performed in a laminar flow hood to prevent contamination of the culture tubes from bacteria in the air. Also, the culture tubes were placed in an incubator at a constant temperature of 37° , and there was minimal outside interference with the incubator. Therefore, differences between resistance to nanoparticles between the parent strain and the mutant strain could be confidently attributed to the deletion of the *cusC* gene. Furthermore, external validity was ensured by having a representative sample of *E. coli* and a culture environment, LB, that resembles natural *E. coli* habitats.

E. coli are identical in nature, so any sample obtained would represent the population of *E. coli* well, and the results obtained in this study can be attributed to the entire *E. coli* population; also, they were grown in a representative environment, so these results can be attributed to any *E. coli* culture, not just those grown in a laboratory.

Results

Overview

The purpose of this experimental study was to determine the extent to which the *cusC* deletion influences *E. coli* resistance to green-synthesized silver nanoparticles. Data were collected from February 10 to February 12, 2020, in which the ODs of each of the eight culture tubes incubated at 37°C were recorded on a nanodrop every hour while in school. Then, two tests were executed to determine the extent to which the deletion of the *cusC* gene influenced growth. The first test was to compare the line graphs of the parent strain group and the mutant strain group with each other and the ideal bacterial growth curve (see Appendix A). The second test used inferential statistics to confirm the extent to which the differences in the final OD values were due to chance or due to the deletion of the *cusC* gene.

Visual Representation of Growth

Each hour, 2 µl of each culture were placed on the nanodrop to measure the respective tube's OD value.

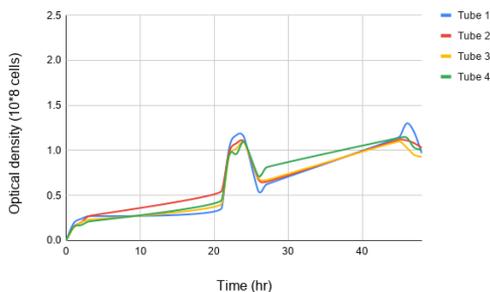


Figure 1a. Change in OD of parent strain tubes over time (left)

These obtained values (see Appendix B) were used to construct a smooth line graph showing the change in OD over time in the tubes containing the parent strain and the tubes containing the mutant strain. Figure 1a shows the line curve for the change in OD over time for the parent strain tubes, and Figure 1b shows the line curve for the change in OD over time for the mutant strain tubes.

As shown in the two figures, silver nanoparticles may have influenced both the parent strain and the mutant strain. In Figure 1a, the parent strain seemed to have entered the exponential phase between 21 and 22 hours, but its growth stagnated at around 23 hours before dropping from 24 to 26 hours. Eventually, the strains grew again at a steady rate. Compared to the ideal bacterial growth curve, the parent strain seemed to have reached the stationary and death phases fairly quickly before recovering and re-entering the lag and exponential phases. In Figure 1b, the mutant strain seemed to have entered the exponential phase at around the same time as the parent strain, but its growth was more rapid. Its growth then declined rapidly between 23 and 24 hours before growth appeared to have ceased. Compared to the ideal bacterial growth curve, the mutant strain seemed to have also reached the stationary and death phases fairly quickly, but it did not seem to re-enter the exponential phase since growth stagnated altogether. This trend is somewhat similar to the study conducted by Salopek and Salopek-Sondi (2004) in which they let *E. coli* grow on agar plates in different concentrations of silver nanoparticles. In their case, growth of the bacteria was delayed when exposed to nanoparticles, similar to how growth stagnated in this experiment.

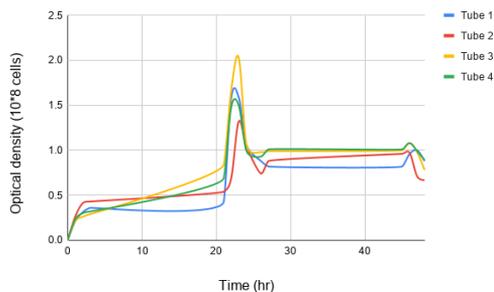


Figure 1b. Change in OD of mutant strain tubes over time (right)

Chance Variation Calculation

To determine whether the deletion of the *cusC* gene truly had an effect on bacterial growth, the OD values at 48 hours were taken. The sample mean of the OD values of the parent strain tubes, or \bar{x}_1 , was 0.985, with a standard deviation of approximately 0.04435. The sample mean OD values of the mutant strain tubes, or \bar{x}_2 , was 0.805, with a standard deviation of approximately 0.10279. Then, using inferential statistics, a null hypothesis was formed, which was that the difference between the means of the OD values of the two groups is zero, or $\mu_1 - \mu_2 = 0$, in which μ_1 is the true mean OD value of all parent strain tubes, and μ_2 is the true mean OD value of all mutant strain tubes. Since the original hypothesis stated that the mutant strain growth would stagnate, and the sample data showed that $\bar{x}_1 - \bar{x}_2 = 0.18 > 0$, the alternative hypothesis formed was $\mu_1 - \mu_2 > 0$. An alpha (α) significance level of 0.05 was used to make sure the null hypothesis was not prematurely rejected. After running a two sample t distribution test with approximately 4.08 degrees of freedom, the obtained P-value was 0.016. In context, this P-value means that assuming $\mu_1 - \mu_2 = 0$, there is only a 1.6% chance that a sample mean difference would be at least as extreme as 0.18. Therefore, the difference in means most likely did not occur due to chance.

Summary of Results

Overall, the results suggest a relationship between the deletion of the *cusC* gene and resistance to nanoparticles. First off, mutant strain growth seemed to stagnate after a large decline in growth while parent strain growth steadily increased under the same conditions. In addition, the difference in final OD values between the parent strain and the mutant strain was likely not a coincidence.

Discussion

Overview

To reiterate, the purpose of this study was to determine the extent to which the deletion of the *cusC* gene influences *E. coli* growth in medium contain-

ing green-synthesized silver nanoparticles, which attempted to fill a gap in research relating to how mutations of the *cusCFBA* operon affect bacterial growth when exposed to nanoparticles. This relationship was examined using a quantitative approach and more specifically a true experimental method with a post-test-only control group design. A parent strain with the *cusC* gene was separated into four culture tubes from a mutant strain without the *cusC* gene, which were also placed in four culture tubes. Both strains were incubated at 37°C, and their ODs were measured on a nanodrop every hour during the school day for 48 hours. After data collection, the obtained OD values were plotted on a smooth line graph to examine differences in growth, and inferential statistics was used to determine whether chance variation was a reasonable conclusion for the differences in data. The smooth line graphs show that growth of the two groups were similar in the beginning until the exponential growth and subsequent decline in growth of the mutant strain was sharper, and the parent strain resumed its growth after the decline, whereas growth ceased for the mutant strain. Inferential statistics showed that there is a low probability of obtaining two sample mean OD values in which their difference is as extreme as the calculated difference of 0.18.

Significance of Results

The results show that both strains grew in a similar nature for the first 21 hours. Growth was slow but progressing until the 22nd hour when growth exponentially increased for both strains. The mutant strain had a higher growth peak at 23 hours, but its growth ultimately dropped before stagnating. The parent strain grew at a steady rate after 26 hours after a small drop at 24 hours. Both curves had another small drop in growth after 46 hours. Afterwards, a two sample t distribution test was executed to determine how likely the difference in the mean OD values at 48 hours between both strains was as extreme as was observed. The difference in sample means was 0.18, which was only 1.6% probable assuming that the true difference in mean OD values is 0.

In terms of the graphs, there seems to be enough evidence to conclude that the deletion of the *cusC* gene influenced bacterial growth. First, both strains experienced the lag phase for about 21 hours. This

extended lag phase corresponds to the study conducted by Krishnamurthi et al. (2019) which concluded that the lag phase of *E. coli* was significantly elongated when exposed to nanoparticles. After 26 hours, growth of the parent strain increased, and growth of the mutant strain stopped. Additionally, the drop of growth was sharper for the mutant strain from 24 to 26 hours. All of these factors seem to indicate that the silver nanoparticles affected growth of the mutant strain more than the growth of the parent strain. Franke et al. (2003) gave cognizance to the fact that the CusC efflux pump is responsible for full resistance to heavy metals. Therefore, it would be logical that the deletion of the *cusC* gene, which codes for the CusC efflux pump, decreases bacterial resistance to silver nanoparticles. Overall, this result is significant in the field of biology and biotechnology because the above trends show that green-synthesized silver nanoparticles, which have not been explored in the field often, are effective in inhibiting *E. coli* growth. Since green synthesis is a simple and cheap method of obtaining silver nanoparticles, as it only requires soluble starch and silver nitrate, future medicine and pharmaceuticals that treat bacterial diseases could be made more cost efficient.

However, the larger peak growth for the mutant strain deviated from its expectation that it would not grow well in the presence of silver nanoparticles. This phenomenon could be explained by the mutant strain initially growing better in the presence of silver nanoparticles than the parent strain. Krishnamurthi et al. (2019, p. 8) commented that approximately 7% of bacterium were able to “win the battle” against nanoparticles and eventually reproduce, which may explain the initial large growth for the mutant strain before quickly dying off. Also, imperfections in the laboratory setting or equipment could have contributed to this high peak. Overall, this experiment should be conducted in a better setting with better equipment and timing to determine whether this higher peak is of any significance.

The results are also statistically significant because the obtained P-value, 0.016, is less than the α significance level of 0.05. Again, this P-value means that there is only a 1.6% probability of obtaining two samples of culture tubes in which their mean OD values have a difference at least as extreme as 0.18. Therefore, the null hypothesis is rejected because there is

convincing evidence of a difference in the true mean OD values between the parent strain and the mutant strain. Thus, the extent of the difference in mean OD values between the parent strain and the mutant strain was probably caused by an outside factor. Since this experiment was carefully controlled in a sterile environment with little outside interference, and the independent variable was the presence of the *cusC* gene, this factor most likely contributed to this difference, which corresponds with previous studies; Delmar et al. (2013) asserted that the CusC efflux pump serves as the last step in heavy metal extrusion within *E. coli* and essentially opens the outer membrane channel. Therefore, it would be logical to conclude that when the CusC pump is ineffective via a deletion of its gene, silver nanoparticles cannot be extruded, and these nanoparticles can carry out their cytotoxic effects within bacteria. Overall, this result is significant because it rules out chance variation as a factor influencing the growth of the parent strain and the mutant strain.

However, the difference in final OD values appears to be small, which raises the question of the practical significance of this study. If this difference is as minute as 0.18, then chance variation may truly have had an effect instead of the deletion of the *cusC* gene. Thus, this study should be replicated to determine the extremity of the influence of the *cusC* gene on bacterial growth. Nevertheless, the data have statistical significance.

Limitations

Despite its straightforwardness, many obstacles were encountered concerning the developed procedure. First, the OD of the culture tubes could not be recorded between school days because the building was closed, which led to gaps in data collection. Thus, the line graphs were not continuous, and making comparisons between the line graphs became difficult because the OD of the culture tubes during these times were unknown. In addition, the cost of silver nanoparticles was well outside the budget for this experiment, so these nanoparticles were synthesized from scratch using common laboratory substances. The color change of the reaction was the only indication that nanoparticles were present, so it was un-

certain whether these nanoparticles were abundant enough for the experiment due to the lack of resources for a screening process.

Due to limited resources, there was no indicator that determined how both strains grew in the culture tubes. In fact, the experiment failed the first time it was executed. An inoculating loop was used to transfer the bacteria directly into the culture tubes from the disks they were delivered on. However, the strains did not grow in the culture tubes overnight. The next week, the disks were placed on agar plates, and the bacteria were allowed to grow. Then, using an inoculating loop, one colony was selected to place into each culture tube. This time, there was growth in all eight tubes overnight. In addition, gaps in data collection result in uncertainty over the true growth trends of the two strains because they could not be monitored every hour. All in all, the lack of resources extended the duration of the experiment, and the gaps in data collection led to unanswered questions about *E. coli* growth. The conclusions made in this study should be confirmed by future studies with better resources.

Future Studies

Future studies can focus on the specific pathways that green-synthesized silver nanoparticles take to inhibit cell growth, especially bacteria lacking the *cusC* gene. This study only determined the extent of the relationship between the deletion of the *cusC* gene and bacterial growth and predicted the nature of the bacterial strains while being grown. Hence, this study opens up many more questions about how the deletion affects growth when exposed to other metals and how deletions of genes that code for other efflux pumps affect growth. Ultimately, future studies can use this experiment as a jumpstart to answer more questions about *E. coli*, efflux pumps, and silver nanoparticles.

Conclusion

The original hypothesis of this study, which stated that mutations in the *cusCFBA* operon causing the underexpression of the CusC efflux pump should result in reduced antimicrobial resistance and nanoparticle extrusion, seems to be supported through the

data collected. The mutant strain was not able to grow in the presence of silver nanoparticles after some time, which was significant when compared to the parent strain that continued to grow in the same environment. Additionally, inferential statistics showed that a factor outside of chance variation must have had an effect on the differences in growth between the two strains. Overall, the hypothesis along with the obtained data worked together to develop the following argument: the deletion of the *cusC* gene appears to inhibit the growth of *E. coli* in medium containing green-synthesized silver nanoparticles. With this assertion, this study attempted to address a gap in knowledge concerning how manipulating efflux pump function through a novel method influences bacterial resistance to an emerging antimicrobial agent. By manipulating efflux pump function through the deletion of a key gene that codes for an important efflux pump in *E. coli*, this study effectively fills this gap by visualizing and calculating the major differences caused by this manipulation.

The silver nanoparticles in this study were of utmost importance because of their method of synthesis. In a process that has not been replicated often, the silver nanoparticles were synthesized through the reaction of silver nitrate and soluble starch, both of which are easily accessible and fairly inexpensive. Thus, the observable effect of these green-synthesized silver nanoparticles on both the parent strain and mutant strain of *E. coli* opens more doors to investigate their true nature and severity so that future therapeutics are able to incorporate them and thus reduce the cost of production. Also, this study affirms that efflux pumps play a key role in bacterial resistance to antimicrobial agents, thus opening more doors to investigate practical methods to inhibit their function in the human body when people are infected. Ultimately, this study has taken a step towards answering how to combat the trend of increased bacterial resistance to antimicrobial agents.

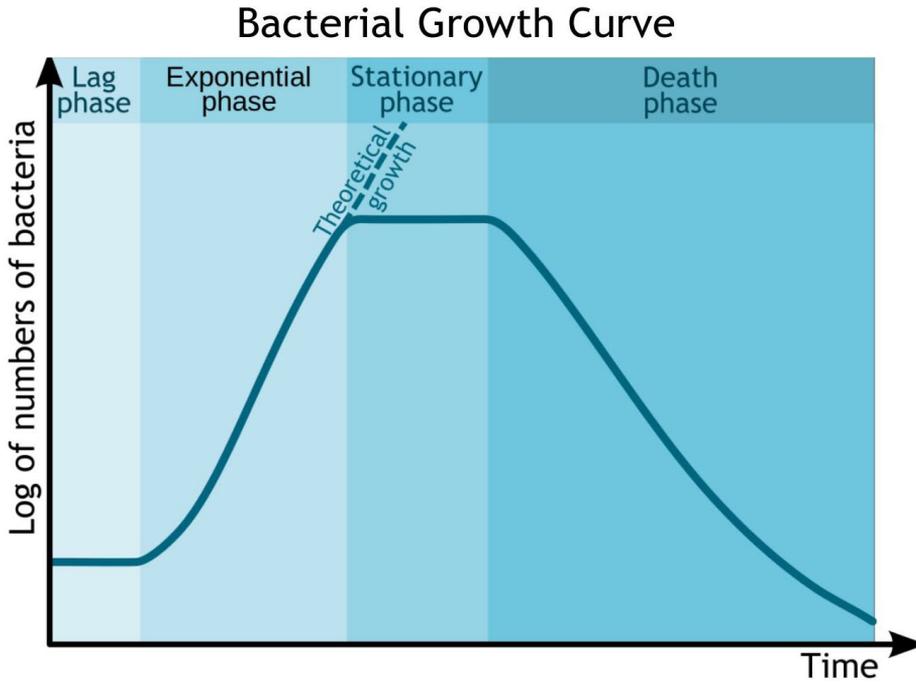
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Appendix A

Ideal Bacterial Growth Curve

Figure A1. Growth curve showing the stages of bacterial growth (Komorniczak 2009)



Appendix B

Obtained OD Values

Table B1. Recorded optical density values for each culture tube

Time (hr)	Optical density (10^8 cells)							
	<i>cusC</i> + (parent strain)				<i>cusC</i> - (mutant strain)			
	Tube 1	Tube 2	Tube 3	Tube 4	Tube 1	Tube 2	Tube 3	Tube 4
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.19	0.15	0.14	0.15	0.21	0.26	0.21	0.23
2	0.24	0.20	0.20	0.17	0.31	0.41	0.26	0.30
3	0.27	0.27	0.23	0.21	0.36	0.43	0.29	0.32
21	0.36	0.55	0.41	0.45	0.43	0.54	0.84	0.69
22	1.02	0.98	0.93	0.95	1.58	0.69	1.67	1.48
23	1.17	1.08	1.02	0.96	1.59	1.32	2.03	1.50
24	1.15	1.10	1.09	1.10	1.07	1.05	1.08	1.00
26	0.54	0.67	0.69	0.71	0.88	0.74	0.98	0.93
27	0.62	0.65	0.67	0.81	0.82	0.88	0.99	1.01
45	1.15	1.12	1.10	1.14	0.82	0.96	1.00	1.01
46	1.30	1.11	1.03	1.14	0.96	0.97	1.08	1.08
47	1.20	1.08	0.95	1.03	1.00	0.71	0.98	0.99
48	0.97	1.03	0.93	1.01	0.88	0.67	0.78	0.89

The Assessment of Unpaid Dementia Caregivers By Primary Care Clinicians

Asha Kalapatapu

This research study explores the relationship between the mental health of informal dementia caregivers and the assessment of this issue by primary care clinicians. Through the use of a survey, data was gathered to answer the question as to whether primary care clinicians address and identify the needs of caregivers in the outpatient setting, given the high rate of caregivers of dementia patients suffering from caregiver burden and its effect on their wellbeing. This study captures the frequency of primary care clinician identification of caregivers, evaluation of their stress, and referral to outside resources. It hypothesizes that primary care clinicians oftentimes do not address caregiver needs, due to time constraints, the large number of informal dementia caregivers, and the extent of their unmet needs and need for additional aid. After surveying primary care clinicians, the study concludes that while the majority of primary care clinicians identify the informal dementia caregiver, they less frequently evaluate their level of stress or refer them to outside organizations or resources.

Keywords: primary care clinician, informal dementia caregiver, persons with dementia (PWDs)

Introduction

Dementia is defined by the National Institute of Aging (2017) as a loss of cognitive function -- thinking, remembering, and reasoning -- to the extent to which it hinders a person's day to day activities. As the proportion of the elderly diagnosed with Alzheimer's dementia in the United States continues to grow significantly (Khanassov & Vedel, 2016), research indicates 8.4 million Americans aged 65 or older will suffer from the illness by 2030, according to the Alzheimer's Association (2019). Given the "complex interactions between cognitive deficits, psychological symptoms, and behavioral abnormalities" (Muller-Spahn, 2003) that persons with dementia, or PWDs,

endure, the support of a caregiver is essential for bettering the patient's and caregiver's quality of life (Brodaty & Donkin, 2009).

While research shows that PWDs are far more likely to live in a community or care facility than other recipients of care (American Association of Retired Persons), it is nevertheless true that approximately 75% of PWDs receive support from relatives or friends (Schultz & Martire, 2004), often referred to as informal, or unpaid, caregivers. There are quite a few explanations as to why informal caregivers fulfill this role, including "a sense of love or reciprocity, spiritual fulfillment, a sense of duty, guilt, social pressures, or in rare instances, greed" (Eisdorfer, 1991). The AARP reported that 60% of these informal caregivers are female, 57% are married, and roughly 41% are un-

employed. Studies have demonstrated that unpaid caregivers of PWDs often take the role of providing hands-on care, including dressing, toileting, bathing, and feeding, among other daily activities (Brodaty & Donkin, 2009; AARP, 2015). Studies find that the burden of these essential tasks result in emotional and physical stress and puts the caregiver's health at risk (AARP, 2015).

Literature Review

The Impact on Unpaid Dementia Caregivers

The strenuous tasks executed by unpaid dementia caregivers often increases their risk for high levels of stress, anxiety, and depression, among other health complications. Research at the University of California at Berkeley found that up to 40% of dementia caregivers suffer from depression, and most experience raised levels of social isolation, anxiety, and irritation (Anwar, 2017). The poor health outcomes caused by the daily stress of caregiver tasks is attributed to what is known as caregiver burden (Litzelman et al., 2015). This conclusion is supported by the *American Journal of Nursing* (2008), which found that "psychological distress, impaired health habits, physiologic responses, psychiatric illness, and physical illness" can be held responsible by the consequence of caregiver burden.

On the other hand, research reveals that playing the role of an informal caregiver could be associated with positive wellbeing. The U.S. National Library of Medicine (2009) reported that between 55% and 90% of dementia caregivers enjoy the feelings of togetherness, reciprocal bonding, increased faith, and the sharing of activities through the time spent with the PWD. However, given the extensive amount of time needed to provide adequate care for the PWD, dementia caregivers tend to experience an influx of negative consequences rather than positive ones. A study surveying 227 U.S. dementia caregivers concluded that almost 25% spent 40 hours or more each week caring for the PWD, in comparison with 16% of non-dementia caregivers (AARP, 2015). Thus, it becomes difficult to balance the responsibilities of work and caregiving, contributing to financial, social psychological and physical stress (Brodaty & Donkin, 2009). Indeed, numerous groups, including the Alzheimer's

Association and the U.S National Library of Medicine (2009), have conducted studies concluding that dementia caregivers experience higher burden rates due to the increased amount of time required to tend to their loved one.

Available Resources

While the support offered to informal dementia caregivers is tailored to each individual, research consistently demonstrates the positive correlation between the well-being of the caregiver and the amount of support received (Brodaty & Hadzi-Pavlovic, 1990; Cohen, 2004). The U.S National Library of Medicine (2009) explains three categories of support: instrumental support (aid with daily tasks and work in the household), informational support (insight from healthcare professionals or those knowledgeable about caregiver burden) and emotional support. A popular resource for dementia caregivers is the Alzheimer's Association, which provides "information, emotional support, practical advice, support groups, training programs, help sheets, toll-free helplines, and useful websites" (Brodaty & Donkin, 2009; Alzheimer's Association 2019).

Yet over 80% of unpaid dementia care-takers state that they could use more information or help regarding caregiving, according to the AARP (2015). More specifically, those caring for PWDs are more likely to undergo emotional stress and furthermore desire additional information pertaining to controlling their stress (49%) and managing difficult behaviors (31%) in regards to the PWD (AARP 2015). Given the plethora of available resources, it is frequently questioned as to why informal dementia caregivers are unaware of free or low-cost services and resources. Many attribute this information gap to healthcare providers, as only 16% of unpaid dementia caregivers report being questioned by a healthcare provider about what they may need in order to improve their well-being (AARP 2015). Consequently, 39% of dementia caregivers believed that discussions with healthcare providers regarding recipient care would be helpful and 27% were intrigued by conversations about self-care (AARP, 2015). The World Health Organization (2012) states that ultimately it will become difficult to intervene in the detrimental symptoms dementia caregivers experience without the consistent involvement of primary care.

Gap in Research

Despite the abundance of research regarding the impact taking care of PWDs has on a caregiver's health, research on the primary care clinician's assessment of dementia caregivers is minimal. As recorded previously, researchers have gained information pertaining to the unpaid dementia caregiver's belief as to whether or not their needs are being met by healthcare providers (AARP, 2015). However, insight into whether primary care clinicians believe that they are holding such discussions has yet to be fully accounted for. For instance, while Davis et al. (2019) did study the frequency of dementia caregiver assessment and identification by healthcare professionals, its methodology was somewhat limited, as electronic medical records (EMRs), or a digital collection of stored health information, were assessed, rather than direct conversations with healthcare professionals. Conversations regarding the needs of the caregiver may have been held in the outpatient setting, however may not be recorded in the EMRs. After reviewing research about informal dementia caregivers, and the resources that may be directed to them by healthcare professionals, there appears to be a lack of information on whether primary care clinicians hold these essential discussions with the caregivers. The purpose of this study is to explore whether primary care clinicians are adequately identifying unpaid dementia caregivers and directing them to available resources after assessing their level of burden or stress. This leads to the question: Do primary care clinicians address and identify the needs of unpaid dementia caregivers in the outpatient setting¹? I made the assumption that healthcare providers most suitably fill the role of assessing the needs of unpaid dementia caregivers and directing them to adequate resources, due to their experience and knowledge in the field. Given the large proportion of caregivers of PWDs that believe that further help would be beneficial to improving their mental health, I hypothesize that primary care clinicians in most cases do not address caregiver needs to the extent in which it is necessary.

1 Outpatient care is most frequently provided in medical offices

2 Emails distributed under the supervision of internist Dr. Viswanath Kalapatapu MD at Katy Internal Medicine Associates

Methodology

Participants

Participants of this study included primary care clinicians such as nurse practitioners, physician assistants, internists, geriatricians, and family doctors working in the outpatient setting. Although predominantly in practices located in Houston, Texas, participants were surveyed from varying cities across the country. Given the diversity in the race and gender of the participants, results were not skewed to one reigning background. All participants were volunteers.

Materials

A self-created survey via Google Forms (Appendix A) was required for the participants to complete. Thus, it was essential for the participants to acquire a device, such as a smartphone, laptop computer, or desktop computer, in addition to internet access. The survey link was distributed to primary care clinicians via email². Participants needed to have a regularly checked email address in order to access the survey link.

Design and Procedure

Methodology employed in the study was a survey due to its ease of use and its flexibility of time to complete the survey. First and foremost, approval from the Campus Review Board was necessary, given the distribution of my survey to outside organizations and research performed on human subjects. The survey examined possible correlations in the identification and assessment of unpaid dementia caregivers by primary care clinicians in order to indicate whether they are adequately providing help to the caregivers. Variables such as race, gender, and number of years in practice of the medical professionals were taken into account. In addition to a direct link to the survey, an explanation of the research project was sent through email. The brief explanation described who I was and what I was studying for my Advanced Placement Research course, given my precursory interest in dementia. The

importance of receiving a high response rate and valid results was also outlined. The participants were told that this was an anonymous survey requiring approximately five minutes, and to complete it within a week of receiving it. A note was provided in the introduction clarifying questions that incorporated a Likert scale. The survey consisted of ten questions, eight of which were multiple choice and two allowed free response. The free response questions inquired about the background of the clinician, including the amount of time they have practiced medicine and the number of patients with dementia they see each week. Two multiple choice questions were interposed regarding the gender and the field of medicine the primary care clinician was in. The four responses pertaining to the background of the primary care clinicians were used to describe the demographics and diversity of the sample participants. Four of the eight multiple choice questions employed a Likert scale, in which participants were asked to rate how often they execute the given action, such as how often they identify the dementia caregiver, evaluate their burden or stress, direct them to an outside resource, in addition to the usefulness of better communication with the Alzheimer's Association. For the two remaining multiple choice questions, the participants were told to "mark all that apply" pertaining to the resources, if any, they directed the caregivers to, and the major factors that have historically hindered this referral.

Analysis of Data

Given the fact that the survey was created through Google Forms, responses were automatically processed and categorized. Responses were programmed to be transcribed onto a Google Spreadsheet upon its submission by the participants. Furthermore, Google Spreadsheets were essential for the overview of responses. In addition, Google Forms categorized all responses by question and the participants' selected answers through its automation of pie charts and bar graphs in a visually clean manner, providing the percentage and the number of responses for each category or question. For questions utilizing a Likert scale, a high percentage of responses under the "always" category indicated the raised frequency of clinicians properly assessing the caregiver, whereas more responses under the "never" category indicated the opposite.

As for "mark all applicable" questions, the number of boxes checked indicated the extent clinicians' played in directing resources to caregivers. The primary data for my study was furthermore extracted from both the number and the percentage of participants who selected the given response in their survey. It was thus clear to understand the percentage of primary care clinicians that were assessing and identifying the needs of the unpaid caregivers of persons with dementia. Thus, the use of Google Forms for conducting my research was most convenient in its observation and analysis of the data due to its straightforwardness and simplicity.

Method Advantages

The use of a survey allowed me to easily gain insight into whether primary care clinicians identified unpaid dementia caregivers and their needs. The creation of the survey through Google Forms not only allowed for simple extraction of data, as stated previously, but also enabled participants to complete the survey anonymously and in any length of time. Jones et al. (2013) stated that the use of survey research "allows large populations to be assessed with relative ease." Conducting my research via survey provided the participants with more time to consider their past actions regarding their assessment of dementia caregivers, rather than in person interviews or phone calls. The utilization of a survey also warranted a greater depiction of whether primary care clinicians identify and address the needs of unpaid dementia caregivers than direct observations of electronic medical charts as done in Davis et al. (2019), which stated that it was "quite possible that many providers conduct caregiver assessments routinely without documenting them." Despite the limited amount of questions in my survey, it was concisely able to address my research question, given that my questions were closed ended and directly pertained to my gap in research. My questions specifically inquired about the frequency of dementia caregiver identification and the resources being directed to them by the healthcare professionals, aligning with my initial query as to whether primary care clinicians are addressing and identifying the needs of unpaid dementia caregivers.

Results

In total, 33 primary care clinicians participated in this research study, with a response rate of approximately 70%. Based on the data extracted from the survey (Appendix A) it is evident that while primary care clinicians overall identify the caregiver (Figure 5), they less frequently evaluate the burden of stress the caregivers may face (Figure 6) and direct them to the proper resources (Figure 7). The majority of participants believed that the insufficiency of direction to the adequate resources is due to a lack of awareness of the available resources (Figure 9); this too was presented in the findings of whether a more concrete system of communication between the Alzheimer’s Association and the practices of primary care clinicians was implemented (Figure 10). Furthermore, the results affirm my hypothesis in that primary care clinicians are not identifying and addressing the needs of the caregivers to the extent to which it is necessary.

Survey Data

Type of primary care clinician

33 responses

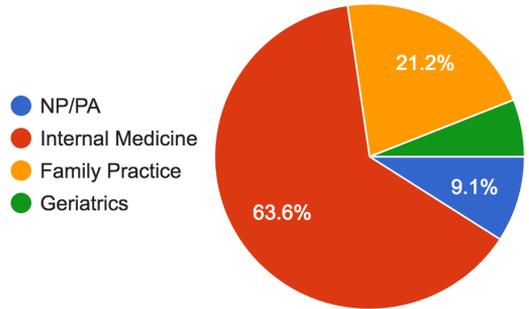


Figure 1. Participant responses regarding the type of primary care clinician they are. 63.6% reported being in internal medicine, 21.2% family practice, 9.1% nurse practitioner/ physician assistant, and 6.1% geriatrics.

Number of years in practice

33 responses

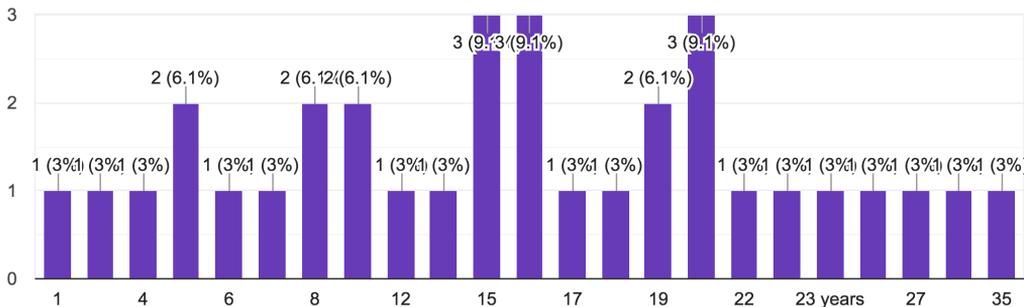


Figure 2. Participant responses regarding the number of years they have practiced medicine. Responses ranged from 1 year to 35 years, with a mean of 15.15 and a standard deviation of 7.94.

ASSESSMENT OF UNPAID DEMENTIA CAREGIVERS BY PRIMARY CARE CLINICIANS

Gender

33 responses

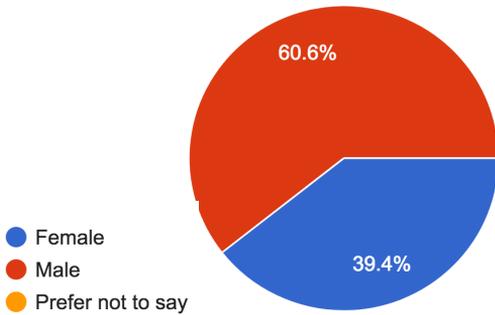


Figure 3. Participant responses regarding their gender. 60.6% identified as male, and 39.4% identified as female. No participants opted out of providing their gender.

How often do you identify the primary unpaid /family caregiver of your patients with dementia?

33 responses

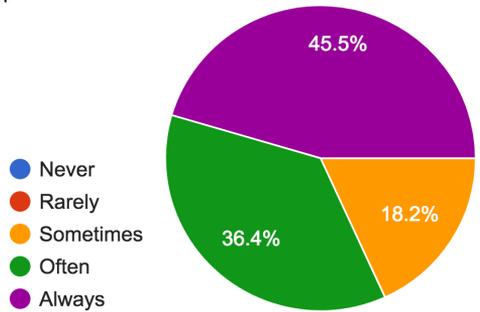


Figure 5. Participant responses to the question “How often do you identify the primary unpaid/family caregiver of your patients with dementia?” 45.5% of participants stated “always,” 36.4% “often,” 18.2% “sometimes,” and no participants reported “never” and “rarely.”

How many patients with dementia do you see each week?

33 responses

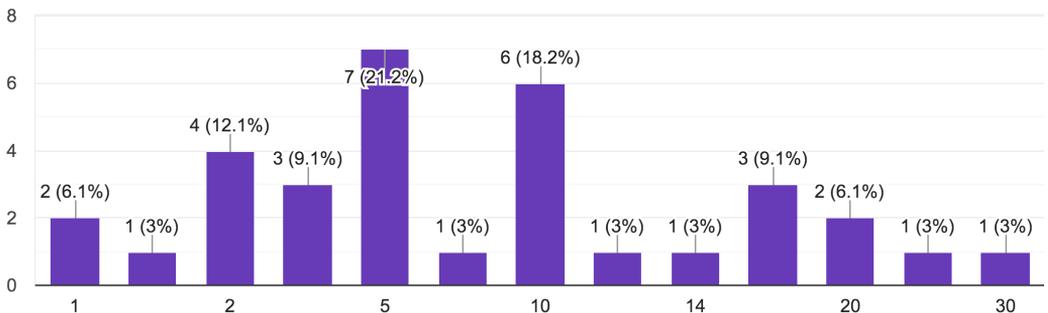


Figure 4. Participant estimates as to how many patients with dementia they see each week. Responses ranged from 1 patient to 35 patients, with a mean of 9.32 and standard deviation of 7.06.

How often do you evaluate caregiver burden and stress?

33 responses

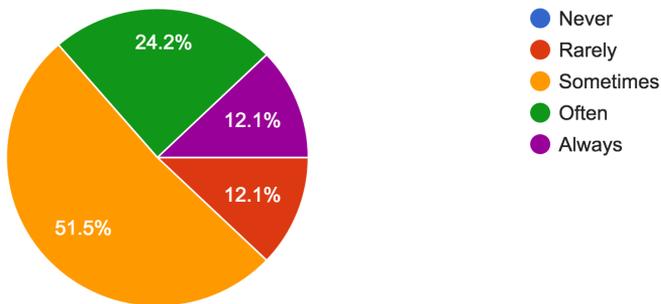


Figure 6. Participant responses to the question “How often do you evaluate caregiver burden and stress?”. 51.5% of participants responded “sometimes,” 24.2% “often,” 12.1% “always,” and 12.1% “rarely.” No participants stated “never.”

How often do you refer caregivers to another provider or organization to address their stress and/or knowledge related to caring for persons with dementia?

33 responses

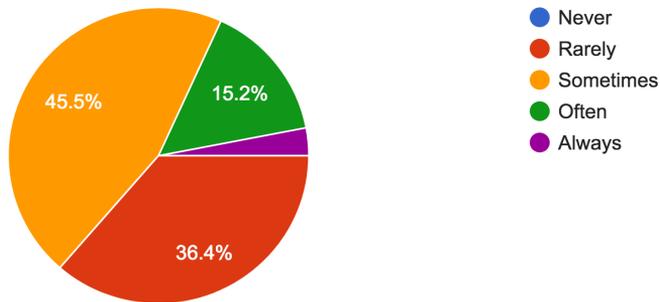


Figure 7. Participant responses to the question “How often do you refer caregivers to another provider or organization to address their stress and/or knowledge related to caring for persons with dementia?”. 45.5% stated “sometimes,” 36.4% stated “rarely,” 15.2% stated “often,” and 3% stated “always.” No participants stated never.

ASSESSMENT OF UNPAID DEMENTIA CAREGIVERS BY PRIMARY CARE CLINICIANS

Which of the following resources do you direct caregivers to? (Mark as many as applicable)

33 responses

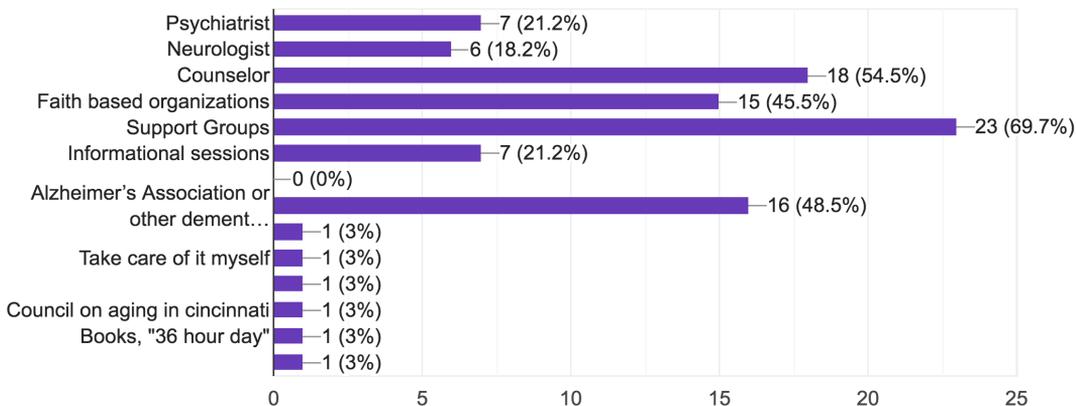


Figure 8. Participant responses to the question “Which of the following resources do you direct caregivers to? (Mark as many as applicable)”. 69.7% of participants direct caregivers to support groups, 54.4% to counselors, 48.5% to dementia-serving nonprofit organizations, and 45.5% to faith-based organizations.

What are the major factors that prevent connecting caregivers with the appropriate resources? (Mark as many as applicable)

33 responses

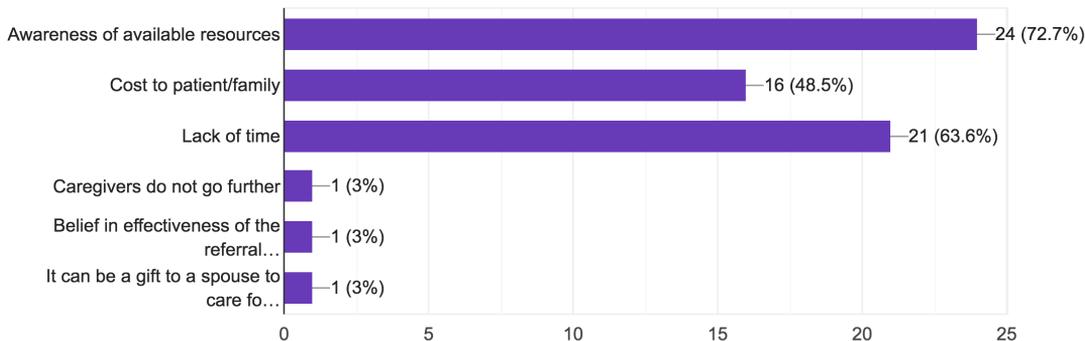


Figure 9. Participant responses to the question “What are the major factors that prevent connecting caregivers with the appropriate resources? (Mark as many as applicable)”. 72.2% of participants believe the lack of awareness of available resources is a major factor preventing the connection, 63.3% stated “lack of time,” and 48.5% stated “cost to patient/family.”

How useful would increased communication from the Alzheimer's Association to your practice be to serving patients and caregivers in your practice?

33 responses

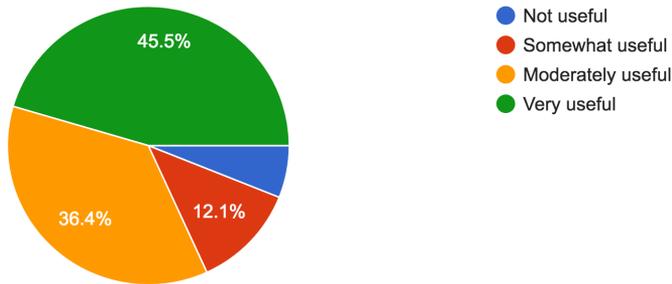


Figure 10. Participant responses to the question “How useful would increased communication from the Alzheimer’s Association to your practice be to serving patients and caregivers in your practice?” 45.5% of participants believe it would be “very useful,” 36.4% “moderately useful,” 12.1% “somewhat useful,” and 6.1% “not useful.”

Analysis of the Survey

Identification of Caregivers: As shown in figure 5, 45.5% of participants stated “always,” 36.4% “often,” 18.2% “sometimes,” and no participants reported “never” and “rarely”. This indicates that overall, primary care clinicians prioritize identifying the caregiver of the dementia patient, given how crucial the aid of a carer is toward PWDs.

Evaluation of Caregiver Stress: Though caregivers are commonly identified, the stress that the PWD caregiver endures is less frequently evaluated, according to figure 6. When asked how often they evaluate caregiver burden and stress, 51.5% of participants responded “sometimes,” 24.2% “often,” 12.1% “always,” and 12.1% “rarely”. No participants responded “never”. Seemingly, while primary care clinicians do not give precedence to assessing the mental health of the caregivers, it would be inaccurate to conclude that they never do so.

Referrals for Treatment: When asked the question “How often do you refer caregivers to another provider or organization to address their stress and/or knowledge related to caring for persons with dementia?” 45.5% of participants stated “sometimes,” 36.4% stated “rarely”, 15.2% stated “often”, and 3% stated “al-

ways”. No participants stated “never” (figure 7). This indicates that primary care clinicians possibly refer PWD caregivers to outside sources if it seems urgent or if necessary given the circumstances surrounding the health of the caregiver.

Use of Available Resources: Shown in figure 8, primary care clinicians were asked to select the given resources, or others not listed, they may direct caregivers to. 69.7% of participants direct caregivers to support groups, 54.4% to counselors, 48.5% to dementia-serving nonprofit organizations, and 45.5% to faith-based organizations. It was evidently less common for the primary care clinicians to refer the caregivers to another medical specialist, as only 21% refer them to psychiatrists, and 18% to neurologists.

Preventatives of Caregiver Referral: After being asked what the major factors that prevent connecting caregivers with the appropriate resources were, 72.2% of participants believe it is the lack of awareness of available resources, 63.3% stated “lack of time”, and 48.5% stated “cost to patient/family” (figure 9). Though it is true that not much can be executed on behalf of the healthcare provider to prevent many of these limiting factors, their awareness of available resources can alter. Perhaps, if primary care clinicians further understood the available resources to caregiv-

ers and their benefits, they would take greater consideration in addressing the needs of the caregivers.

Communication with the Alzheimer’s Association: Presented in figure 10, participants were given the question “How useful would increased communication from the Alzheimer’s Association to your practice be to serving patients and caregivers in your practice?” . 45.5% of participants believe it would be “very useful”, 36.4% “moderately useful”, 12.1% “somewhat useful”, and 6.1% “not useful”. It is indicated that a better means of communication with dementia-serving organizations would bring recognition to the available resources. This reconfirms the conclusion that increased awareness of the available resources would aid in serving caregivers.

Discussion

Due to the significant proportion of unpaid dementia caregivers suffering from mental health issues, attributed to caregiver burden (Anwar 2017), it is concerning that primary care clinicians do not take greater initiative to offer them additional resources, considering their insight into the individual’s wellbeing. The primary care clinicians do not often take the supplementary step of evaluating the burden of the unpaid dementia caregiver, as 51% only do so “sometimes.” This supports the 2015 finding that 39% of dementia caregivers believe discussions with healthcare professionals regarding patient care would be beneficial (AARP 2015), and thus further establishes the need for primary care clinicians to play a larger role in diminishing the common side effects of caregiver burden. When asked how often they direct the caregivers to another provider or organizations to ease their stress, nearly 46% of primary care clinicians stated that they do so “sometimes” and 36% stated “rarely,” only 3% stating “always.” The participants may identify the caregiver, and possibly evaluate their level of stress, yet a significant proportion do not take the initiative to resolve the common phenomenon of caregiver burden. However, the finding that they do not direct unpaid dementia caregivers to the appropriate resources could be out of their hands, considering that about 73% of participants stated that the lack of awareness of the available resources is a major barrier, 63.3% stated “lack of time,” and 48.5% believed it was also the “cost

to patient/family.” Additionally, 45% of primary care clinicians “always” and 36% “often” identify the primary caregiver of the dementia patient, demonstrating that they recognize the responsibility of the lives of PWDs the caregivers bear. Primary care clinicians seem to be aware of the task ahead of the caregivers, however multiple factors influence the likelihood of their recognition of caregiver burden.

Solutions

Given the conclusion that primary care clinicians do not adequately identify and address the needs of the dementia caregivers, there are a number of plausible approaches to diminishing this common issue. One of the major factors preventing the evaluation of caregiver burden is the lack of time with the patient. Furthermore, if caregivers were told to complete a form regarding their level of caregiving-related stress while in the waiting room, primary care clinicians could take it under review when assessing other mandatory medical forms. Questions could include: “How emotionally distressing do you find (patient’s) behavior?”; “How often in the past six months, have you felt like screaming or yelling at (patient) because of the way he/she behaved?”; “In the past month or so has caregiving made you feel overwhelmed or extremely tired?”; or “In the past month, have you felt depressed, sad, had crying spells or felt like you often needed to cry?”. After taking review of the caregiver’s completed form, primary care clinicians would be able to further address the needs of the caregiver and subsequently make referrals to the appropriate resources. However, there is seemingly a gap in knowledge between the primary care clinicians and the available resources. Dementia-serving nonprofit organizations such as the Alzheimer’s Association offer a free 24/7 helpline created to coach caregivers and connect them with the appropriate resources. Resources offered by the Alzheimer’s Association includes but is not limited to: live chats, support groups, online courses, informational sessions, message boards, help sheets, and helpful websites (Alzheimer’s Association 2019). The Alzheimer’s Association or other dementia-serving organizations could team with the healthcare providers to better relay the available resources to the caregivers. I suggest that primary care clinicians attend a seminar on caregiver health, offered by nonprofit de-

mentia-serving organizations, to gain a better understanding of how to treat unpaid caregivers of PWDs. However, out-of-office participation may not be truly feasible given a lack of time medical professionals often experience. If faced with this issue, perhaps they can watch an online video provided by the Alzheimer's Association covering the treatment of caregivers.

Limitations

As four out of the ten questions inquired about the background of the participants, only six questions were used to determine the identification and assessment of caregivers, due to the low likelihood of participant willingness to complete longer surveys. Furthermore, additional questions may have better gauged whether or not the initial hypothesis was correct, and may have better demonstrated the complexity of the assessment of caregivers. Supplementary questions could include "How aware are you of the available resources to caregivers," and "Do you believe that healthcare providers have an obligation to fulfill caregiver needs." Another prominent limitation may be the number of primary care clinicians partaking in this research survey; I received 33 responses at approximately a 70% response rate, and a greater scope of responses may have adjusted the accuracy of the final results. Additionally I did not poll the city and/or clinic each participant was from, which ignores the question of the extent to which location influences the assessment of caregivers. It should be taken into consideration that it is highly possible that participants may not have been aware of what the Alzheimer's Association provides to caregivers looking for additional support. Perhaps this justifies the large proportion of participants that do not believe better communication between the Alzheimer's Association and healthcare providers would aid in addressing caregiver needs. It may also confirm the reasoning behind the low likelihood of the clinicians directing caregivers to outside resources or organizations (*figure 7*). Another consideration is the social desirability bias of the participants- they may have not completed the form with complete honesty, or may have exaggerated the frequency of executing the given actions on the survey out of a sense of embarrassment or denial. However, the survey was anonymous, so it is unlikely that the participants had any motivation to be untruthful.

Lastly, only one past research study investigated the extent to which healthcare providers assess the needs of caregivers (Davis et al. 2019). Furthermore, my research study cannot be widely compared to past research due to the lack of previous studies.

Conclusion

Implications

My research was successfully able to bridge the gap between the mental health of caregivers of PWDs and whether their needs are being met by healthcare professionals. It was previously established that unpaid dementia caregivers are frequently subject to mental health issues due to caregiver burden (*American Journal of Nursing* 2008). Considering the vast amount of resources available to caregivers, it was unanticipated to see that 80% of dementia carers believe they could use additional support regarding caregiving (AARP 2015). Thus, research was conducted on the role primary care clinicians play in the identification and addressing of caregiver needs in the outpatient setting. With the exception of the 2019 American Geriatrics Association clinical study (Davis et al. 2019), research on the identification and assessment of informal dementia caregivers was minimal. Furthermore, I gained insight into whether primary care clinicians were assessing the stress of the caregivers and directing them to the adequate resources, as needed. My research shows that while the primary care clinicians overall identify the caregiver, they do not frequently evaluate their level of burden and direct them to the proper resources, confirming my hypothesis. This implies that the healthcare providers are not playing a major role in resolving the burden caregivers may face; they instead accept that such mental health struggles are present, however may not put in exponential effort into diminishing these common issues. My results align with the finding that a large proportion of dementia caregivers could use more support (AARP 2015), as the lack of involvement of the healthcare providers may contribute to the growing need for additional caregiver help. This may primarily be due to the primary care clinicians' lack of awareness of the resources available to unpaid dementia caregivers. While a variety of resources are available to further aid in dissolving the

stress of caregiving, primary care clinicians have yet to take advantage of these opportunities. If primary care clinicians were to have a better understanding of the resources and their benefits, perhaps they would subsequently direct caregivers to the appropriate resources adequately. Additionally, my results align with those of the American Geriatrics Society (Davis et al. 2019), which concluded that while healthcare providers overall identified the caregiver, they were less likely to assess their wellbeing and needs. Therefore, my hypothesis that primary care clinicians do not address the needs of unpaid dementia caregivers to the extent to which it is necessary is confirmed.

Future Research

My findings have shown that the majority of participants believe the lack of awareness of the available resources is a hindrance of connecting caregivers with the appropriate resources. Thus, future research can be conducted on the aptitude of primary care clinician knowledge on resources available for caregivers of PWDs. Tackling this question would allow us to further understand the complexity of why the caregivers need additional help. In addition, further research can be conducted on whether increased communication between primary care clinicians and organizations involving the care of dementia patients would help in addressing the needs of caretakers. This will aid in determining whether improving this relationship will increase the proportion of healthcare providers directing informal dementia caregivers to outside resources. Ultimately, the project goal was fulfilled in that I reached the conclusion that primary care clinicians do often identify the dementia caregiver, however do not assess their needs and burden to the extent to which is necessary.

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Appendix A: Survey Questions and Explanation

The Assessment of Unpaid Dementia Caregivers by Primary Care Clinicians in the Outpatient Setting

My name is [REDACTED] am an [REDACTED] student at [REDACTED] taking an Advanced Placement Research Class. In this course, I must complete a compelling, scientifically valid research study. I am studying primary care clinicians' identification and needs of unpaid/family caregivers of persons with dementia. In order for me to have valid results and a final product for my class, it is essential to receive a high response rate. I hope you can help me. This survey is anonymous and will only take five minutes. Please complete it within one week of receiving it. Thank you for taking the time to help me with my research.

Disclaimer:

For questions on frequency of caregiver assessment, consider how often you conduct these actions out of all interactions with patients/caregivers, not in relation to how often you see an individual patient or dyad (i.e., "Patient A/Caregiver A").

Family/unpaid caregivers are unpaid individuals, such as a spouse, family member, or friend, involved in assisting others with daily living or medical tasks.

"Needs" of caregivers can be psychological, monetary, time, materials needed for care such as medications, modifications to living environment, etc.

* Required

1. Type of primary care clinician *

Mark only one oval.

- NP/PA
- Internal Medicine
- Family Practice
- Geriatrics

2. Number of years in practice *

3. Gender *

Mark only one oval.

- Female
- Male
- Prefer not to say

4. How many patients with dementia do you see each week? *

ASSESSMENT OF UNPAID DEMENTIA CAREGIVERS BY PRIMARY CARE CLINICIANS

5. How often do you identify the primary unpaid/family caregiver of your patients with dementia? *

Mark only one oval.

- Never
- Rarely
- Sometimes
- Often
- Always

6. How often do you evaluate caregiver burden and stress? *

Mark only one oval.

- Never
- Rarely
- Sometimes
- Often
- Always

7. How often do you refer caregivers to another provider or organization to address their stress and/or knowledge related to caring for persons with dementia? *

Mark only one oval.

- Never
- Rarely
- Sometimes
- Often
- Always

8. Which of the following resources do you direct caregivers to? (Mark as many as applicable) *

Check all that apply.

- Psychiatrist
- Neurologist
- Counselor
- Faith based organizations
- Support Groups
- Informational sessions
- Alzheimer's Association or other dementia-serving nonprofit organization
- Other: _____

9. What are the major factors that prevent connecting caregivers with the appropriate resources? (Mark as many as applicable) *

Check all that apply.

- Awareness of available resources
- Cost to patient/family
- Lack of time
- Other: _____

10. How useful would increased communication from the Alzheimer's Association to your practice be to serving patients and caregivers in your practice? *

Mark only one oval.

- Not useful
- Somewhat useful
- Moderately useful
- Very useful

Not a Children's Game: Misogyny in the North American Online Gaming Community

Siyu (Elaine) Liu

This ethnographic study examines gamers' in-game text-based conversations in *League of Legends* to study the gender relations in the North American online gaming community in the post-#MeToo era. While it finds the overall environment to be supportive regardless of players' gender, the *League* community deems heterosexual men as prototypical players, and female players actively fulfill this stereotype. Players with female usernames receive more negative comments, especially when their teams are winning. The highest-ranking players use the most positive language to communicate, while medium-ranking players use the least positive language. Recommendations to improve gender relations include imposing stricter policies to target toxicity, implementing computer programs to identify offensive language and warn the perpetrators, and initiating and publicizing toxicity ratings for players to promote self-regulation. By installing these suggestions into Riot Game's existing anti-toxicity measures, the online gaming environment could become more inclusive.

Keywords: misogyny, *League of Legends*, video games, #MeToo

Introduction

Five hours per week. This is how much time an average adult gamer spends playing video games with others online (McGonigal, 2010). As video games continue to replace TV, movies, and board games as the most popular source of entertainment, female participation has dramatically increased, making up 46% of the American gaming community as of 2019 (Entertainment Software Association, 2019). This expansion, however, has not been accompanied by greater gender equality in the anonymous, virtual gaming space, particularly in terms of verbal harassment, the

excessive sexualization of female avatars, and gender-based exclusion.

Players of multiplayer often communicate through text chats. In this anonymous, instantaneous, and unmoderated platform, like social media, "harsh criticism, anger, hatred and threat[s]" can proliferate under the effects of "individuation and disinhibition," and women are frequently victims of verbal sexism (Kessler, 2013, p. 29). In particular, the devastating effects of 2014's GamerGate controversy¹ on feminist developers and critics can be attributed to the explicit hostility, contentious debates, and polarized opinions facilitated by online anonymity. As such, misogynistic speech

¹ The GamerGate controversy was an outcry by the gaming community against female influences in games, ultimately leading to cyber-aggression towards women in the industry (Chatzakou et al., 2017).

proliferates in chatrooms, further perpetuating sexism both in and outside of the online gaming community.

League of Legends

With more than 33 million monthly players, *League of Legends* (hereinafter *League*) is one of the most popular battle arena games in the world (Ratan et al., 2015). While *League* doesn't release specific player demographics, many studies found that most battle arena game players are young men below the age of 30 (Jenson & de Castell, 2018; Ratan et al., 2015; Trepte et al., 2009). In *League*, players team up for a "capture-the-flag"-style race. The game arena is a forest consisting of three lanes that meet at the two ends. To win the game, the five-player team must cooperate to destroy the three enemy "towers" in each lane, the three "inhibitors"² at the end of the lanes, and finally the "Nexus"³ behind the "inhibitors." *League* players select from a wide assortment of avatars called "Champions" with different appearances and strengths. Some are more suitable for certain positions than others. Specifically, the five positions are Carry, Support, Top, Mid, and Jungle. Top and Mid are each responsible for one lane; Carry (typically offensive) and Support (typically defensive) cooperate in the third lane; Jungle plays in spaces in between the lanes and assists all other roles. Ratan et al.'s narrative research found that many people deem Support the "easiest" position, hence the most "suitable" for women despite it being the least popular among men (2015).

There are multiple "game modes" in *League*. Players are allowed in Ranked games⁴ upon reaching Level 30, which requires roughly 100 hours of gameplay. This research studies interactions between Ranked players.

Players on each team are connected via a text chat, where their usernames, actions (kills, in-game purchases, requests for assistance) and dialogue are displayed. Despite its popularity and widespread social implications, little is known about the gender dispar-

ity in the *League* community. As such, understanding the extent to which *League* players' in-game conversation perpetuates sexism in the North American gaming community is crucial to evaluating the gender equality landscape in 2020. This study analyzes how gendered usernames, female-leaning avatars, and playing skills correlate with misogynistic speech to examine the roots of sexism in *League*.

Literature Review

Female Gamers' Experience

Verbal Harassment

While swearing and "flaming"⁵ in chatrooms are prevalent regardless of the targets' gender (Gray, 2012, p. 414), women are the principal victims of verbal sexual harassment during gameplay (Ballard & Welch, 2017; Brehm, 2013; Fox & Tang, 2014; Gray, 2012; Shaw, 2010). Ballard and Welch's 2015 online survey found that women experience significantly higher rates of sexual harassment and pursuit and that heterosexual men are most frequently the perpetrators. These results are confirmed in Kuznekoff and Rose's experiment (2013), which found that, in *Halo 3*—a game that uses voice chat—female voices receive negative attention three times more often than male voices or no voice at all. Kasumovic and Kuznekoff, Professors in Communication, discovered through a true experiment that lower-skilled male players are more hostile toward female-voiced teammates but more submissive towards male-voiced players in the identical scenario (2015). Professional female gamers face similar obstacles—Ratan et al. summarize a series of incidents, such as a female e-sport athlete being sexually harassed by a male *League* during a live webcast, and the feminist game critic Anita Sarkeesian being threatened by gamers dissenting with her

2 Structures in the game that a team must destroy before attacking the enemy "Nexus."

3 A structure that serves as the primary objective of League games. A team destroys their opposition's Nexus to win the game.

4 Ranked games are the competitive alternative to normal games, as players who finish with higher ranks by the end of the season receive monetary rewards. With money as an incentive, Ranked players are often more engaged in the gaming community and emotionally charged during gameplay.

5 spontaneous creation of homophobic, racist, and misogynist language

cause of improving female representation in games (2015, p. 440). The lack of respect for professionals further discourages women from entering the gaming community; companies failing to address gender issues risk losing potential female customers.

Online anonymity magnifies sexism in the gaming community. In the absence of real-life repercussions, users behave less responsibly (Gray, 2012; Kessler, 2013; Ruvalcaba et al., 2018; Suler, 2004). For instance, two groups of researchers led by Joseph Thompson (2017) and Shane Murnion (2018), respectively, analyze in-game chats from *StarCraft 2* and *World of Tanks*. Both find prevalent profanity, abusive language, racism, and cyberbullying. Additionally, a research team led by Omar Ruvalcaba, Psychology Professor at California State University, investigated misogyny in comments on Twitch⁶ (2018). They find that female streamers are over 10 times more likely to receive sexual comments than males, and that 37% of the positive comments toward women players focused on appearance, compared with 7.5% for men (2018, p. 13). While Ruvalcaba et al.'s research finds a correlation between gender and sexual harassment, Maass et al. (2003) attribute this to male gamers' need to "bolster their own masculinity," especially when they perceive their gender identity to be threatened.

Given the power of verbal communication in perpetuating sexism, chatroom sexual harassment reinforces real-life harassment (Menegatti & Rubini, 2017). Fox, Cruz, and Lee's 2015 experiment establishes a cause-and-effect relationship between online and offline sexist behaviours: exposure to and participation in sexism on social media encourage misogynistic attitudes and actions in the workplace. Results from numerous studies confirm that overt sexism affects women's psychology and behaviour, disengages them from social activities, harms their self-esteem, and diminishes their career aspirations (Fedi & Rollero, 2016; Jarunratanakul & Jinchang, 2018; Kuchynka et al., 2018; Maass et al., 2003).

Female Representation in Games

Sexualizing female characters perpetuates stereotypes in gaming communities. Studies have found

that exposure to sexualized content exacerbates gender stereotyping and objectification, causes viewers to develop prejudicial beliefs on sexual assault, and constructs unrealistic beauty standards (Bègue et al., 2017; Cassell & Jenkins, 1998; Dietz, 1998; Ivory, 2006; Morawitz, 2007; Ogletree & Drake, 2007; E. Taylor, 2007). It also causes female players to become concerned with their body image and self-efficacy (Karsay et al., 2018; Kondrat, 2015; Morawitz, 2007; Vandenbosch et al., 2017). These results can be explained by the designing algorithms: as the idealized body image is often defined by that of the strongest character, players constantly compare themselves to the characters they are roleplaying and viewing. This leads women to believe they are unable to achieve success with their "imperfect" bodies.

In contrast, the freedom to choose usernames and Champions makes *League* a medium for players' self-expression, as they experiment with genders, sexualities, personalities, and ways of interacting with the world in the socio-political context of the game. This freedom, however, makes determining the players' genders impossible.

Marginalization and Exclusion

Regardless of gender, participation, skill level, or game platform, gamers are more likely to perceive heterosexual men as prototypical gamers (Brehm, 2013; Easpaig, 2018; Wasserman & Rittenour, 2019). As a result, women are frequently excluded and often compelled to hide their gender (Brehm, 2013; Holz Ivory et al., 2014; McLean & Griffiths, 2018; Vermeulen et al., 2017). Specifically, women typically play alone, anonymously, and avoid verbal communication (McLean & Griffiths, 2018). They are also less likely to participate in offline gaming communities: Local Area Network parties, Internet cafés, and competitive gaming tournaments remain overwhelmingly male-dominated despite the recent spike in female gamers (Bryce & Rutter, 2003; Ratan et al., 2015; N. Taylor et al., 2009). While some women enjoy the comfort of anonymity, those who reveal their gender often find their legitimacy and competence questioned (McLean & Griffiths, 2018, p. 976). As misogyny proliferates and normalizes (Brehm,

6 a popular streaming platform for gamers that allows viewers to comment in the chat window embedded next to player video streams

2013; Easpaig, 2018), women find gaming less enjoyable, they then underperform and become less likely to self-identify as gamers (Kaye & Pennington, 2016; McLean & Griffiths, 2018; Vermeulen et al., 2014). The effects of marginalization extend beyond the online community. McLean and Griffiths' survey found female gamers frequently experience anxiety and loneliness due to the lack of social support they receive while gaming. Vermeulen et al.'s study corroborates McLean and Griffiths, emphasizing how this gender-based exclusion is detrimental to women's self-conception, well-being, and social relationships outside of the gaming community (Vermeulen et al., 2017).

League of Legends

Riot Games takes various initiatives to minimize toxicity in the *League* community, including publishing a summary of expected behaviours in "Summoner's Code," allowing players to report toxic players or turn off text chats, banning frequent offenders, and offering a filtering option to replace coarse language in the text chat with asterisks (*Summoner's Code - League of Legends*, 2017). Meanwhile, excessive sexualization of female Champions (Carvalho & Cappelli, 2018, pp. 5–6) and misogyny in the *League* community perpetuate gender stereotypes just like games in previous studies. Combining results from qualitative experiment and analysis of users' behavior-log data provided by Riot Games, Ratan et al. contend that, while men and women develop skills at the same rate, women are less confident in their skills, often pressured to fulfill particular "lesser" in-game roles (usually Support), and are frequently perceived as "unwelcomed and/or unskilled" in the *League* community (2015, p. 440). These findings lead the researchers to hypothesize that the "often toxic, misogynistic nature of exchanges between players" is responsible for the dearth of female gamers (2015, p. 443).

Gap Analysis

Verbal sexual harassment, sexualization of female characters, and the exclusion of women contribute to gender disparity in the gaming community and overall online sexism. *League*, particularly, harbours

all three attributes, further perpetuating misogyny. Indeed, the culture of video games and gamers is detrimental to the worldwide gender equality landscape.

These challenges, however, have seen improvements in the past two years, especially since the #MeToo movement of 2017. Many women have spoken up about sexual harassment, companies have updated their anti-harassment policies, and society has become more engaged in feminist initiatives, leading to unparalleled "cultural resonance and reach" (Cobb & Horeck, 2018). The number of sexual harassment cases reported to the police has spiked in America and Canada (Morgan & Oudekerk, 2019; Rotenber & Cotter, 2018). While the status quo for gender equality has shifted significantly in entertainment, hospitality, and fashion, harassment culture has not come to an end (Tippett, 2018; Williams & Lebsock, 2018). No study, however, has investigated misogyny in gamers' in-game, text-based conversations in the post-#MeToo world. Shane Murnion's study comes closest. It focuses on the development of cyberbullying identification technology rather than the potential causes and societal implications of misogynistic language (2018). While this research examines sexist practices in *League*, the results provide insight into the social dynamics of the greater online gaming community.

Methodology

This study employed ethnography to investigate online gaming communities' "shared patterns of behavior, language, and actions" (Creswell, 2014). According to British sociologists Martyn Hammersley and Paul Atkinson (2007), ethnography is an extremely flexible research methodology that generates qualitative and/or quantitative data through the researcher's participation in other people's communities. Rich and authentic data can be collected through visual and auditory observation, interviews, and document and artifact collection.

Virtual ethnography—which collects data from the Internet—is a viable method for this research. Since each game's text chat is only accessible to its players, gaining a deep understanding about sexism requires immersion in the *League* community. Moreover, ethnography uncovers insights that would otherwise be missed, because players' language and the context of

the gameplay provide information that cannot be predicted. Many researchers have used virtual ethnography to collect authentic and generalizable data to investigate gaming practices and norms (Chee, 2015). Kuznekoff and Rose (2013) used ethnography to study gamers' verbal interactions in Halo 3, interviewing female volunteers about their experience and quantitatively analyzing audio chats. Sociologist Simona Isabella (2007) wrote ethnographic diaries about her gaming experience to study relationships between players of role-playing games. Dr. Michael Strangelove (2007) from the University of Ottawa has used ethnography to study violence and hegemonic incidents in the warfare simulation game Battlefield 2 from video recordings. This research combines previous studies' methodologies to research communications in *League*.

Data Collection

League's algorithm-based matchmaking process assigns players into two teams that have an equal chance of winning. Players may choose to communicate through a built-in text chat. This study collected data from recorded *League* games. The variables studied are the gamer's username (female-sounding versus male-sounding or gender-neutral), skill levels (low, medium, high), and Champion (commonly deemed suitable for women versus others). Stereotypically, women play Champions including Janna, Soraka, Lux, Morgana, Sona, Nami, that are easier to control and more suitable for defense, internalizing the gender-based expectation to play Support. Skill level is determined as follows:

Low: Iron, Bronze. This tier accounts for 33.7% of *League* players.

Medium: Silver (36%).

High: Gold and above (30.3%) (Rank Distribution, 2019).

This study then used content analysis to compare the types of comments directed toward players in order to determine the association (or lack thereof) between the type of feedback a player gives or receives and their skills, Champions, and the gender indicated by their username.

Ranked players of all levels were recruited through email and social media as research participants (hereinafter "volunteers"). This study collected video record-

ings⁸ of Ranked games played on the North American server. Volunteers were asked to "solo-queue," so they were paired with four randomly selected players of similar ranks to ensure random sampling. Volunteers were asked to avoid using inappropriate language and play and communicate as they naturally would to minimize inter-observer variability (Pannucci & Wilkins, 2010). In each game, the volunteers' teammates' verbal interaction as the game progresses was observed. Their teammates remained unaware of this study so that they would behave naturally, ensuring that players neither reduced nor increased misogynistic language to adhere to social or in-game expectations.

Qualitative observation and quantitative data analysis were employed in this research. Namely, I played Ranked games with strangers for two months, qualitatively observing their interactions with me. I also examined my volunteers' video recordings to evaluate players' attitudes toward each other. To quantitatively analyze audio recordings, gamers' conversations were transcribed with OCR.space (*About the Free OCR API*, n.d.) and analyzed with Lexalytics to evaluate sentiment, assigning each line of conversation a sentiment score between -2 and 2, with -2 being the most negative and 2 being the most positive (*Lexalytics Sentiment Analysis Whitepaper*, n.d.). The "sentiment library"—Lexalytics' database that comprises a set of adjective and phrases manually scored by Lexalytics' coders—was customized to identify and evaluate misogyny in the context of *League* (see Appendix 1). Scoring each line, misogynistic and low-scoring comments were then manually analyzed to determine their implications and significance.

This study aimed to understand the perpetrators of sexism and circumstances under which misogyny occurs by comparing the types of comments directed toward male and female players of different skill levels. This research design is similar to Kuznekoff and Rose (2013). My preliminary research and literature review led to the following hypotheses:

H1: Female usernames (e.g. "KatieCandy-Cane83") receive more negative comments than male (e.g. "Jason123") or gender-neutral usernames (e.g. "DTHD079").

H2: Players receive more negative comments when playing as stereotypical female Champions.

8 Volunteers were asked to record their games and submit the recordings for analysis.

MISOGYNY IN THE ONLINE GAMING COMMUNITY

H3: Lower-level players give and receive negative comments more frequently, because advanced players would focus more on the game than the players.

Ethical Note

This research—approved by the school’s Internal Ethics Review Board—did not pose ethical concerns to my target community. It is impossible to determine the real-world identities of players through their usernames. Additionally, players’ usernames were anonymized in this report.⁹

Results

Ethnographic data were collected during January and February 2020, by myself and 14 volunteers. In total, 54 games were recorded, from which 2,435 lines of conversation between 230 players were extracted via OCR.space (see Appendix 2 for python code), analyzed with Lexalytics (see Appendix 3 for an example of sentiment scoring), and plotted in histograms (see Appendix 4).

Among the 54 games:

- 11 were played with female usernames;
- 31 with stereotypical female Champions;
- 19 played at Low level, 21 at Medium, and 14 at High;

- The volunteer’s team won in 17 games and lost in 33 games.¹⁰

The mean sentiment score (hereinafter “MSS”) for all 2,435 entries was 0.014090 with a standard deviation of 0.371645, indicating a slightly positive gaming environment. The mode was 0, as most entries communicate factual information and contain minimal emotion.

Two-sample T-tests (see Appendix 5) were performed to evaluate the association between the MSSs and the username gender (female or male), Champion gender (female or male), and game outcome (win or lose). A one-way Analysis of Variance (ANOVA) (see Appendix 6) was performed to determine the correlation between the MSSs and the player’s rank.

The probability values (p-values) were computed for all statistical tests in this study. A p-value less than the significance level¹¹ indicates statistical significance in the result. This study chose 0.1 as the significance level to offset limitations in Lexalytics’ analysis algorithm and sampling bias, as discussed in the Limitations section.

Correlation #1 – Username Gender and Sentiment Scores

To process this data, the sample was divided into two categories based on username gender. Sample size, MSS, and sample standard deviation were calculated for each. Players with female usernames received

Table 1: Sentiment Score by Username Gender

	Female	Gender-Neutral or Male
Sample Size	317	2118
Mean Sentiment Score (MSS)	-0.011653	0.017943
Sample Standard Deviation	0.359977	0.373290

9 All usernames provided as examples in this report are pseudonyms that communicate the same gender identity as those used or observed in this study, instead of the actual usernames. For example, if the real username was “James987,” this report would anonymize it as “Jake123.”

10 The outcome of four games cannot be determined, as the recordings were cut off. Data from these four games were included to examine Correlation #1, 2, and 3, but not Correlation #4.

11 Significance level (α) for social studies research is typically chosen as 0.1, 0.05, or 0.01, depending on factors including sample size, power of the test, and expected losses from Type I and II errors (Starnes et al., 2015). It is chosen before the tests are carried out.

MISOGYNY IN THE ONLINE GAMING COMMUNITY

more negative comments than players with male or gender-neutral usernames, as evidenced by the statistics in Table 1. A 2-sample T-test indicates statistical significance ($t=-1.3586$, $p=0.0875$) in the difference between the sample MSSs for female and male or gender-neutral usernames. Specifically, since $p<0.1$, the significance threshold, the null hypothesis (the MSS among the two groups is equal) was rejected, proving sufficient evidence supports Hypothesis 1: female-username players receive more negative comments.

Correlation #2 – Champion Gender and Sentiment Scores

The difference in the MSSs shown in Table 2 suggests that gamers playing female Champions received fewer negative comments, contradicting Hypothesis 2, which predicted that players receive more negative comments when playing stereotypical female Champions. This result, however, is not statistically significant ($t= 0.50020$, $p= 0.61699$).

Correlation #3 – Rank and Sentiment Scores

Table 3 shows a statistical summary of the sentiment scores by rank. The highest-ranking players experienced the lowest level of verbal negativity, supporting Hypothesis 3, predicting that more advanced players give and receive fewer negative comments. Medium-ranking players received the most negative comments, which was not hypothesized. A one-way

ANOVA shows that the differences between ranks, as represented by the MSSs, however, are not statistically significant ($f=1.20337 \times 10^{(-9)}$, $F=63$).

Correlation #4 – Outcome and Sentiment Scores

According to Table 4, players received more positive comments when their teams won. A 2-sample T-test indicates statistical significance ($t= 2.13169$, $p= 0.0165765$) in the difference between the sample MSSs.

The strong association between sentiment scores and game outcome sheds light on a potential confounding variable for Correlation #1, as the volunteer's team lost the game in six out of the eight female-username games that used the text chat. Female-username players, however, were found to receive more negative comments when their teams won, as illustrated in Table 5. The statistical significance of this result ($t= -1.67742$, $p= 0.04884$) verifies the correlation between username gender and sentiment scores. With female usernames receiving more negative comments when their teams won, this result highlights notable gender disparity as, in general, players tend to receive more positive comments when winning.

Qualitative Observations

Table 6 suggests that players frequently devalued themselves, refused responsibility for their teams' losses, and expressed frustration when their teammates

Table 2: Sentiment Scores by Champion Gender

	Female	Male
Sample Size	1565	870
Mean Sentiment Score (MSS)	0.016804	0.009209
Sample Standard Deviation	0.387286	0.342322

Table 3: Sentiment Scores by Rank

	Low	Mid	High
Sample Size	854	898	683
Mean Sentiment Score (MSS)	0.009576	0.006402	0.029842
Sample Standard Deviation	0.359369	0.394749	0.355116

Table 4: Sentiment Scores by Game Outcome

	Win	Lose
Sample Size	927	1460
Mean Sentiment Score (MSS)	0.034545	0.001356
Sample Standard Deviation	0.367044	0.376415

Table 5: Sentiment Score by Outcome for Female-Sounding Names

	Win	Lose
Sample Size	57	243
Mean Sentiment Score (MSS)	-0.087752	0.013587
Sample Standard Deviation	0.424859	0.342609

Table 6: Example and Frequency of Observed Phenomena

Trend	Examples	Frequency
Frustration when Teammates Fail to the Team's Expectations	"how can someone be this bad at the strongest role in the game" "zed do u know how to play?" "imagine having 8 kills as talon not being able kill anyone lmfao" "zero mental players"	5 games
Self-Devaluation (self- "flaming")	"im ruining that for the rest of you" "I'm playing terrible" "hopefully the game goes better without me"	4 games
Refuse Responsibility	"that was a glitch" "not my fault"	7 games
Extreme Toxicity (frequent hostile language, insulting teammates, name-calling)	"you are a good player... I hope your parents don't die...hope your dog doesn't die in front of you" "don't bother responding I muted ur disgusting"	6 games
Warn Toxic Gamers	"im gonna report you"	6 games
Encourage Teammates when the Team is Under-Performing	"just try your best, gamer" "stop voting to surrender, we can win"	10 games
Thank Other Players for Their Time	"ggwp" ("good game, well-played")	Almost every game

failed to meet the team's expectations. Players also effectively identified and criticized toxic gamers, cheered on their teammates, and expressed gratitude towards other players regardless of the game's outcome.

In one low-level game, one male-username player who was playing a stereotypical female Champion said, without context, "send noods" (a parody of "send nudes") to the volunteer player, who was playing a stereotypical female Champion with a gender-neutral username. In requesting naked pictures, the offender reduced their teammate's value to their body, leaving their skill and contribution to the team unacknowledged. The volunteer player dismissed the request, saying "yikes"; other teammates perceived it as a joke (one responded with "lol") and moved on to game-related discussions. No other explicitly misogynistic language was observed in this study.

Discussion

Qualitative analysis and hypothesis testing provided critical information about gender relations in the North American gaming community. By using linguistic sentiment as an indicator of misogyny, this study finds that, in the post-#MeToo world, perceivable sexism persists in online gaming communities.

Normalized Masculinity

The *League* community perceives heterosexual men as prototypical players, and female gamers actively fulfill this stereotype by selecting masculine usernames and employing male-like language in in-game chats (e.g. "c'mon bro"). These results corroborate previous studies (Brehm, 2013; Easpaig, 2018; Holz Ivory et al., 2014; McLean & Griffiths, 2018; Vermeulen et al., 2017; Wasserman & Rittenour, 2019). Specifically, although women make up 46% of the American gaming population and it is unlikely that all 230 research participants were men, no player's username was explicitly feminine.¹² On the other hand, explicitly masculine usernames such as "Jake123" or "BrandonXYZ" were common. One female volunteer explained that she had chosen a gender-neu-

tral username to avoid sexual attention or harassment from "thirsty people [crushing] on [her] over the Internet and ask[ing] for [her] socials." This is consistent with women throughout history, such as the Bronte sisters and J.K. Rowling, who have sought male or gender-neutral pseudonyms to improve their career prospects and to fit into a male-dominant world, like *League*. Similarly, female *League* players choose male or gender-neutral usernames to seek acceptance in the male-dominant space, reinforcing gender stereotypes and further marginalizing women in the gaming community.

Linguistic analysis of gamers' conversations also found evidence of the normalization of masculinity in gamers' speech patterns. According to American linguist Mary Talbot, women use more "standard" language (proper and formal grammar, vocabulary, and sentence structure), less slang, and communicate more emotions when speaking than men (2010). Psychologists Susan Herring (1994) and Savicki et al. (1996) further argue that, when communicating online, men challenge group members and use argumentative, coarse, and abusive language more often.

Although 46% of video game players are female, all *League* players in this study texted with similar linguistic habits. Qualitatively analyzing their linguistic patterns found that *League* players, regardless of gender, assume men's speech patterns, using direct and provocative language to challenge teammates (e.g. "I dumb you dumb" for "I'm not sure if I'm dumb or you're dumb"), slang (e.g. "smurf," referring to an experienced player creating a new account to be matched with inexperienced players for easy wins), and shorthand to communicate emotions (e.g. "rofl" for "roll on the floor laughing"; "gg" for "good game"). While the fast-paced, competitive nature of *League* requires players to avoid excessive communication to focus on playing, the persistence of these patterns in pre- and post-game chats signifies the normalization of male-leaning linguistic patterns and ingrained sexism in the gaming community.

Cooperative Gaming

League players are cooperative. In this study, 93% of the games communicated strategies and acknowl-

12 A few usernames were changed to female-sounding usernames for this research, prior to participation in the game for this study. For example, a username similar to "Firespark007" was changed to one similar to "KatieCandyCane83." The finding that none of the 230 usernames are feminine does not take into account this change.

edged skillful teammates via text chat. Often, players paired up to attack the same lane based on their Champions' strengths and weaknesses upon discussions in the chat, enhancing the team's overall performance. This cooperation was present regardless of username or Champion, as defeating the enemies—the ultimate objective—requires systematic planning and all team members' cooperation. Gamers cheered on their teammates, even when the team was underperforming. This study also observed a normalized expectation for players to extend friendly gestures to thank their teammates and opponents for their participation by saying “gg” or “ggwp” when games finish.

Competitive Gaming

League players are competitive. Results have shown that players had high expectations for their teammates' skill level and were pressured to contribute to the team and advance to a higher rank. While statistically insignificant, “High Rank” players (MSS=0.0298) were the most positive and tolerant of their teammates' mistakes and “Mid Rank” players (MSS=0.009576) were the least positive and tolerant. These findings agree with Kasumovic and Kuzneff

(2015), who contend that the prospect of losing their “in-game status” upon the entrance of female players or being defeated in games encourages gender-based hostility. Their theory provides a plausible explanation for trends observed in this study: “Mid-Rank” players are the most prone to this “hierarchical reorganization,” and “High Rank” players are the most focused and most confident in their skills, and therefore the least fearful of the consequences of losing.

League's competitive nature may explain toxicity in the gaming community. Alfie Kohn (1992), studying human behavior, noted how competition “poisons” relationships and intensifies aggression. This research observed higher levels of negativity in the text chat when the team lost or forfeited (MSS=0.001356), as opposed to when the team won (MSS=0.034545). However, the opposite holds for feminine-username players. Blaming teammates for the team's losses and using excuses like technical difficulties were com-

mon among players of all levels, while self- “flaming” when the player expected their teammates to “flame” them was more prominent among players in lower ranks. Nevertheless, more comprehensive studies are required to explain this gender disparity and verify whether the observed trend was due to sampling bias, as only 11 games were played with female usernames in this study.

Effectiveness of Existing Policies

This study finds that *League* players are aware of and effectively utilize anti-toxicity measures to forge a more positive gaming environment. Eight of the 14 volunteers opted to filter coarse language. In all six games where a player exhibited extreme toxicity, their teammates asked them to stop and threatened to report their accounts (“report Veigar¹³ for toxicity please and ty”). These accusations were mostly direct and lacked explanation, which may be due to the fast-moving nature of the game. Toxic behavior stopped after such warnings in four of the six games, whereas the toxic player reacted defensively (“report me”) and continued using toxic language in the other two. While Kwak et al.'s analysis (2015) of over 10 million player reports found that the reporting feature was rarely used, this study found the threat of reporting to be an effective means of diminishing toxic behaviors. No association was found between extreme toxicity and username gender, Champion gender, rank, or the game outcome.

While online anonymity gives players greater confidence to call out inappropriate behaviors, it may be abused to exacerbate sexism, racism, and hatred in the gaming community. According to feminist Loretta Ross (2019), call-out culture¹⁴ can be toxic, as justified call-outs to challenge ill-intended provocateurs often regress to public shaming, inspire self-indulgence, and discourage genuine discourse. Although these phenomena were not observed in *League*, her suggestion of employing honest conversation rather than “weaponiz[ing] suffering” is nevertheless applicable to the gaming community.

¹³ Veigar is the name of a Champion.

¹⁴ A form of public humiliation or shaming often seen on social media that aims to hold individuals and groups accountable for actions perceived to be offensive by others, who then call attention to this behaviour.

Limitations

This study has a few limitations. First, the experiment design assumes gender to be binary, as non-binary genders are difficult to identify through *League* usernames and Champions. Additionally, sentiment scores assigned by Lexalytics might be biased, as its “sentiment library” was constructed by human coders and myself, and is unable to accommodate for spelling mistakes, sarcasm, or *League*-specific abbreviations.

Furthermore, researcher bias might have occurred in the qualitative analysis of gamers’ conversations, as the sentiment of language was subjectively determined. Volunteers played and communicated differently, which might have affected other players’ behavior. Moreover, the sample size was small (54 games). A greater sample size would provide results that more accurately reflect the gender relations in *League*.

Conclusion

This study examined the gender relations in the North American gaming community. The quantitative and qualitative evaluation of in-game discourse in *League of Legends* sheds light on the perpetrators of sexism in the post-#MeToo era. Hypothesis 1 was supported; Hypothesis 2 was rejected. Hypothesis 3, predicting that more advanced players give and receive fewer negative comments, was partially supported, as high-ranking players were found to use the most positive language to communicate, whereas mid-ranking players used the least positive language.

In general, *League*’s anti-toxicity policies are effective in promoting a supportive gaming environment, and *League* players have an integral understanding of expected behavior, communicating cooperative strategies and calling out toxicity. While female username players received more negative comments, the gender disparity was less prominent than that found in previous studies conducted pre-#MeToo. This study finds no significant instances of misogyny—the only incident of explicit gender-based harassment was dismissed by the target and perceived as a joke by their teammates. While this result signifies that the post-#MeToo gender equality landscape is generally improving, the difference between the perception and treatment of female versus male gamers highlights

that entrenched gender bias persists, as men continue to be perceived as archetypal gamers and women are marginalized due to their gender.

The many challenges posed by gender-based exclusion and toxicity can be mitigated by creating an environment that supports women in the gaming community. To start, given the hyper-sexualization of female *League* Champions (Bell, 2017), Morawitz highlights the possibility of reversing gender stereotypes by desexualizing female Champions and adding female Champions who are equally strong, if not stronger, than their male counterparts (2007, p. 99). Simultaneously, Riot Games should encourage players to report inappropriate behavior, impose stricter policies to target toxicity, and penalize abusers of the online space. A linguistic analysis program like Lexalytics could be developed specifically to identify offensive language in *League*, and implemented in the in-game chat room to warn toxic players of their inappropriate behavior in real time or block them from the text chat. Riot Games might also consider implementing a toxicity rating for *League* players to promote self-regulation by making the ratings public.

Further Research

Studies using a similar methodology should attempt to achieve greater control and minimize inter-observer variability by recruiting more volunteers to dilute differences in their playing and communication styles. A larger sample should be collected, and more researchers should participate in content analysis to mitigate sampling and researcher bias. Additionally, a more robust sentiment analysis program needs to be developed to analyze more accurately gamers’ language. Moreover, future studies should explore correlations between verbal toxicity and other factors, such as the players’ win rates and time of the day the game was played. Finally, although a different methodology is required, future studies can explore the age and socioeconomical status of the perpetrators and victims of misogyny.

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Appendices

Appendix 1

Name	Weight
grill	-0.45
boobs	-0.5
bitch	-1
whore	-1.2
honey	-0.3
babe	-0.3
(woman OR women) NEAR ((no right) OR (no rights))	-0.6
go back to support	-0.9
slutty OR slut OR thicc ¹	-1
(honey OR babe OR bitch OR girl) NEAR (single OR hot OR cute)	-0.7
(honey OR babe OR bitch OR girl) NEAR (fat OR ugly OR carried OR cute OR boyfriend OR suck)	-0.7
gj ²	1
boomer	-0.2
wtf	-1
fkin OR fk OR fuck OR fucking	-1
bs	-1
op	1
glhf ³	1
ez	0.4
stfu	-0.8
gg OR ggwp ⁴	1

1 An internet slang for used to describe a woman with a body that is voluptuous and curvy.

2 Short for “good job”

3 Short for “good luck, have fun.”

4 Short for “good game, well played.”

Appendix 2: Python Code Optical Character Recognition

read image OCR module

```
import requests,os
def ocr_space_file(filename, overlay=False, api_key='05ff7903c388957', language='eng'):
    """ OCR.space API request with local file.
        Python3.5 - not tested on 2.7
    :param filename: Your file path & name.
    :param overlay: Is OCR.space overlay required in your response.
        Defaults to False.
    :param api_key: OCR.space API key.
        Defaults to 'helloworld'.
    :param language: Language code to be used in OCR.
        List of available language codes can be found on https://ocr.space/OCRAPI
        Defaults to 'en'.
    :return: Result in JSON format.
    """
```

```
payload = {'isOverlayRequired': overlay,
           'apikey': api_key,
           'language': language,
           'detectOrientation': True,
           'OCREngine':2
          }
with open(filename, 'rb') as f:
    r = requests.post("https://api.ocr.space/parse/image",
                     files={filename: f},
                     data=payload,
                     )
return r.content.decode()
```

TextOutputParse module used in Step 3

```
def addNew(locStr,iReadThisList):
    # check whether the 2 list has i overlaps is true
    # list 1 is the old list, list 2 is the read readings
    def checkIOverlap(i, list1, list2):
        len1=len(list1)
        j=0
        while j<i:
            # print(list1[len1-i+j].replace("\n",""))
            # print(list2[j])
            if (list1[len1-i+j-1].replace("\n",""))!=list2[j]:
                return False
            j=j+1
        return True
    # determine how many elements overlap
    def compare(newList, oldList):
        for i in range (1,min(len(newList), len(oldList))+1):
            if checkIOverlap(i, oldList, newList):
                return i
        return 0
```

MISOGYNY IN THE ONLINE GAMING COMMUNITY

```
# append the non-overlapping part to file
def writeToFile(previousList, newReading):
    overlap=compare(newReading,previousList)
    # number of entries that overlap
    print(overlap)
    for i in range (overlap,len(newReading)):
        existing.write(newReading[i].replace("","")+ "\n")
myFile=open(str(locStr),"r",encoding="utf-8")
lines = myFile.readlines()
myFile.close()
existing=open(locStr,"a+",encoding="utf-8")
# what is already in the file
print(lines)
writeToFile(lines,iReadThisList)
existing.close()

# Step 1: write all names of pic files
def tFramesTotal(directoryPrefix, t,imageListFile):
    file = open (str(imageListFile),"w")
    if t<100:
        for i in range (1,10):
            file.write(directoryPrefix + " 0"+str(i)+ ".jpg" + "\n")
        for i in range (10,t+1):
            file.write(directoryPrefix + " "+str(i)+ ".jpg" + "\n")
    else:
        for i in range (1,10):
            file.write(directoryPrefix + " 00"+str(i)+ ".jpg" + "\n")
        for i in range (10,100):
            file.write(directoryPrefix + " 0"+str(i)+ ".jpg" + "\n")
        for i in range (100, t+1):
            file.write(directoryPrefix + " "+str(i)+ ".jpg" + "\n")
    file.close()

subfolder= input("hi, what is the subfolder name (directoryPrefix)")
frameNum=int(input("how many frames?"))
imageListFile=input("PlayerName-game number?")
tFramesTotal(subfolder,frameNum,imageListFile)

# Step 2: create aggregate text file for lines
AggFileName=input("how would you like to name your aggregate file?")
AggFile = open (str(AggFileName), "w", encoding="utf-8")

# Step 3: Read each line in the file created in Step 1 and run it through OCR
imageFileNames_in_a_List = open (str(imageListFile),"r",encoding="utf-8").readlines()
print(imageFileNames_in_a_List)
for i in range (0,len(imageFileNames_in_a_List)):

    newLineLoc = imageFileNames_in_a_List[i].find("\n")
    imageFileNames_in_a_List[i]=imageFileNames_in_a_List[i][:newLineLoc]
    read_image=""
    if os.path.exists(imageFileNames_in_a_List[i]):
        print(i)
```

```
        read_image = ocr_space_file(filename=str(imageFileNames_in_a_List[i])) # read the image
        # parse out each line
        result = read_image.find("ParsedText:")
        read_image = read_image[result + 14:]
        result = read_image.find("ErrorMessage")
        read_image = read_image[result]
        newList=read_image.split("\n")
        myLocStr = "C:\Users\2020057\OneDrive - Appleby College\2019-2020 APPLEBY\S_Capstone\Programming\ + AggFileName
        addNew(str(myLocStr),newList)

AggFile.close()
```

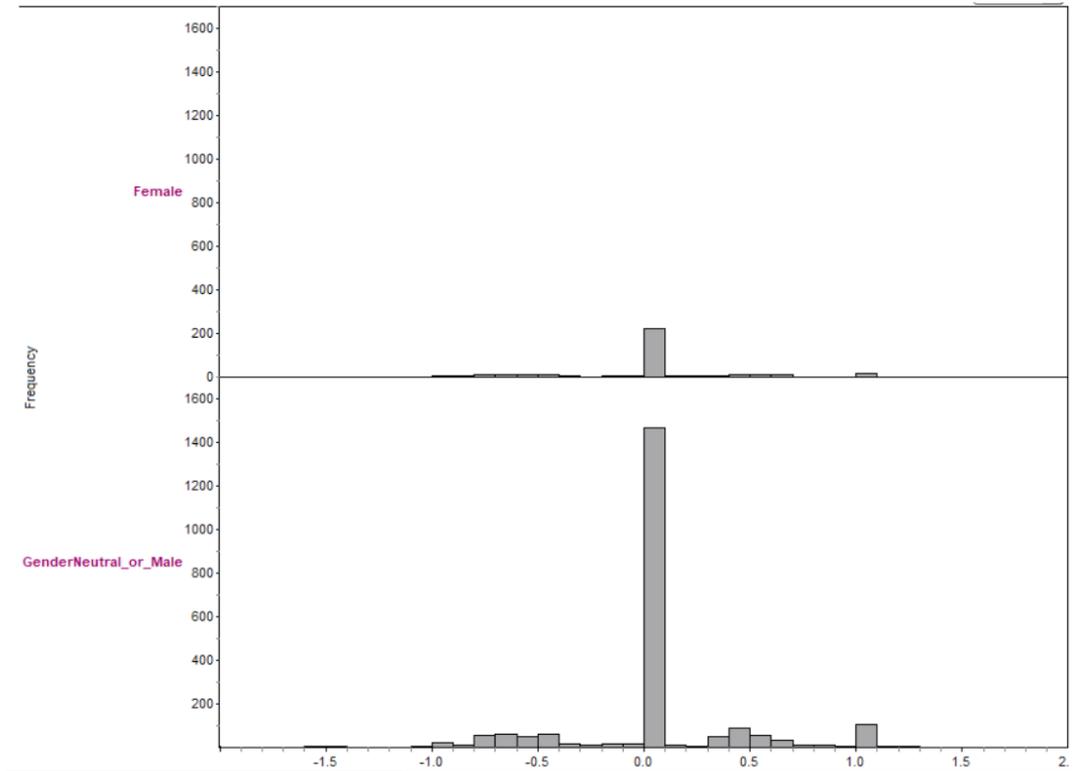
Appendix 3: Sample Raw Data and Sentiment Score Evaluation

Note: Players' usernames were anonymized.

Entries	Sentiment Score
Player A: Good luck everyone! At\ Hope your morning day evening or night is going well so far and if not i hope it gets better soon	0.5325
Player B: out of range	0
Player C: dont understand why do we havea yummi who deosnt heal	-0.04
Player D: good nett	0.5
Player B: didnt expect that	0
Player E: was oom	0
Player E: didnt have ult	0
Player B: expected that tho	0
Player C: ?	0
Player C: caIt	0
Player C: what u doing	-0.58
Player E: didnt expect renger: to lose	0
Player E: what	0
Player E: wtf	-1
Player E: time for us to throw lol	0
Player C: cant we group?	0
Player D: sure	
Player E: group for once	
Player C: gg	1
Player A: ez	0.4
Player D: gg	1
Player C: ez your mom	-0.09

Appendix 4: Histograms for Sentiment Score Distribution

Figure 1: Sentiment Score by Username Gender



MISOGYNY IN THE ONLINE GAMING COMMUNITY

Figure 2: Sentiment Score by Champion Gender

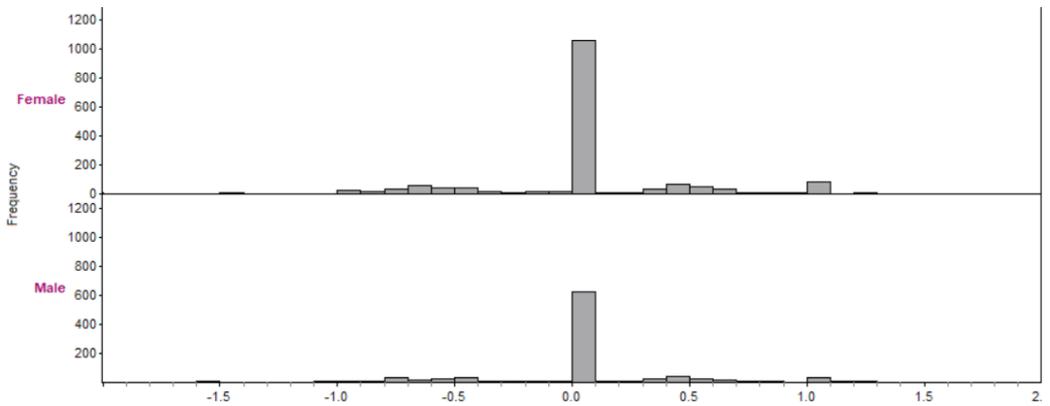
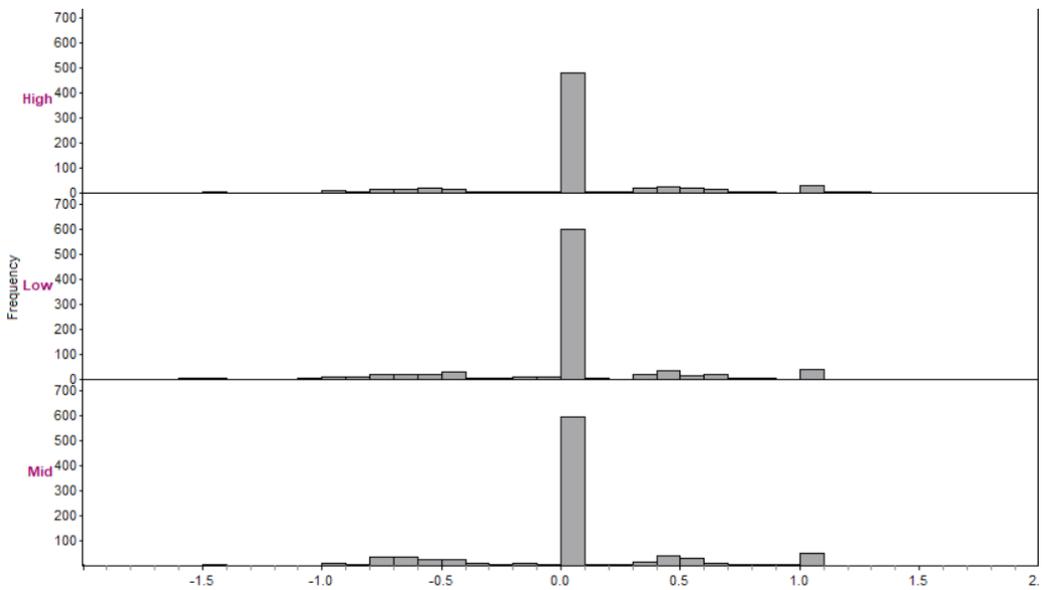


Figure 3: Sentiment Score by Rank



MISOGYNY IN THE ONLINE GAMING COMMUNITY

Figure 4: Sentiment Score by Outcome

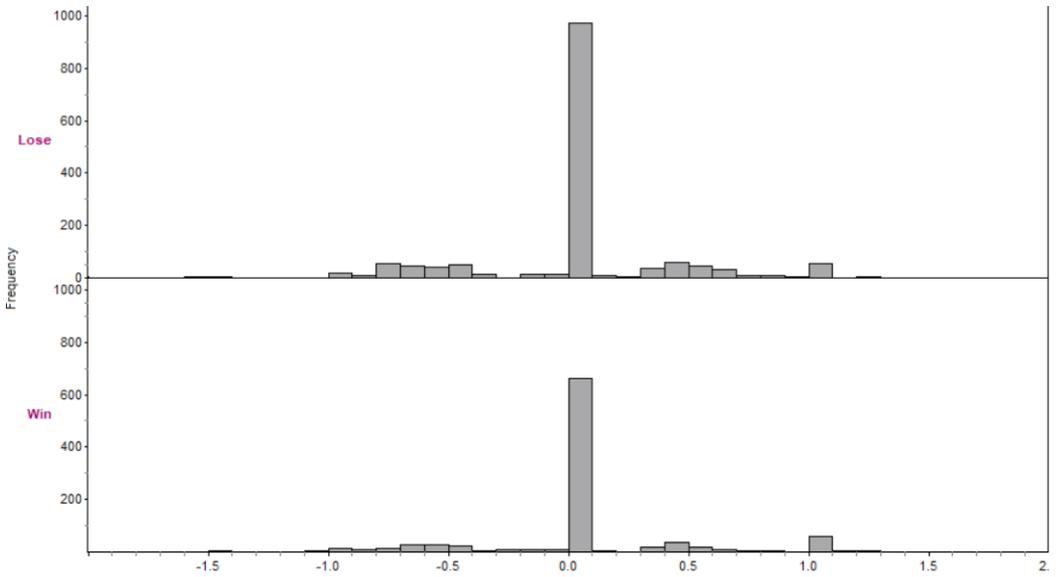
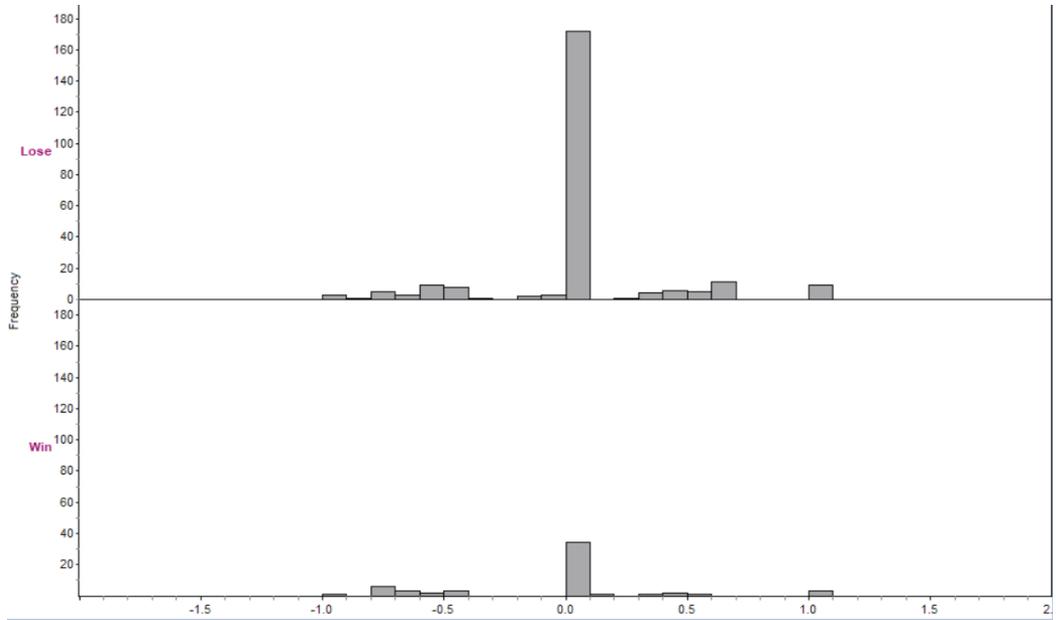


Figure 5: Sentiment Score by Outcome (Female Username Only)



Appendix 5: Mathematical Explanation of the 2-Sample T-Test

A T-test uses the test statistic, t , to assess whether the difference between the means of two numerical samples occurred by chance (Starnes et al., 2015).

Sample 2-Sample T-Test for Correlation 1

Let μ_1 denote the population mean of the sentiment scores collected from female-sounding username games, x_1 denote the sample mean, and n_1 the sample size of data collected in this strata.

Let μ_2 denote the population mean of the sentiment scores collected from male-sounding or gender-neutral username games, x_2 denote the sample mean, and n_2 the sample size of data collected in this strata.

$$x_1 = -0.01165347, \quad s_1 = 0.359976992, \quad n_1 = 317$$

$$x_2 = 0.017943041, \quad s_2 = 0.373289555, \quad n_2 = 2118$$

$H_0 : \mu_1 - \mu_2 = 0$. There is no different in the means of sentiment scores of conversations collected from both groups.

$H_1 : \mu_1 < \mu_2$. The mean sentiment scores of conversations collected from female-sounding username games is less than the mean sentiment scores of conversations collected from male-sounding and gender-neutral username games.

We choose $\alpha = 10\%$, and compute the degree of freedom, standard error, and t value with the two samples.

$$\begin{aligned} df &= \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{1}{n_1 - 1} \left(\frac{s_1^2}{n_1}\right)^2 + \frac{1}{n_2 - 1} \left(\frac{s_2^2}{n_2}\right)^2} \\ &= \frac{\left(\frac{0.359976992^2}{317} + \frac{0.373289555^2}{2118}\right)^2}{\frac{1}{317 - 1} \left(\frac{0.359976992^2}{317}\right)^2 + \frac{1}{2118 - 1} \left(\frac{0.373289555^2}{2118}\right)^2} \\ &= 424.2617 \end{aligned}$$

$$\begin{aligned}
SE(x_1 - x_2) &= \sqrt{VAR(X_1 - X_2)} \\
&= \sqrt{VAR(X_1) + VAR(X_2)} \\
&= \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} \\
&= \sqrt{\frac{0.359976992^2}{317} + \frac{0.373289555^2}{2118}} \\
&= 0.0217846605
\end{aligned}$$

$$\begin{aligned}
t &= \frac{x_1 - x_2}{SE} \\
&= \frac{-0.01165347 - 0.017943041}{0.0217846605} \\
&= -1.3585941
\end{aligned}$$

$$\implies p = P(H_1 | H_0) = 0.087499.$$

Therefore, in this instance, H_0 is rejected in favour of H_1 . There is sufficient evidence to suggest that the mean of sentiment scores in games where the volunteer's username is female-sounding is less than the mean of sentiment scores in games where the volunteer's username is not because our p-value (0.087499) is greater than α . This result is statistically significant.

Appendix 6: Mathematical Explanation of F-Statistic and P-Value

ANOVA uses the test statistic, f , to assess the statistical different among the means of two or more groups (Starnes et al., 2015). The f-statistic for one-way ANOVA is determined as follows,

$$f = \frac{\text{between-groups variance}}{\text{within-group variance}}$$

The between-groups variance is determined by

$$\sum_{i=1}^k n_i \frac{(\bar{Y}_i - \bar{Y})^2}{k - 1}$$

where \bar{Y}_i stands for the sample mean in the i th group, n_i the number of observations in the i th group, \bar{Y} the overall mean of the data, and k the number of groups.

Within-group variance is determined by

$$\sum_{i=1}^k \sum_{j=1}^{n_i} \frac{(Y_{ij} - \bar{Y}_i)^2}{N - k}$$

where Y_{ij} is the j th observation in the i th group and N is the overall sample size. This F-statistic follows the f-distribution with degrees of freedom $d_1 = k - 1$ and $d_2 = N - k$ under the null hypothesis, which maintains that the mean is the same for all experimental groups in different categories.

If the f-value calculated from the sample was greater than the critical F-value at the selected critical level (10%, 5%, or 1%), then the null hypothesis can be rejected, and the categorical differences are statistically significant.

Theory of Mind Ability in Opposite-Sex Twin Females: The TTT Hypothesis

Rakshita Kota

This study researched the Twin Testosterone Transfer hypothesis, which predicts that “Female fetuses developing between two males [in the womb] tend to show masculinized ... traits as adults ... due to the transfer of testosterone from male fetuses” (1). This study aimed to determine whether opposite-sex twin females had lower socio-cognitive ability as compared to singleton females through the “Reading the Eyes Through the Mind Test” (RMET) test, which measures a form of social cognition known as “Theory of Mind”. Thus, the study tested the question, “Does the exposure to elevated levels of prenatal testosterone for opposite-sex twin females result in lower Theory of Mind ability?” Ultimately, the results showed that opposite-sex twin females have lower RMET scores, and therefore lower socio-cognitive ability than singleton females, thus validating the Twin Testosterone Transfer hypothesis.

Keywords: Twin Testosterone Transfer hypothesis, Theory of Mind, Social cognition, Opposite-sex twins

INTRODUCTION AND BACKGROUND INFORMATION

Research regarding fraternal twins is very limited compared to the extensive amount of studies and research done on identical twins. Within fraternal twins, one recent and under-researched topic is the Twin Testosterone Transfer (TTT) theory, which is

a specific case of the Prenatal Testosterone Transfer (PTT) theory. The PTT theory is the phenomenon that hypothetically occurs when testosterone utilized by a developing fetus transfers to other embryos in the womb through either amniotic fluid or via the mother’s blood stream, therefore influencing the development of these fetuses (1). While this has been researched in various animals such as rodents and pigs (1), it has rarely been tested in twins, due to its recent discovery in the field of twin studies. The PTT theory

in regards to humans specifically is the TTT theory, which hypothesizes that females in opposite-sex (OS) twin pairs, are exposed to higher levels of testosterone than singleton, or single-birth, females due to testosterone transfer from their male co-twins (2). The TTT theory in OS twins has been tested by various studies in order to determine whether this elevated exposure of testosterone for OS twin females results in more male-typical behavior in the OS twin females.

LITERATURE REVIEW

Previous studies on the TTT Theory on OS Twin Females

There is currently limited research on the Twin Testosterone Transfer theory. Past studies have tested the effect of the TTT theory on female opposite-sex twins in regards to physical (3), socio-economic (4), behavioral (5), and cognitive (6) perspectives. The results of past studies are split, with some studies being in support of the TTT theory and some studies either rejecting it or stating that they can neither validate nor invalidate the theory.

The studies in support of the TTT theory^{3, 4, 5, 6} determine that these individuals seem to be more male-typical than singleton females. For example, in relation to the physical perspective of the TTT theory, researchers at the University of Adelaide in Australia tested the dental crown size of OS twin and singleton (S) females. Dental crown size is a reliable measure used by many researchers to test the biological difference between males and females, as it is established that females consistently have smaller dental crown sizes than males (3). Dempsey, Townsend, and Richards (1999) found that OS twin females had significantly larger dental crown sizes than the S females, therefore supporting the theory that the TTT phenomenon results in OS twin female masculinization (3). In relation to the *socio-economic* perspective of the TTT theory, a large-scale study was done using a total of 13,800 twin births. By tracking these twins over the course of 30 years, researchers found that OS twin females are less likely to graduate from high school (-15.2%) or get married (-11.7%) (4). Additionally, researchers also found that OS twin females have lower fertility rates (-5.8%) and life-cycle earn-

ings (-8.6%) (4). While the findings of their study do not necessarily show that OS twin females are more “male-like”, the findings are “consistent with the idea that passive exposure to prenatal testosterone changes women’s education, labor market, and fertility outcomes”, which proves a biological sex-difference as a result of exposure to prenatal testosterone (4).

Additionally, in respect to the *behavioral* perspective, a study conducted on 422 British twin pairs tested the Sensation Seeking Scale (SSS) score of each pair (5). Sensation seeking is defined as the tendency to take risks to pursue sensory and complex pleasures (for example, skydiving). Because males are found to consistently have higher SSS scores, this British study tested the SSS in OS twin females to determine whether OS twin females are more male-typical in this aspect. In this study, the researchers found an increase in SSS scores in OS twin females (5). In addition, several studies were conducted regarding the spatial visualization ability (*cognitive* perspective) of OS twin females via mental rotation tests. Mental rotation is the ability to rotate objects in one’s mind by merely visualizing it, and it is established that men consistently perform better in these tests than females. In a mental rotation study on OS twins published by the Association for Psychological Science, OS twin females exhibited superior spatial abilities than their S female counterparts (6).

In all four of the aforementioned studies, the results of each of the studies support the TTT theory regarding their various perspectives. However, it is important to note that there are also several studies that either reject the Twin Testosterone Transfer theory or state that they can neither validate or invalidate the theory^{7, 8, 9}. For example, in a cognitive national Danish cohort study conducted on 1812 OS twins, 4050 same-sex (SS) twins, and 13,900 singletons, by comparing ninth grade test scores of several subjects, researchers found that males performed significantly better than females in mathematics tests, and the opposite was true for Danish tests (7). However, the researchers “did not find that OS females performed better in mathematics than SS and singleton females”. Thus, they concluded that the study showed no evidence for the masculinization of OS twin females with their male co-twins, meaning that the TTT theory in regards to academic performance was invalidated with this study (7). In another study done by research-

ers from the Indiana University Department of Psychology, researchers studied the attitudes associated with femininity and the fertility of Finnish SS and OS twins. They found that “there was no evidence of differences between sisters from same- and opposite-sex twin pairs, and thus, no evidence of either androgenization or cross-sex socialization” (8). While the last two studies rejected the TTT hypothesis, there are also studies that state that it cannot be proved or disproved until further research is conducted. For example, in a study done by the School of Psychology at the University of Western Australia, researchers conducted a systematic review by consolidating and reviewing the evidence of previous studies that also focused on the TTT hypothesis. For example, they used studies on “behavioral, perceptual, cognitive, morphological and physiological traits”, sensation-seeking, perception (otoacoustic emissions), visuo-spatial ability, and physiology and morphology (specifically tooth size, 2D:4D ratio, and brain volume) and evaluated whether the culmination of this evidence can determine a clear-cut “yes” or “no” answer on whether the TTT phenomenon is apparent in humans (9). Ultimately, they concluded that although the evidence is inconsistent, “the evidence for the TTT hypothesis is sufficient to warrant further investigation” (9). Thus, given the varying conclusions regarding the TTT hypothesis, more research needs to be done to ensure that the scientific community one day reaches a consensus on this theory.

Under-researched Cognitive Perspective of the Twin Testosterone Transfer

While the TTT theory has been previously tested^{1,2,3,4,5,6,7,8,9} regarding the behavioral, physical, socioeconomic, morphological, physiological, and cognitive perspectives, one of the most important and under-researched perspectives of the TTT is the cognitive perspective, which is the perspective that studies how excess prenatal exposure to testosterone affects the cognition of OS twin females. There are three basic, major variables under the cognitive field that can be tested due to previously demonstrated biological sex differences: spatial visualization, language comprehension, and social cognition. Previous studies have attributed male advantage in spatial visualization to their higher levels of testosterone (10). On the other

hand, past studies have attributed female advantage in language comprehension and social cognition to their lower levels of testosterone, meaning that these variables can be attributed back to the Twin Testosterone Transfer theory, if tested in OS twin females (11). The TTT theory in relation to spatial visualization has already been tested in multiple studies in OS twin females, by measuring mental rotation ability, as mentioned previously. However, the other two variables, language comprehension and social cognition, have yet to be tested in opposite-sex twin females.

Theory of Mind Ability and the RMET Test

Between the two variables, language comprehension and social cognition, I chose to test social cognition because it is easier to measure quantitatively than language comprehension.

Within social cognition, I chose to test the Theory of Mind trait. Theory of Mind is the socio-cognitive ability to “explain and predict other people’s actions in terms of underlying mental states, such as beliefs, intentions, or feelings” (12). Theory of Mind is often tested using the Reading the Mind in the Eyes test (RMET).

Additionally, low Theory of Mind ability is typically associated with Autism Spectrum Disorder thus, as a result, the RMET test is generally used to test the degree of Autism Disorder in an individual. In a previous study, Mauro Adenzato and her team found that females significantly perform better than males in Theory of Mind ability (12); thus, in relation to the TTT theory, it is practical to test the Theory of Mind ability of OS twin females and S females. However, in a notable previous study conducted that researched a similar topic, the results were opposite to what was expected. In this study conducted from data from the Swedish Child and Adolescent Twin Study, researchers tested whether OS twins were more likely to reach the cutoff score for ASD than same-sex (SS) twins. Contrary to what the researchers hypothesized, the findings of the study were that SS twin females were closer to the Autism Spectrum Disorder cutoff score than OS twins. Furthermore, the researchers were at a loss as to explain why, as according to the TTT theory, OS females should be closer to the Autism Disorder spectrum (13).

RESEARCH GAP

My research addresses an apparent gap in current literature because as mentioned previously, the TTT theory is a recent topic in the twin studies field and thus needs to be more extensively studied. Additionally, the cognitive perspective of the TTT theory is an important aspect of the TTT; however, it is currently under-researched. Furthermore, the confusion and inconsistent results regarding ASD and the TTT theory further validates my choice of research. Thus, I have chosen to conduct a study similar to the ASD study mentioned previously. However, instead of measuring ASD prevalence in general, I am measuring the prevalence of a specific trait of ASD: Theory of Mind.

PURPOSE AND HYPOTHESIS

The purpose of my study is to determine whether OS twin females have lower RMET scores, and therefore lower social cognition ability due to the TTT theory as compared to females. Since it is assumed that OS twin females have higher testosterone levels than S females, there is a chance that this will result in lower Theory of Mind scores. With this arises the research question: “Does the exposure to elevated levels of prenatal testosterone for opposite-sex twin females result in lower Theory of Mind ability?” Given my review of literature, I am predicting that opposite-sex twin females have a lower Theory of Mind ability (RMET scores) than their singleton female counterparts due to their exposure to excess prenatal testosterone in the womb.

METHODOLOGY

RMET and Data Collected

For this study, I tested two groups: OS twin females and S females. For these two groups of females, I assessed their Theory of Mind ability, which is a form of social intelligence that determines how well one can read facial expressions and interpret social cues. I assessed their Theory of Mind ability using the RMET (Reading the Mind in the Eyes Test) developed by professor Simon Baron-Cohen at the University of

Cambridge in order to test social intelligence.

It has been adapted by the Autism Research Center (ARC) and is sometimes used to test for certain autism traits. The RMET test is publicly available for research purposes on the ARC website (14). The RMET test is an assessment in which the participant is given 36 questions.

Each question consists of a picture of a set of eyes, and the participant is asked to choose the emotion that the person in the picture is feeling by merely looking at the set of eyes. Because the test is a multiple-choice exam, it was feasible and convenient for me to conduct the study and quantify the results. The only data or information I needed to collect from my study participants was their RMET score.

Participants

For this study, participants include one group of singleton females (41) and one group (7) of opposite-sex twin females. This was because in order to determine whether OS twins had higher average RMET scores than S females, both groups of data had to be analyzed. In order to get opposite-sex twin participants, I sent out a survey (Appendix A) to English teachers of all high schools in a large and racially diverse Texas school district. The teachers distributed the survey to their students via a QR code that I had given them ahead of time. I also sent the survey to other AP Research teachers in the United States, who forwarded my survey to their students.

In the survey, I asked the students whether they were an opposite-sex twin female and if so, I asked them to provide their email address in order to contact them. I kept the survey open for approximately three weeks to allot adequate time to gather interested participants. After the three weeks, I sent out an email (Appendix F) to the OS twin females regarding the details and purpose of my study in order to provide them with context regarding my research. In this email, I also sent out a link to the online RMET test (Appendix C) and requested the opposite-sex twin females to take the test. I instructed them to take a maximum of 10 minutes for the test so that each participant takes roughly the same amount of time in order to complete the test. This way, no one person is at an advantage for having more time to take the test than another. They were also allowed to use

THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

a supplementary vocabulary document (Appendix E) to aid them. The document consisted of the words and definitions of all of the words on the RMET test: most words were above-average in vocabulary level. Because of the supplementary document provided, no one person was at an advantage for having a higher vocabulary than another.

In order to attain participants for my singleton female group, I sent a survey (Appendix B) to all English teachers of one high school in the aforementioned school district as well as the same AP Research teachers around the US. The rest of this process was the same as the process described in the previous paragraph (Appendix D, E, and G). The survey participants were high school students mostly from the same large, racially and economically diverse, urban Texas school district so that the Theory of Mind ability of students from varying backgrounds could be analyzed and interpreted.

Data Analysis

After getting back RMET scores from both the singleton females and the opposite-sex twin females, I then compared the averages for both groups using the t-test to determine whether or not RMET scores (and therefore Theory of Mind ability) of OS twin females are significantly lower - and also not due to random chance - than singleton females, thus validating or disproving the TTT hypothesis.

Materials

For this study, necessary materials included a computer with internet access. This was necessary for procedures such as emailing participants and teachers (Gmail), attaining participants (Google Forms), and analyzing data (Google Sheets). There was no need for any additional special equipment or resources to collect data or information, because all parts of my study was done via online surveys and an online RMET test. The RMET test that I had used for my study was provided by the Autism Research Center. Their tests are public for researchers to use. The paper version of the test can be found at the Autism Research Center website in the "Tests" tab under the "Eyes Test (Adult)" drop-down menu (14).

Limitations of Methodology

The biggest limitation to this methodology is that if the S or OS twin females become frustrated with the RMET assessment midway, they may not give their best attempt on some -or all- of the questions, which would impact the data. While this may be true for any adolescent that takes the RMET test, it especially applies to this study because this study is not professionally administered. Due to the lower stakes and low pressure nature of my study compared to the professional administration of the test (which is used to screen for autism), this concern is especially apparent in my study.

RESULTS AND DISCUSSION

Survey Data

In total, the survey (online RMET test) for OS twin females gained 7 responses from students. The RMET test for singleton females gained 41 responses overall. As shown by Figure 1, OS twin females had an average RMET score of 29.43 and the singleton females had an average RMET score of 32.19 meaning that the singleton females had a higher average score of RMET.

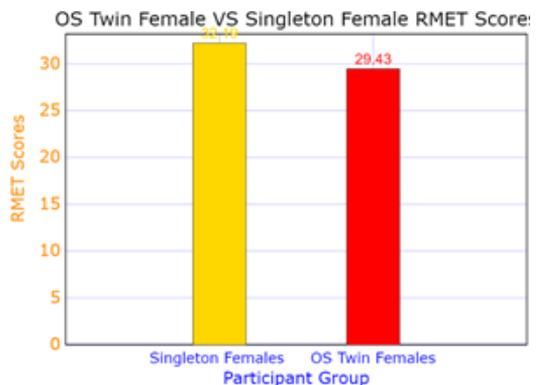


Figure 1 compares the average RMET scores of opposite sex twin females and singleton females

While these two numbers may be different, in order to be sure that my RMET averages were statistically different (meaning that the discrepancy is

THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

not a result of natural fluctuation), I conducted a two-sample t-test. After inputting information such as the sample means of the groups, the sample standard deviations, and the sample sizes into an online calculator, the final p-value turned out to be 0.033. Because this value of 0.033 is less than the standard significance level of 0.05, I reject the null hypothesis that the two RMET averages are not statistically different. This means that the data support the alternate hypothesis that the average RMET score of opposite sex twin females is statistically different from the average RMET score of singleton female. This means that the discrepancy of average RMET scores between singleton and opposite-sex twin females is not due to random chance. Instead, we attribute it to a biological reason: the twin testosterone transfer hypothesis. The study's results support the TTT hypothesis that opposite sex twin females display more male-typical characteristics due to their exposure to higher levels of testosterone. Ultimately, despite the possible shortcomings listed in the previous limitations section, the methodology still proved successful in answering my research question

and fulfilled my purpose of determining whether OS twin females had lower social cognition ability due to the TTT theory.

Limitations of Results

A major possible limitation to my findings is the small sample size of singleton and OS twins. According to the Central Limit Theorem, a statistics concept that states "if you take sufficiently large random samples from the population with replacement, then the distribution of the sample means will be approximately normally distributed", a sample size of 30 is sufficient to represent a population (16). Although the results of the singleton females may be relatively reliable because their sample size of 41 was greater than 30, the reliability of the OS twin results is admittedly questionable, as their sample size of 7 was significantly lower than 30: this small sample size allows for high variability in the OS twin group's data. Furthermore, another possible limitation of my findings is that because most (about 75%) of the singleton females were from the same school, a highly competitive school with students of comparatively high socio-economic status, their Theory of Mind ability may in some way

be skewed compared to the general population. Additionally, the same goes with the OS twin females, although to a lesser extent. This is because although all of the OS twin females are from the same district, the district is comprised of high schools with various backgrounds and socioeconomic statuses.

Thus, this limitation may not drastically change the data.

CONCLUSION

The study's results confirmed the initial hypothesis that opposite-sex twin females have a lower Theory of Mind ability (RMET scores) than their singleton female counterparts. The findings that I have presented support previous studies, because similar to the work done by the University of Adelaide on dental tooth crowns (3), the work done by Northwestern University on the socio-economic aspect (4), and the work done by the Association for Psychological Science on mental rotation (6), the results of my study confirm the twin testosterone transfer theory.

Specifically in this case, they show that the decreased RMET scores, or Theory of Mind ability for opposite sex twin females can be attributed to the increased exposure to testosterone for opposite sex twin females in comparison to singleton females.

Implications and Reflection

My findings have implications in the twin community. For one, it shows the extent to which the mother's womb and an individuals' prenatal environment can have on an individual throughout their life. This is important because it can lead to further exploration of differing maternal environments that may also affect individuals later on in their lives. Second, it shows that opposite sex twin females differ in thinking from singleton females. This is important because it may lead to future research on how and which types of cognitive function differ between singleton and opposite-sex twin females: my study only looked specifically into social cognition. Most importantly, my results bring the scientific community one step closer to one day reaching a consensus regarding the twin testosterone theory.

Future Research

Most research conducted on the Twin Testosterone Transfer Theory examines the effect of prenatal testosterone transfer between male and female co-twins in the womb on behavioral and physical perspectives 2, 4, 6, 7; however, few studies have examined the effect of this testosterone transfer phenomenon in regards to the cognitive perspective, specifically, social cognition. Consequently, future research for determining the validity of the Twin Testosterone Transfer Theory should further and expand on my study by comparing RMET scores of four groups: singleton males, singleton females, opposite-sex twin males, and opposite-sex twin females. This avenue for future research is significant since it allows one to determine whether the difference in social cognition of opposite-sex twin females aligns more with males than females, vice-versa, and by how much. Additionally, by adding an opposite-sex twin male group as well in the study, one can observe the effects, if any, of the females hormone transfer in the womb on their male co-twin.

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Appendix A:

Survey to district High Schools to attain opposite-sex twin female participants

Research Study Participation Survey - OS Twin Females

This survey is meant to get the contact information of opposite-sex twin females for a research study being conducted.

Are you an opposite-sex twin female? (In other words, are you a female that has a twin brother?) *

Yes

No

If you answered yes to the previous question, please provide your email address so that you can be contacted regarding a research study. The research study will just be a quick, 10 minute online assessment. Results will not negatively affect you in any way. Your participation would greatly help!

Short answer text

Appendix B:

Survey to English teachers at High School to attain singleton female participants

Research Study Participation Survey - Singleton Females

This survey is meant to get the contact information of singleton females for a research study being conducted.

*** Required**

Are you a female? Because this survey is focused on females, if you are not a female, the survey will end for you. *

Yes

No

Do you have a twin or triplet? *

Yes

No

If you answered "yes" to the first question and "no" to the second question, please provide your email address below in order to participate in a research study. The research study is just a quick, 10 minute online assessment. Results will not negatively affect you in any way. Your participation would greatly help! *

Your answer _____

Appendix C:

Online RMET test images for opposite-sex twin females

Section 1 of 37

Research Study RMET Test - OS Twin Females

Thank you so much for participating!

Please fill out the following form and answer the following 36 questions to the best of your ability. DO NOT TAKE MORE THAN 10 MINUTES. If you do not know what a word means, you may search it up in the supplementary definitions handout provided.

1. What emotion do you believe the eyes below are showing? *

Playful

Comforting

Irritated

Bored

Picture 1



Section 2 of 37

Question 2

Description (optional)

2. What emotion do you believe the eyes below are showing? *

Terrified

Upset

Arrogant

Annoyed

Picture 2



Section 3 of 37

Question 3

Description (optional)

3. What emotion do you believe the eyes below are showing? *

Joking

Flustered

Desire

Convinced

Picture 3



Section 4 of 37

Question 4

Description (optional)

4. What emotion do you believe the eyes below are showing? *

Joking

Insisting

Amused

Relaxed

Picture 4



Section 5 of 37

Question 5

Description (optional)

5. What emotion do you believe the eyes below are showing? *

- Irritated
- Sarcastic
- Worried
- Friendly

Picture 5



Section 6 of 37

Question 6

Description (optional)

6. What emotion do you believe the eyes below are showing? *

- Aghast
- Fantasizing
- Impatient
- Alarmed

Picture 6



Section 7 of 37

Question 7

Description (optional)

7. What emotion do you believe the eyes below are showing? *

- Apologetic
- Friendly
- Uneasy
- Dispirited

Picture 7



Section 8 of 37

Question 8

Description (optional)

8. What emotion do you believe the eyes below are showing? *

- Despondent
- Relieved
- Shy
- Excited

Picture 8



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 9 of 37

Question 9

Description (optional)

9. What emotion do you believe the eyes below are showing? *

- Annoyed
- Hostile
- Horrified
- Preoccupied

Picture 9



Section 10 of 37

Question 10

Description (optional)

10. What emotion do you believe the eyes below are showing? *

- Cautious
- Curious
- Bored
- Aghast

Picture 10



Section 11 of 37

Question 11

Description (optional)

11. What emotion do you believe the eyes below are showing? *

- Terrified
- Amused
- Regretful
- Flirtatious

Picture 11



Section 12 of 37

Question 12

Description (optional)

12. What emotion do you believe the eyes below are showing? *

- Indifferent
- Embarrassed
- Skeptical
- Dispirited

Picture 12



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 13 of 37

Question 13

Description (optional)

13. What emotion do you believe the eyes below are showing? *

- Decisive
- Anticipating
- Threatening
- Shy

Picture 13



Section 14 of 37

Question 14

Description (optional)

14. What emotion do you believe the eyes below are showing? *

- Irritated
- Disappointed
- Depressed
- Accusing

Picture 14



Section 15 of 37

Question 15

Description (optional)

15. What emotion do you believe the eyes below are showing? *

- Contemplative
- Flustered
- Encouraging
- Amused

Picture 15



Section 16 of 37

Question 16

Description (optional)

16. What emotion do you believe the eyes below are showing? *

- Irritated
- Thoughtful
- Encouraging
- Sympathetic

Picture 16



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 17 of 37

Question 17

Description (optional)

17. What emotion do you believe the eyes below are showing? *

- Doubtful
- Affectionate
- Playful
- Aghast

Picture 17



Section 18 of 37

Question 18

Description (optional)

18. What emotion do you believe the eyes below are showing? *

- Decisive
- Amused
- Aghast
- Bored

Picture 18



Section 19 of 37

Question 19

Description (optional)

19. What emotion do you believe the eyes below are showing? *

- Arrogant
- Grateful
- Sarcastic
- Tentative

Picture 19



Section 20 of 37

Question 20

Description (optional)

20. What emotion do you believe the eyes below are showing? *

- Dominant
- Friendly
- Guilty
- Horrified

Picture 20



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 21 of 37

Question 21

Description (optional)

21. What emotion do you believe the eyes below are showing? *

- Embarrassed
- Fantasizing
- Confused
- Panicked

Picture 21



Section 22 of 37

Question 22

Description (optional)

22. What emotion do you believe the eyes below are showing? *

- Preoccupied
- Grateful
- Inquiring
- Implying

Picture 22



Section 23 of 37

Question 23

Description (optional)

23. What emotion do you believe the eyes below are showing? *

- Contented
- Apologetic
- Defiant
- Curious

Picture 23



Section 24 of 37

Question 24

Description (optional)

24. What emotion do you believe the eyes below are showing? *

- Pensive
- Irritated
- Excited
- Hostile

Picture 24



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 25 of 37

Question 25

Description (optional)

25. What emotion do you believe the eyes below are showing? *

- Panicked
- Incredulous
- Despondent
- Interested

Picture 25



Section 26 of 37

Question 26

Description (optional)

26. What emotion do you believe the eyes below are showing? *

- Alarmed
- Shy
- Hostile
- Anxious

Picture 26



Section 27 of 37

Question 27

Description (optional)

27. What emotion do you believe the eyes below are showing? *

- Joking
- Cautious
- Arrogant
- Reassuring

Picture 27



Section 28 of 37

Question 28

Description (optional)

28. What emotion do you believe the eyes below are showing? *

- Interested
- Joking
- Affectionate
- Contented

Picture 29



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 29 of 37

Question 29

Description (optional)

29. What emotion do you believe the eyes below are showing? *

- Impatient
- Aghast
- Irritated
- Reflective

Picture 29



Section 30 of 37

Question 30

Description (optional)

30. What emotion do you believe the eyes below are showing? *

- Grateful
- Flirtatious
- Hostile
- Disappointed

Picture 30



Section 31 of 37

Question 31

Description (optional)

31. What emotion do you believe the eyes below are showing? *

- Ashamed
- Confident
- Joking
- Dispirited

Picture 31



Section 32 of 37

Question 32

Description (optional)

32. What emotion do you believe the eyes below are showing? *

- Serious
- Ashamed
- Bewildered
- Alarmed

Picture 32



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 33 of 37

Question 33

Description (optional)

33. What emotion do you believe the eyes below are showing? *

- Embarrassed
- Guilty
- Fantasizing
- Concerned

Picture 33



Section 34 of 37

Question 34

Description (optional)

34. What emotion do you believe the eyes below are showing? *

- Aghast
- Baffled
- Distrustful
- Terrified

Picture 34



Section 35 of 37

Question 35

Description (optional)

35. What emotion do you believe the eyes below are showing? *

- Puzzled
- Nervous
- Insisting
- Contemplative

Picture 35



Section 36 of 37

Question 36

Description (optional)

36. What emotion do you believe the eyes below are showing? *

- Ashamed
- Nervous
- Suspicious
- Indecisive

Picture 36



After section 36 Continue to next section

Section 37 of 37

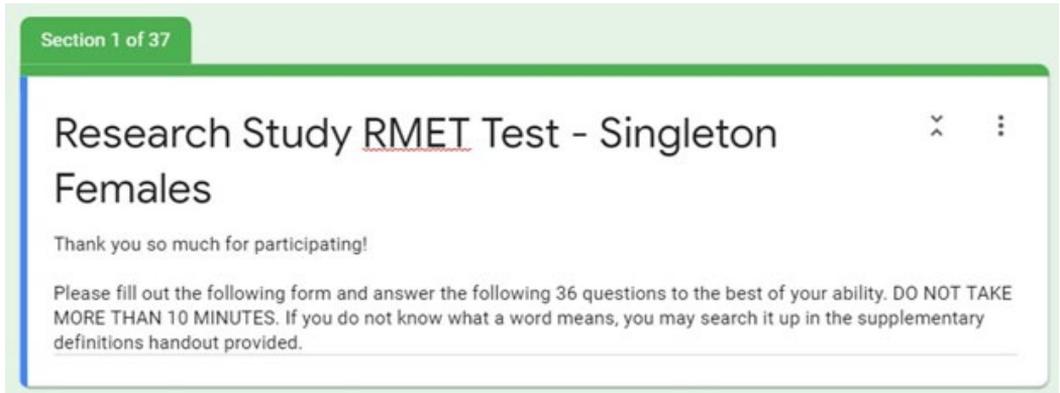
That is it! Thank you for participating in the survey!

Description (optional)

Appendix D:

Online RMET test images for singleton females

It is the same as Appendix C, with only one difference, the starting description:



The image shows a screenshot of a web-based test interface. At the top left, there is a green tab labeled "Section 1 of 37". The main title of the test is "Research Study RMET Test - Singleton Females", with "RMET" underlined in red. To the right of the title are two small icons: a close button (an 'x') and a menu button (three vertical dots). Below the title, the text reads: "Thank you so much for participating!". This is followed by instructions: "Please fill out the following form and answer the following 36 questions to the best of your ability. DO NOT TAKE MORE THAN 10 MINUTES. If you do not know what a word means, you may search it up in the supplementary definitions handout provided." The text is enclosed in a light blue border.

Appendix E:

RMET test supplementary document with definitions

RMET Test Instructions

For each set of eyes, choose and circle which word best describes what the person in the picture is thinking or feeling. You may feel that more than one word is applicable but please choose just one word, the word which you consider to be most suitable. Before making your choice, make sure that you have read all 4 words. If you really do not know what a word means, you can look it up in the following definition handout.

WORD DEFINITIONS

ACCUSING: blaming

The policeman was accusing the man of stealing a wallet.

AFFECTIONATE: showing fondness towards someone

Most mothers are affectionate to their babies by giving them lots of kisses and cuddles.

AGHAST: horrified, astonished, alarmed

Jane was aghast when she discovered her house had been burgled.

ALARMED: fearful, worried, filled with anxiety

Claire was alarmed when she thought she was being followed home.

AMUSED: finding something funny

I was amused by a funny joke someone told me.

ANNOYED: irritated, displeased

Jack was annoyed when he found out he had missed the last bus home.

ANTICIPATING: expecting

At the start of the football match, the fans were anticipating a quick goal.

ANXIOUS: worried, tense, uneasy

The student was feeling anxious before taking her final exams.

APOLOGETIC: feeling sorry

The waiter was very apologetic when he spilt soup all over the customer.

ARROGANT: conceited, self-important, having a big opinion of oneself

The arrogant man thought he knew more about politics than everyone else in the room.

ASHAMED: overcome with shame or guilt

The boy felt ashamed when his mother discovered him stealing money from her purse.

ASSERTIVE: confident, dominant, sure of oneself

The assertive woman demanded that the shop give her a refund.

BAFFLED: confused, puzzled, dumbfounded

The detectives were completely baffled by the murder case.

BEWILDERED: utterly confused, puzzled, dazed

The child was bewildered when visiting the big city for the first time.

CAUTIOUS: careful, wary

Sarah was always a bit cautious when talking to someone she did not know.

COMFORTING: consoling, compassionate

The nurse was comforting the wounded soldier.

CONCERNED: worried, troubled

The doctor was concerned when his patient took a turn for the worse.

CONFIDENT: self-assured, believing in oneself

The tennis player was feeling very confident about winning his match.

CONFUSED: puzzled, perplexed

Lizzie was so confused by the directions given to her, she got lost.

CONTEMPLATIVE: reflective, thoughtful, considering

John was in a contemplative mood on the eve of his 60th birthday.

CONTENTED: satisfied

After a nice walk and a good meal, David felt very contented.

CONVINCED: certain, absolutely positive

Richard was convinced he had come to the right decision.

CURIOUS: inquisitive, inquiring, prying

Louise was curious about the strange shaped parcel.

DECIDING: making your mind up

The man was deciding whom to vote for in the election.

DECISIVE: already made your mind up

Jane looked very decisive as she walked into the polling station.

DEFIANT: insolent, bold, don't care what anyone else thinks

The animal protesters remained defiant even after being sent to prison.

DEPRESSED: miserable

George was depressed when he didn't receive any birthday cards.

DESIRE: passion, lust, longing for

Kate had a strong desire for chocolate.

DESPONDENT: gloomy, despairing, without hope

Gary was despondent when he did not get the job he wanted.

DISAPPOINTED: displeased, disgruntled

Manchester United fans were disappointed not to win the Championship.

DISPIRITED: glum, miserable, low

Adam was dispirited when he failed his exams.

DISTRUSTFUL: suspicious, doubtful, wary

The old woman was distrustful of the stranger at her door.

DOMINANT: commanding, bossy

The sergeant major looked dominant as he inspected the new recruits.

DOUBTFUL: dubious, suspicious, not really believing

Mary was doubtful that her son was telling the truth.

DUBIOUS: doubtful, suspicious

Peter was dubious when offered a surprisingly cheap television in a pub.

EAGER: keen

On Christmas morning, the children were eager to open their presents.

EARNEST: having a serious intention

Harry was very earnest about his religious beliefs.

EMBARRASSED: ashamed

After forgetting a colleague's name, Jenny felt very embarrassed.

ENCOURAGING: hopeful, heartening, supporting

All the parents were encouraging their children in the school sports day.

ENTERTAINED: absorbed and amused or pleased by something

I was very entertained by the magician.

ENTHUSIASTIC: very eager, keen

Susan felt very enthusiastic about her new fitness plan.

FANTASIZING: daydreaming

Emma was fantasizing about being a film star.

FASCINATED: captivated, really interested

At the seaside, the children were fascinated by the creatures in the rock pools.

FEARFUL: terrified, worried

In the dark streets, the women felt fearful.

FLIRTATIOUS: brazen, saucy, teasing, playful

Connie was accused of being flirtatious when she winked at a stranger at a party.

FLUSTERED: confused, nervous and upset

Sarah felt a bit flustered when she realised how late she was for the meeting and that she had forgotten an important document.

FRIENDLY: sociable, amiable

The friendly girl showed the tourists the way to the town centre.

GRATEFUL: thankful

Kelly was very grateful for the kindness shown by the stranger.

GUILTY: feeling sorry for doing something wrong

Charlie felt guilty about having an affair.

HATEFUL: showing intense dislike

The two sisters were hateful to each other and always fighting.

HOPEFUL: optimistic

Larry was hopeful that the post would bring good news.

HORRIFIED: terrified, appalled

The man was horrified to discover that his new wife was already married.

HOSTILE: unfriendly

The two neighbours were hostile towards each other because of an argument about loud music.

IMPATIENT: restless, wanting something to happen soon

Jane grew increasingly impatient as she waited for her friend who was already 20 minutes late.

IMPLORING: begging, pleading

Nicola looked imploring as she tried to persuade her dad to lend her the car.

INCREDULOUS: not believing

Simon was incredulous when he heard that he had won the lottery.

INDECISIVE: unsure, hesitant, unable to make your mind up

Tammy was so indecisive that she couldn't even decide what to have for lunch.

INDIFFERENT: disinterested, unresponsive, don't care

Terry was completely indifferent as to whether they went to the cinema or the pub.

INSISTING: demanding, persisting, maintaining

After a work outing, Frank was insisting he paid the bill for everyone.

INSULTING: rude, offensive

The football crowd was insulting the referee after he gave a penalty.

INTERESTED: inquiring, curious

After seeing Jurassic Park, Hugh grew very interested in dinosaurs.

INTRIGUED: very curious, very interested

A mystery phone call intrigued Zoe.

IRRITATED: exasperated, annoyed

Frances was irritated by all the junk mail she received.

JEALOUS: envious

Tony was jealous of all the taller, better-looking boys in his class.

JOKING: being funny, playful

Gary was always joking with his friends.

NERVOUS: apprehensive, tense, worried

Just before her job interview, Alice felt very nervous.

OFFENDED: insulted, wounded, having hurt feelings

When someone made a joke about her weight, Martha felt very offended.

PANICKED: distraught, feeling of terror or anxiety

On waking to find the house on fire, the whole family was panicked.

PENSIVE: thinking about something slightly worrying

Susie looked pensive on the way to meeting her boyfriend's parents for the first time.

PERPLEXED: bewildered, puzzled, confused

Frank was perplexed by the disappearance of his garden gnomes.

PLAYFUL: full of high spirits and fun

Neil was feeling playful at his birthday party.

PREOCCUPIED: absorbed, engrossed in one's own thoughts

Worrying about her mother's illness made Debbie preoccupied at work

PUZZLED: perplexed, bewildered, confused

After doing the crossword for an hour, June was still puzzled by one clue.

REASSURING: supporting, encouraging, giving someone confidence

Andy tried to look reassuring as he told his wife that her new dress did suit her.

REFLECTIVE: contemplative, thoughtful

George was in a reflective mood as he thought about what he'd done with his life.

REGRETFUL: sorry

Lee was always regretful that he had never travelled when he was younger.

RELAXED: taking it easy, calm, carefree

On holiday, Pam felt happy and relaxed.

RELIEVED: freed from worry or anxiety

At the restaurant, Ray was relieved to find that he had not forgotten his wallet.

RESENTFUL: bitter, hostile

The businessman felt very resentful towards his younger colleague who had been promoted above him.

SARCASTIC: cynical, mocking, scornful

The comedian made a sarcastic comment when someone came into the theatre late.

SATISFIED: content, fulfilled

Steve felt very satisfied after he had got his new flat just how he wanted it.

SCEPTICAL: doubtful, suspicious, mistrusting

Patrick looked sceptical as someone read out his horoscope to him.

SERIOUS: solemn, grave

The bank manager looked serious as he refused Nigel an overdraft.

STERN: severe, strict, firm

The teacher looked very stern as he told the class off.

SUSPICIOUS: disbelieving, suspecting, doubting

After Sam had lost his wallet for the second time at work, he grew suspicious of one of his colleagues.

SYMPATHETIC: kind, compassionate

The nurse looked sympathetic as she told the patient the bad news.

TENTATIVE: hesitant, uncertain, cautious

Andrew felt a bit tentative as he went into the room full of strangers.

TERRIFIED: alarmed, fearful

The boy was terrified when he thought he saw a ghost.

THOUGHTFUL: thinking about something

Phil looked thoughtful as he sat waiting for the girlfriend he was about to finish with.

THREATENING: menacing, intimidating

The large, drunken man was acting in a very threatening way.

UNEASY: unsettled, apprehensive, troubled

Karen felt slightly uneasy about accepting a lift from the man she had only met that day.

UPSET: agitated, worried, uneasy

The man was very upset when his mother died.

WORRIED: anxious, fretful, troubled

When her cat went missing, the girl was very worried.

Appendix F:

Instruction email to opposite-sex twin female participants

Dear opposite-sex twin females,

Thank you all for providing me your email addresses and showing interest in this research study!

Please read this email in its entirety. You are of great value to this research study and this entire process will only take a maximum of 15 minutes.

My name is ----- and I am a junior at ----- . This school year, I was given an amazing opportunity to take the College Board AP Research class at my school and to conduct research myself on a topic of my interest.

For my research study, I chose to test social cognition ability in opposite-sex twin females in comparison to singleton females. I am testing this using the Reading the Mind in the Eyes test (RMET).

The link below is a link to the online RMET test. The RMET test is an assessment in which the participant is given 36 questions. Each question consists of a picture of a set of eyes, and you are asked to choose the emotion that best fits the set of eyes.

LINK TO RMET TEST: <https://forms.gle/xYV1AWNbLJ8o9ekAA>

Please fill out the above form and answer the 36 questions to the best of your ability. DO NOT TAKE MORE THAN 10 MINUTES. If you do not know what a word means, you may search it up in the supplementary definitions handout provided below. Your assessment score will not negatively affect you in any way nor will your name be exposed.

Thank you so much for taking the time to participate in this study! Your effort is greatly appreciated. Feel free to ask any questions you may have.

Thank you once again!

Appendix G:

Instruction email to singleton female participants

Dear singleton females (females who are not twins, triplets, or other multiple-birth individuals),
Thank you all for providing me your email addresses and showing interest in this research study!
Please read this email in its entirety. You are of great value to this research study and this entire process will only take a maximum of 15 minutes.

My name is ----- and I am a junior at --. This school year, I was given an amazing opportunity to take the College Board AP Research class at my school and to conduct research myself on a topic of my interest.

For my research study, I chose to test social cognition ability in opposite-sex twin females in comparison to singleton females. I am testing this using the Reading the Mind in the Eyes test (RMET).

The link below is a link to the online RMET test. The RMET test is an assessment in which the participant is given 36 questions. Each question consists of a picture of a set of eyes, and you are asked to choose the emotion that best fits the set of eyes.

LINK TO RMET TEST: <https://forms.gle/DrsdXpmzz5MzvfUPA>

Please fill out the above form and answer the 36 questions to the best of your ability. DO NOT TAKE MORE THAN 10 MINUTES. If you do not know what a word means, you may search it up in the supplementary definitions handout provided below. Your assessment score will not negatively affect you in any way nor will your name be exposed.

Thank you so much for taking the time to participate in this study! Your effort is greatly appreciated. Feel free to ask any questions you may have.

Thank you once again!

The Effects of Instagram Media Usage Frequency of Females in an Urban Public High School on Perceptions of Body-Image for Teenage Female Athletes and Non-athletes

Abigail Bohn

The purpose of this study was to examine the effects of photo-based media frequency on teenage females who attend an urban public high school and identify differences between athletes and non-athletes within that group. In order to determine the relationship of body image with media frequency, twenty participants were tested during a mixed correlational study where individuals completed a Likert-scale and open-response questionnaire. Responses included quantitative sums of Likert-scaled questions and qualitative quotes from open responses. Quantitative scores were correlated to media frequency through Linear Regression, while qualitative scores were coded and quantified to be compared to athletic participation. It was found that results were not statistically significant; however, a general negative correlation between media frequency and body image was calculated, meaning as frequency increases, teenage female body image decreases. Furthermore, quantified quotes revealed a positive correlation with athletic participation, so as a sport interaction increases, so does female adolescent body image.

Keywords: body-image, female athletes, social media, large city- urban public high school, Instagram, social pressures

Introduction

The humanistic desire for 'beauty' is similar to that of our biological needs like food, happiness, and nurturing. An individual's level of attractiveness—beauty—plays a significant role in an individual's confidence due to its innate origin within the brain (Bell & Milic, 2002). Physical appearance has shown to impact daily lives in relationships, work, self-esteem, and social status (Levin, 2009). A person's body-image—a multidimensional concept which conveys individuals' feelings and behavior in consideration to their physical features—can be impacted by daily activities: a significant example is social media. (Morrison & Morrison, 2004). Currently, there is a problem with how photo-based media platforms affect the body satisfaction of female teenagers. Specifically in the United States, "approximately 80% of women and 34% of men are dissatisfied with their current appearance in some way" (Greene, 2017). Females tend to use pho-

to-based social media platforms more frequently than males and often view different types of posts. With the varying factors between genders, one idea remains constant: Leon Festinger's social comparison theory. This theory states that when objective criteria are absent, individuals tend to compare personal opinions, appearances, abilities, and features to those of others (Morrison & Morrison, 2004; Jin, 2018). Festinger's theory allows for an investigation into the potential effects social media applications may have on female athletes between the ages of thirteen to eighteen years.

To gain a new understanding of how photo-based platforms affect the view of ideal body-image for female teenagers—athletes in comparison to non-athletes—it is essential to analyze the media conveyance and usage frequency. Media conveyance refers to the types of media an individual views and interacts with on the platform. Social media posts can fall in a plethora of categories: quotes, selfies, full-body, scenery/nature, food, politics, animals, user-generated, trends,

and videos among others. Therefore, to improve the understanding of female teenagers' relationships with photo-based social media platforms, it becomes necessary to answer the following question: How does Instagram media frequency of use affect the view of ideal body-image for female athletes compared to non-athletes between the ages of thirteen to eighteen years in an urban public high school? Focusing on one school and restricting the age range increases the probability that the participants' educational and social experiences will have been similar. Additionally, several theories involving body-image—Theory of Social Comparison, Sociocultural Theory, and Social Cognitive Theory—support further research by investigating higher-level questions: What role do social pressures play as described in the Social Comparison Theory? How does the concept of body-image change as described in varying cultures? Furthermore, how could the potential effects of body-image alter society's view on physical appearance?

Literature Review

Body-Image Components and Cultural Aspects

Body-image can be considered a blend of an individual's physical characteristics with their feelings, thoughts, and opinions about their body. Furthermore, body image has less to do with someone's actual physical appearance than it does their feelings and thoughts about it. (Davis, 1992). There are two distinct components of body-image: body-image evaluation and body-image investment. The first variable—body-image evaluation—can be described as an individual's cognitive opinions which evaluate their physical appearance. Body-image investment denotes an individual's behavior with a purpose to alter and enhance their appearance (Morrison & Morrison, 2004). These pressures on body dissatisfaction play a significant role in determining a person's attitude toward their appearance and often lead to the increasing similarities among "desired" body-types in not only Western culture but globally (DeBraganza, 2010).

Popular culture tends to originate in more developed countries such as the United States or Japan. Likewise, these places often create the common physi-

cal standards and expectations due to their higher exposure to media (DeBraganza, 2010). Research by Dr. Hanan, Professor of Media Psychology at the University of Management and Technology, concluded that cosmetic surgery demand in western countries is increasing rapidly due to the rising pressures to alter and enhance women's body shapes. In contrast, society often views cosmetic enhancement surgery as 'extreme' and 'unrealistic' which leads women to choose more subtle manners such as wearing a padded or binding bra that still create an illusion of a different appearance (Hanan, 2017). As other countries observe media from these areas, individuals suffer unique pressures related to body dissatisfaction and disordered eating due to a highly promoted thin ideal (McLean & Wertheim, 2017).

Popular media's effects on Western and global culture align with a theory designed by Lev Vygotsky: the Sociocultural Theory. This theory states that physical appearance dissatisfaction stems from Western society's portrayal of a thin body ideal and their belief that thin is 'good' and 'attractive' (Morrison & Morrison, 2004). Many ancient cultures worshipped "the body as a process" and recently have adopted a "body as an object" belief due to Western expression of perfection through thin ideals (Morrison & Morrison, 2004).

Social Media's Relationship with body-image

Societal norms encourage the use of social media for 'positive' purposes such as advertising, socializing, learning and more. However, social media platforms are highly interactive and self-exposing which could be the root of their stronger associations with body-image (McLean, Paxton, Wertheim & Masters, 2015). Repeated exposure to these platforms has led its audience to believe that "lean, toned bodies are normal, attainable, expected and central to attractiveness" (Clark, 2017). Researchers McLean and Wertheim determined that the frequent use of these social networking websites is likely to contribute to the development of risk factors and eating disorders for girls due to the unrealistic body expectations that the media promotes. When individuals post revealing images, they often subject themselves to negative consequences of self-objectification and online bully victimization (Kapidzic, 2015).

Those who post media tend to suffer consequences similar to the viewers of media. Posting revealing images may cause viewers to feel “inadequate, anxious and preoccupied with perceived body flaws” (Clark, 2017). Because 91% of teens who use social media post photos of themselves, these adverse consequences significantly affect their bodies (McLean, Paxton, Wertheim & Masters, 2015). Health care professionals and researchers recently have emphasized that “the current standard of a thin and fit physique is omnipresent and virtually impossible for the average woman to achieve without an unhealthy amount of dieting and exercise (Johnson & Wartle, 2005). Engagement with these ‘perfect’ images on media sites is associated with lower weight satisfaction and a higher drive for thinness in 15-year old girls (McLean, Paxton, Wertheim & Masters, 2015). Thinness internalization refers to the extent to which an individual cognitively submits into societal expectations of a perfect and thin body-type to the point of altering their behavior or appearance to the standards (Thompson and Stice, 2001). Internalization beliefs are one of the most consistent factors in the development of eating disorders in adolescent girls. They factor into numerous psychological and physical health problems such as depression and self-esteem issues (Clark, 2017). These effects often develop into more severe conditions as media exposure continues (Dhillon, 2017).

Women and Body-image

Body-image affects all individuals regardless of race, gender, or ethnicity. However, not everyone is equally vulnerable to the negative effects of media images. Research suggests that “the negative effects of viewing the ideal physique have been limited to mostly groups of women” (DeBraganza, 2010). Moreover, not all women are equally affected by the media’s adverse effects. (Gerbner, 1998). Specifically, heavier women, women with higher levels of body dissatisfaction and women with a greater internalization of thin-ideals are more likely to experience more consequences of interacting with the portrayal of the ideal physique (DeBraganza, 2010). In addition to these groups, athletes are at high-risk of lower body image due to coaching pressures, athlete comparison, and competition needs, among others (Gerbner, 1998). From these women who are affected, only a minority

develop eating disorders (Dhillon, 2017).

Eating disorders can be as minor as excess dietary restraint. Sociocultural theories suggest that pressures from family, peers, and media may significantly affect a woman’s body dissatisfaction (McLean, Paxton, Wertheim & Masters, 2015). These attitudes, formulated within popular culture and thus the media, often originate from the misrepresentation of women’s body types and weights. For example, researchers concluded that the average American woman has become increasingly heavier but media images of women have become significantly thinner. This media distortion correlates negatively with an attractiveness self-evaluation and has altered views of social reality (Morrison & Morrison, 2004; Gerbner, 1998). An individual’s altered social opinion also reflects a behavioral change in both mainstream media and social interactions. This online behavior can be reinforced with “rewards” such as increased followers, likes, and comments or weakened with opposite punishment such as a decrease in followers, likes, and comments. Contrary to outward social behavior, media content often reinforces physical attributes instead of prosocial traits. Research has emphasized the lack of models which shows the body in its entirety, and instead focuses on ‘perfect’ individual parts: hands, feet, eyes, face, legs (Morrison & Morrison, 2004). Furthermore, media portrayals teach adolescent women that society will judge their success based on physical traits instead of valuable personality characteristics (Kapidzic, 2015).

Research Gap and Purpose

A comprehensive look at studies done on Instagram’s effects on ideal body-image between female, teenage athletes and non-athletes has been significantly neglected in past research. More specifically, there has never been a mixed correlational research study conducted on an urban public high school considering the differences between female athletes versus non-athletes. Moreover, research studies using Instagram to analyze these effects remain nonexistent. A study that examines Instagram media frequency effects would allow for an analysis of the differences between athletes’ and non-athletes’ ideal body-image with consideration to the type of school and age range. Thus, the research question is as follows: How does Instagram media frequency of use affect the view

of ideal body-image for female athletes compared to non-athletes between the ages of thirteen to eighteen years in an urban public high school? The answer to this question is essential for the adaptation of media intervention classes and the advancement of public knowledge to increase awareness of body-image issues and eating disorders.

Research on the effects of media has proliferated over recent years due to the increasing role that social technology plays in our lives. Many researchers now understand the tendency of social media to negatively affect those who interact with it most frequently: female adolescents. However, studies that compare the effects of media on different groups of individuals remain under-researched. The insufficiency of research in this scope displays a need for future research focused on social media's effects on body image. This study examines the differences between adolescent female athletes and female non-athletes who attend an urban public high school.

Assumptions

No hypothesis was developed for this research to avoid potential researcher bias in this mixed methods study. Instead, two assumptions were made. It was assumed that all participants will answer the questionnaire prompts and questions in an honest and candid manner. Additionally, it was assumed that participants will fully understand each question or prompt and their responsibility in the research project.

Methodology

Credibility and Ethical Practices

The significance of safe and ethical practices within the conducted research remains a primary focus. In order to minimize risks and guarantee all ethical processes, Institutional Review Board approval was obtained. In addition, all participants signed a consent form which informed them of the research's purpose, risks, anonymity, and expectations among other information. To ensure reliable and valid data, the following methodology—the Instagram Media Conveyance and Frequency Questionnaire—was tested on a previous group whose data was not examined within this

research. Advice was recommended from the tested individuals and was used to modify the questionnaire to better fit the participants who would take it and collect more informative, reliable, and secure data to lead to the new, significant understanding.

Privacy: Each participant was asked their age, current educational grade level, race/ethnicity, and information about their high school athletics for future purposes. No names were collected with association to an individual's responses; instead, each questionnaire was assigned a letter for reference (Morrison & Morrison, 2004). Consent forms were signed by individuals and their parent/guardian if the participant was under the legal age (See Appendix A). Any questions that arose were discussed in detail with the participant and/or guardian.

Sample

The sample comprised twenty female high school students aged 13-18 years. Participants were drawn from one urban public high school located in Louisville, Kentucky. Individuals were collected through convenient sampling. Informative fliers with a consent form were handed out to gather the desired amount of participants for questionnaire responses. The first twenty individuals who submitted the questionnaire were included. Any responses after were nullified; therefore, these were not analyzed or considered into the data.

Detailed Procedure

A non-experimental mixed correlational research study was conducted in which females between the ages of 13 to 18 years completed a questionnaire involving Likert-style and open-response questions in order to explain their perceptions of the effects of Instagram media conveyance and frequency of use on views concerning ideal body-image for female athletes in comparison to non-athletes. This approach was adapted from a study done by Drs. Todd and Melanie Morrison (2004) who are PhD professors at the University of Saskatchewan in its department of Psychology. They used this technique to explore the correlational relationship between universalistic social comparison and the following variables: weight restricting and gaining diets, steroids, self-esteem and

body dissatisfaction. The primary factor for choosing this approach as a guide is the similar topic which their research and this research share. They analyzed the relevance of the Social Comparison Theory and Sociocultural Theory with differing variables while this research focused on the impacts of universalistic social comparison on one variable: female adolescent body image. A study done by Drs. McLean, Paxton, Wertheim and Masters (2015) acted as another mentor source. This study was used as a guide for data analysis in the way they categorized and coded the collected responses.

This method targets the specific population of female teenagers in an urban public high school; therefore, method alignment to this group is essential. In order to fulfill this research aspect, Instagram was chosen to analyze the relationship between social media and female adolescent body image. This social media network was chosen due to its popularity among this age group and gender; it is the most frequently used application for the majority of female teenagers (Lenhart, 2016). Furthermore, due to its photo conveyance nature, this social network notably contributes to body image perceptions. In order to measure these effects, the following method was utilized.

Participants completed an online questionnaire to provide the necessary correlational data. This survey included fifteen 5-point Likert-scaled questions and five open-ended prompts. The Likert-scaled questions compiled the quantitative data while the open-ended prompts accounted for the qualitative data. This approach incorporated an adapted version of McLean, Paxton, Wertheim, and Master's "Body Dissatisfaction Subscale" which originally included ten items while this research utilizes fifteen. These questionnaires were distributed via individuals' personal electronic devices. Participants had no time limit to complete the survey due to their ability to choose their environment and pace to finish it (See Appendix B for the full questionnaire).

Effects of Instagram Media Conveyance and Frequency Questionnaire

The questionnaire utilized in this approach collected responses concerning demographics, athletic participation (or lack thereof), media frequency,

media post conveyance, and body image. The "Body Dissatisfaction Subscale" composed a large part of the questionnaire—fifteen Likert-scaled prompts—due to its valid and reliable layout with the ability to contribute valuable responses from participants (McLean, Paxton, Wertheim, & Masters, 2015). Five additional items were added in order to retrieve the necessary data that could potentially connect athletic participation and body image. These new prompts asked individuals about their contentment with muscle mass, physical inferiority, strength, and physical habits. The numerical body image score was calculated by summing the numbers given by participants from each scaled prompt (Morrison & Morrison, 2004). The scores could range from fifteen to seventy-five: with higher scores denoting a higher measure on the Appearance Self Esteem Scale (ASES, modified from mentor source) (Morrison & Morrison, 2004). This value became the quantitative value for the participant. Body image was the factor this study measured through numerical data. However, considering the significantly personal topic of body image, quantitative data would not suffice.

The questionnaire also contained five open-response questions that asked participants about more private, particular topics concerning body image and social media. These responses encouraged no word limit or restraint so each individual could describe their feelings as specifically or briefly as she desired. The pure participant feedback was then read thoroughly several times for familiarization with the information. Each question prompted a response from the individual concerning a particular theme. This allowed the participant quotes to be descriptively coded based on the question and theme to which the answer corresponded. Essentially, each quote was analyzed for words that summated their ideas. From here, the relationship between codes was analyzed and the central theme was chosen based on the frequency which it occurs in participant answers. At this point, quantitative and qualitative responses were considered separate.

The codes which arose from participant quotes were given point values based on the quantitative data. For example, the middle—or intermediate—theme from the coded information would be assigned a numerical range which resembled a similar neutrality. While the qualitative information was quantified,

pure responses were not lost; instead, they provided understandable portrayals of participant's feelings on certain topics regarding the research.

Data Analysis

To analyze the data, the Likert-scaled responses were used to create a scatterplot showing the relationship between media frequency and the individual's ASES score. The linear regression analysis test was run on the data to quantify their strength of correlation between variables (McLean, Paxton, Wertheim, & Masters, 2015). Later, each sport was assigned a leanness numerical value based on a healthy individual's average heart rate while participating in the activity. This value allowed the researcher to compare sport difficulties and average body builds for each athletic activity in order to advance the findings of the relationship between athletics and female adolescent body image. Higher average heart rates constituted a higher leanness-score. Linear regression analysis was also run to determine the relationship between athletic participation and an individual's ASES score. For optimal comparison, means of central tendency and standard deviation were also calculated for the data.

Rationale

The method utilized for this research is a mixed—quantitative and qualitative—correlational approach. Quantitative data was collected to determine correlation and connect female adolescent athletic participation with body image. This procedure solved the research problem by conveying the association/relationship between the variables to determine correlation while additionally providing quotes which would strengthen the understanding the data portrayed. However, this approach did not provide the circumstances to prove causation due to the lack of variable control. Further research is required in order to establish a cause and effect relationship: this would remove the qualitative aspect of this approach which provided personal responses—instead of strictly numerical values—and allowed researchers a more significant understanding of the relationships.

Results

After collecting questionnaire responses, quantitative and qualitative analysis were conducted then compared. This comparison was possible through the ASES score assignment to the qualitative themes. Across the participant feedback, overall themes and ideas began to rise.

Overview

After coding the twenty responses for each of the five open-response questions, analytic themes were determined based on frequency throughout responses using methods earlier discussed. From participant responses, four primary themes arose: “Below Satisfied,” “Satisfied,” “Above Satisfied,” and “Mixed”. Relationships among these themes were discovered and further considered when creating their definition for this research.

“Below Satisfied”: Responses which were categorized under this theme convey insecure feelings which discourage acceptance of one's body. Furthermore, these individuals often portrayed a need to improve in order to become closer to societal standards of beauty.

“Satisfied”: Responses identifying with this theme convey acceptance of the individual's body but negative feelings when compared to other females: physically and through media networks.

“Above Satisfied”: Responses which were categorized as this theme portrayed positive feelings toward one's body and insignificant effects of comparison.

“Mixed”: This category arose as a solution for responses which did not fall under the three previous themes. Responses identified as this theme portrayed changing perceptions of one's body based on the environment or circumstances. Overall, these individuals did not convey a specific feeling toward their body.

Comparison of Athletes and Non-athletes' Body Perceptions

Overall Theme Results: In response to the question, “After interacting with the media on Instagram, do you feel that your thoughts change about your own body,” individuals' opinions expressed the four themes previously discussed. When prompted, one respondent answered “Yes. I'm never satisfied. I feel like no

matter what, another person will always [be] better in a certain way,” a feeling which represents “Below Satisfied”. In more positive manners, one individual responded, “Seeing people who are eating and exercising healthy benefit me in a good way, encouraging me to be better,” identifying as “Satisfied,” whereas others expressed happiness and love toward their body, such as, “I don’t have negative thoughts about my body... It’s more inspiring in my opinion than detrimental to my own image,” which conveys “Above Satisfied” perceptions. Some respondent’s feelings were unclear and conveyed “Mixed” feelings. For example, one female said, “Some media posts make me feel so inspired and good about my body... some posts make me want to cry”. The contradicting positive and negative feelings reveal the lack of a single theme.

After the coding of each response, athletic participation was recorded in order to observe body perceptions of those who participated in sports compared to those who do not. Individuals’ responses in each category were calculated and used to compare perceptions of athletes and non-athletes as seen in Figure 1.

Body Image: Athletes versus Non-Athletes

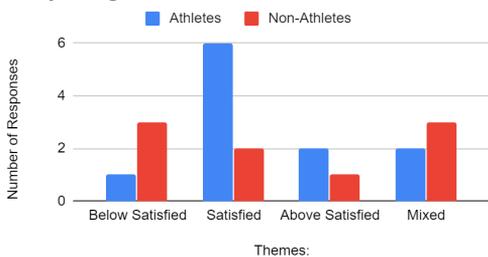


Figure 1: Comparison of Theme Responses

Overall, athletes reported higher rates of body-satisfaction than those who do not participate in athletics. As seen in the graph above, athlete responses expressed “Satisfied” or “Above Satisfied” feelings with a greater frequency than non-athletes: six compared to two, and two compared to one (see Figure 1). Additionally, non-athlete responses expressed “Mixed” or “Below Satisfied” feelings more often than athletes.

For the purpose of strengthening the qualitative data, quantitative responses were used for comparison: which would further confirm or challenge re-

sults. As discussed in the methods section, leanness score values were assigned to sports (0 representing no athletic participation, 3 representing high average heart rates and athletic effort with a focus on lean bodies). The relationship between the ASES score and sport leanness value was analyzed using linear regression and represented in Figure 2.

ASES Score vs. Leanness Score of Sport

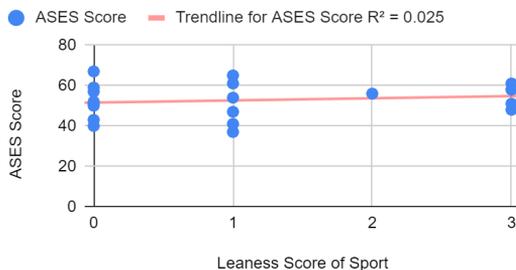


Figure 2: Sport Leanness Values versus ASES Score

Linear regression analysis revealed the direct relationship between these variables. As seen in this graph above, sports which were considered more leanness based had higher values of ASES scores, which represented individuals’ body perceptions. Furthermore, females who participated in lower leanness focused sports or did not participate in athletics conveyed a lower ASES score than other female responders.

Effects of Media Frequency of Use

As mentioned previously, individuals were questioned about their media frequency, the time spent observing media on Instagram. This data was used to examine the relationship between females’ ASES scores and their reported frequencies. This correlation was analyzed using linear regression, as seen in Figure 3.

Figure 3 critically contributes to this study’s findings due to its relevance to the question, specifically the aspect of “frequency.” This graph portrays the inverse relationship between the time an individual uses Instagram and their recorded ASES score. As seen in the graph, higher amounts of time spent on the application correlated with lower body perception scores than those who had lower frequencies. While

results were not calculated as statistically significant, hourly usage remains necessary in closing the research gap; therefore, the general negative relationship between the variables is a principal finding for this research. The majority of respondents reported media frequencies of one or two hours; therefore, these specific values were further examined. Figure 4 compares the measures of central tendencies for media frequency values of one and two hours.

As seen in Figure 4 and Table 1 above, the minimum, median, maximum, and mean were calculated for each frequency value. These results portrayed that a higher media frequency holistically conveys lower ASES score values when compared to a lower media frequency: one hour versus two hours spent on the social networking site. The numerical values represented in Table 1 reflect identical data to Figure 4 in a varying format for quantitative reference.

Discussion

Principal Findings

Both Figure 1 and Figure 2 show the clear positive relationship between level of athletic participation and teen female body image. As shown through these graphs, higher body image (ASES) scores were seen in correlation with a greater

Hours of Use per Day versus ASES Score

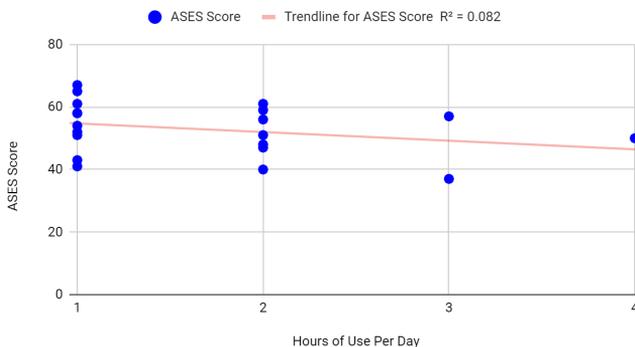


Figure 3: Media Frequency versus ASES Score

ASES Score Comparison: 1 hour versus 2 hours

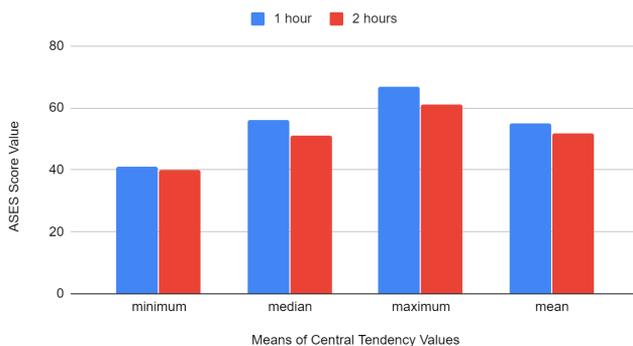


Figure 4: Media Frequency Primary Value Comparisons

Table 1: Media Frequency Measures of Central Tendency

	1 hour	2 hours
Minimum	41	40
Median	56	51
Maximum	67	61
Mean	55	51.71
Standard Deviation	8.58	7.43

focus on high school athletics. The results from Figure 3, Figure 4, and Table 1 indicate the inverse correlation of media frequency and body perceptions. As time spent observing Instagram media increased, ASES scores decreased, which denoted lower body perceptions for those individuals. From these results, it can be inferred that the most popular social media network for the observed population, Instagram, negatively affects female adolescent body image. As elaborated further in the conclusion, this could be due to its majority photo content, relating to the social comparison theory discussed.

These results indicate that there are notable differences in the body perceptions of female athletes in comparison to non-athletes: higher sport participation correlates with a greater individualistic body perception for female teenagers. Additionally, the results emphasized the negative effect of greater Instagram media frequencies on body perceptions. As evident in the results, the answer to the question posed by this research (How does Instagram media frequency of use affect the view of ideal body-image for female athletes compared to non-athletes between the ages of thirteen to eighteen years in an urban public high school?), is that the correlation is negative, there is a relationship between the variables. This correlation, as mentioned, indicated that increased media frequency negatively affects body perceptions for both athletes and non-athletes; however, individuals with athletic participation report holistically higher body images than those who do not participate in sports.

Comparison with Previous Studies

The results from this study of athletic participation and media frequency are consistent with results from Bakker (2011) and Davis (1992), who both indicated significant differences in athlete and non-athlete perceptions overall. This research further aligned with a study by DeBraganza (2010), who concluded that increases in time spent on social networking sites negatively affect personal body-image for a general population.

However, some of the results vary from previous studies. For instance, Bakker (2011) found that higher athletic pressures correlated with lower body perceptions, which is inconsistent with the results in this research. Furthermore, while this study suggests that

more leanness focused sports contribute to a higher individual body-image, other researchers, such as Bakker (2011) and Davis (1992), found that more relaxed athletic environments encourage higher body perceptions among females. These differences may be caused by the limitations of this study and those mentioned.

Limitations

Typical in a mixed—qualitative and quantitative—research methodology, the small sample size used in this research presents several limitations. All of the participants were females between thirteen and eighteen years old, attending an urban public high school located in the Southeast. The majority of the sample reported to be Caucasian (75%), while Hispanic and African American were both recorded at 10%, and 5% was attributed Asian Americans. Because of the small population mentioned, there is a threat of skewness in the data. It is essential to note that due to the specificity of the researched population, generalizations cannot be made. This is conveyed through a p value larger than 0.05 which states that the results are not statistically significant. While this seems to discredit findings, it simply accounts for the small population size. Although general applications are limited, this study provides an investigation of the relationship that a small community has with frequency and athletics. In addition, the small sample size categorizes this study as foundational, with intentions of providing initial discoveries on relationships between media frequency and two groups of female teenagers.

Furthermore, no controls were used in this study. Questionnaire responses showed little variation in the types of media seen by each female; therefore, it was assumed that each individual interacted with similar media on a daily basis. Because of this assumption, media conveyance was disregarded due to significant similarities among individuals and lack of relation to research intention. However, this variable had potential for affecting the studied females and thus presents limitations.

Implications & Future Directions

These findings emphasize that photo-based social media applications present significantly negative effects on female teenagers, whether they participate in athletics or not. These results have clinical and social implications. This study's conclusions can be used in critiquing intervention classes which strive to improve body image for struggling female teenagers; therefore, prevention can be more effective for minimizing eating disorders and other problems rooted within low body perceptions. Furthermore, this study provides findings which could aid in social media application improvement. It was found that an increased time spent on these networks decreases individualistic body image; therefore, limiting interaction time through application tools would benefit individuals. Many corporations, such as Apple, have taken steps in this direction through screen time limits and social media networks need to follow this example.

To continue the exploration into the effects of photo-based social media networks, research should be repeated with a larger sample size and controlled media conveyance. In addition, an investigation into how these factors vary among further sub-communities would advance these findings. The experiences of disabled women, those belonging to the LGBTQ community, and those in other minority groups could differ greatly than those who participated in this research; therefore, it is essential to examine these groups to further the knowledge of the effects of photo-based social networks. A strictly quantitative survey would require a larger sample size, which would address a current limitation of this study, while also providing clear findings among new research in this field.

Conclusions

The exploration of how photo-based media applications' influence female teenagers when comparing athletes and non-athletes reveals insight about a significant aspect of societal life. This investigation is necessary because it offers a further look into the current knowledge of a popular free-time activity. Additionally, it provides foundation for future research into the effects of photo-based social networks on varying communities.

New Understandings

The effects of social networking sites are complicated, especially when considering the number of populations they influence. This study shows that photo-based media networks tend to negatively impact the body image of female teenagers; furthermore, results indicate that high school athletics are correlated to positive body perceptions. This emphasizes the pressures presented by social networking sites and the benefits of participating in high school athletics due to the results discovered through this research. In addition, Leon Festinger's theory of social comparison supports this research's findings: when not distracted, humans seek objects to compare themselves to, hence athletics as a barrier to social media comparison; therefore, this theory significantly explains some results. This study illustrates the significance of lower media frequency coupled with participation in extra-curricular activities, such as high school athletics in order to encourage overall positive body outlooks.

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THE EFFECTS OF INSTAGRAM MEDIA USAGE FREQUENCY ON BODY-IMAGE

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Appendix A—Human Participant Informational and Consent Form

Subject Information and Consent Form

The Effects of Instagram Media Conveyance and Usage Frequency of Females in an Urban Public High-school on Perceptions of Body Image for Teenage Female Athletes and Non-athletes

I am asking for your voluntary participation in my AP Research project. Please read the following information about the project. If you would like to participate, please sign in the appropriate areas below.

What Is The Purpose of The Study?

The purpose of this project is to explain female teenagers' (13-18 years) perceptions of the effects of Instagram media frequency of use on the view of ideal body image for female athletes in comparison to non-athletes.

What Is Your Role While Participating In The Study?

If you choose to participate, you will be asked to complete a questionnaire involving Likert-style and open-response questions. The estimated time to complete this survey is between 5-15 minutes.

How Will Your Information Remain Confidential?

Your responses to the surveys will remain anonymous and your name will not be asked in correlation with your answers. There will be demographic-based questions which will not be shared and are only in the questionnaire in order to help sort participants and analyze data easier.

What Are Potential Risks of Participating In This Study?

Potential risks of participating in this research study is exposure to discussion of mental health, body-image, eating disorders, and social pressures. If you feel uncomfortable thinking about or reading questions/prompts which include these themes, you are not obligated to participate. Benefits to participating in this study

What Are The Benefits of Participating In This Study?

The potential benefits of participating in this research study is to provide data which helps make new discoveries in the world of Academia. By answering a brief questionnaire, more female teenagers will be

aware of the effects social media has on their perception of body image and take action from these conclusions. Hopefully, these conclusions will bring about a new understanding for all those involved.

---If you have any questions about this study, please feel free to contact:---

THIS INFORMATION WAS REMOVED FOR COLLEGE BOARD IDENTIFICATION AND SCORING PROCESSES

Voluntary Participation:

Participation in this study is completely voluntary. If you decide not to participate there will not be negative consequences. Please be aware that if you decide to participate, you may stop participating at any time and you may decide not to answer any specific question. By signing this form I am attesting that I have read and understand the information above and I freely give my consent/assent to participate or permission for my child to participate.

Adult Informed Consent or Minor Assent

Research Participant Printed Name:Signature: Date Reviewed & Signed:

Parent/Guardian Printed Name:Signature: Date Reviewed & Signed:

Appendix B—Effects of Instagram Media Conveyance and Frequency Questionnaire (Morrison & Morrison, 2004)

Effects of Instagram Media Conveyance and Frequency

The purpose of this questionnaire is to explain female teenagers' (13-18 years) perceptions of the effects of Instagram media conveyance and frequency of use on the view of ideal body image for female athletes in comparison to non-athletes.

Demographics Complete the following demographic information. Please note that all personal information will be kept completely confidential and none of the responses you provide will be connected to your name, email address, or other identifying information.

1. What is your age?

Mark only one oval.

- 13
- 14
- 15
- 16
- 17
- 18

2. Which of the following best describes your current level in school?

Mark only one oval.

- Freshman
- Sophomore
- Junior
- Senior

3. Are you White, Black or African-American, American Indian or Alaskan Native, Asian, Native Hawaiian or other Pacific Islander, or some other race?

Mark only one oval.

- White or Caucasian
- Black or African American
- Hispanic or Latino
- Asian or Asian American
- American Indian or Alaska Native
- Native Hawaiian or other Pacific Islander
- Another Race

4. Do you play a sport for the high school which you attend?

Mark only one oval.

- Yes
- No

5. If you answered yes to the previous question, what sport do you play? (Select all that apply) If you answered no, select the appropriate box and continue.

Check all that apply.

- Softball
- Basketball
- Bowling
- Cheer-leading
- Cross Country/Track
- Dance Team
- Field Hockey
- Lacrosse
- Flag Football
- Golf
- Gymnastics
- Hockey
- Soccer
- Swimming
- Tennis
- Volleyball
- I do not play a sport

Media Conveyance and Frequency of Use Complete the following questions. If you feel the answer choice that fits you is absent, choose a close option or the other option if applicable. Please note that all personal information will be kept completely confidential and none of the responses you provide will be connected to your name, email address, or other identifying information.

6. On average, how many days a week do you open and interact with the media on Instagram?

Mark only one oval.

- 1 day per week
- 2 days per week
- 3 days per week
- 4 days per week
- 5 days per week
- 6 days per week
- 7 days per week
- I don't use Instagram

THE EFFECTS OF INSTAGRAM MEDIA USAGE FREQUENCY ON BODY-IMAGE

7. On average, how much time do you spend on Instagram per day?

Mark only one oval.

0-1 hours

1-2 hours

2-3 hours

3-4 hours

4-5 hours

5-6 hours

6+ hours

I don't use Instagram

8. When using Instagram, what types of media do you see most often? (select all that apply)

Check all that apply.

Inspirational Quotes/Posts

Selfies

Full-Body Images

Revealing Full-Body Images

Scenery and Nature

Food

Political

Animals

User-generated Content (MEMES, COLLAGES, ETC)

Trending Posts

Videos

Other

Body Image: Scaled Prompts Complete the following questions. These scales range from 1 to 5: strongly disagree, disagree, neutral, agree, strongly agree. If you feel the answer choice that fits you is absent, choose a close option or the other option if applicable. Please note that all personal information will be kept completely confidential and none of the responses you provide will be connected to your name, email address, or other identifying information.

9. I am satisfied with my body

Mark only one oval.

1 2 3 4 5

10. Other people think I have a good body

Mark only one oval.

1 2 3 4 5

11. I am a good weight for my height

Mark only one oval.

1 2 3 4 5

12. I do not worry about being too muscular

Mark only one oval.

1 2 3 4 5

13. My body makes me feel confident

Mark only one oval.

1 2 3 4 5

14. I respect my body (eat healthy, exercise, etc)

Mark only one oval.

1 2 3 4 5

15. People find me physically attractive

Mark only one oval.

1 2 3 4 5

16. I do not worry about having the "perfect" body

Mark only one oval.

1 2 3 4 5

17. I am not critical of my body

Mark only one oval.

1 2 3 4 5

18. I am comfortable with my body

Mark only one oval.

1 2 3 4 5

19. There is no "perfect body"

Mark only one oval.

1 2 3 4 5

20. My body is strong

Mark only one oval.

1 2 3 4 5

21. When talking to others, I do not feel physically inferior

Mark only one oval.

1 2 3 4 5

22. I am satisfied with the amount of muscle on my body

Mark only one oval.

1 2 3 4 5

23. I do not try to enhance or change my body to fit other standards

Mark only one oval.

1 2 3 4 5

Body Image: Open-response Prompts Respond to the following questions in a clear manner. There is no word limit or count, use as much room as needed to explain your thoughts on the question/prompt. Please note that all personal information will be kept completely confidential and none of the responses you provide will be connected to your name, email address, or other identifying information.

24. How would you describe your feelings toward

your body?

25. Do you feel that there are body image expectations conveyed through Instagram?

26. After interacting with media on Instagram, do you feel that your thoughts change about your own body?

27. Do you feel that some types of media posts affect your opinions about your body differently than others?

The Experiences of Five Southern Ontario High School Principals in Dealing with Student Mental Health: A Qualitative Study

Alistair Langhorne

This paper studies the experiences of five Southern Ontario high school principals in dealing with their students' mental health. A qualitative research method was employed, with each principal sampled participating in a semi-structured interview. A thematic analysis of the principals' responses was also conducted. The principals shared four main experiences: student anxiety and loneliness, the importance of student voice, the link between physical and mental health, and the importance of school intervention in student mental health. Several policies were recommended based on the principals' experiences, such as starting school later in the day, implementing mandatory student mental health training for teachers, and creating more opportunities for students to participate in extra-curricular activities.

Keywords: mental health, principals, Ontario, high school

Introduction

Mental health in Canadian adolescents is a serious social issue. A study conducted by Macey and Tong (2017) found that when 806 parents with children 25 years old and younger were surveyed, half reported concerns about their children's mental health. One-third of those parents had a child miss school because of their anxiety (Macey & Tong, 2017). The World Health Organization (WHO) defines mental health as: "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community"

(Herrman, Saxena & Moodie, 2004). The Mental Health Commission of Canada estimates that 1.2 million youth in Canada have been affected by mental illness, but less than 20% will receive proper treatment ("Children and Youth," 2020). By age 25, one-fifth of Canadians will struggle with mental illness ("Children and Youth," 2020).

This study focuses on high schools because of the connection between the mental health of students and their academic achievement. The World Health Organization acknowledges that students need to be healthy and emotionally secure to fully participate in education (Cushman, Clelland & Hornby, 2011). Previous research has examined teachers' experiences with mental health programs, and the insights

of parents whose children have mental health issues (Cushman, Clelland & Hornby, 2011; Reardon, Harvey & Young, 2018). However, no research has been conducted on how high school principals in Southern Ontario deal with the mental health of their students

Experiences include factors affecting student mental health, the most prevalent mental health issues among students, changes in school mental health policy, the role of schools in dealing with student mental health, policies that improve student mental health, and the barriers in providing mental health services to students. Principals were sampled in this study because they are the head of the school, and they supervise school institutions, the student body, and the staff. To understand the experiences of these principals, a series of semi-structured interviews were conducted with the five principals chosen. The findings from these interviews were then analyzed thematically. This study serves to benefit all members of a school community, including students, teachers, parents, and policymakers. Principals can provide insight into the strengths and weaknesses of school mental health policy and provide direction for improvements. To conduct thorough research on the experiences of five Southern Ontario high school principals, it is necessary to review the current literature on student mental health.

Literature Review

Factors Affecting the Mental Health of Students

Understanding the factors that either improve or worsen the mental health of students was necessary to structure the interviews that were conducted during this study. A study conducted by Riekie et al. (2017) sent out questionnaires to 618 grade 11 students in Southern Australia to examine how elements within a school environment impacted student mental health. The study concluded that student well-being is improved by a student's greater sense of belonging to the school community (Riekie et al., 2017). Only grade 11 private school students were sampled, which is not representative of the entire high school student population and is a limitation of the study (Riekie et al., 2017).

Research conducted by Suldo et al. (2016), measured both the subjective well-being (happiness) and the "factors of psychopathology" (the study of mental illnesses) of a sample of 500 students aged 14-18 through the distribution of multiple scales. This study found that students with low measures of well-being and higher rates of mental health issues were more likely to have poor academic outcomes (Suldo et al., 2016). Although the sample is relatively large, the overall participation rate was low, which may have skewed the results (Suldo et al., 2016).

A cross-sectional study published in the *Croatian Medical Journal* surveyed 1539 students aged 14-19 years from every high school in Istria, Croatia, to find if there was a correlation between internet use and mental health (Bezinović et al., 2015). Bezinović et al. (2015) found that problem behaviour on the internet, such as false identification, and the downloading of unauthorized files were associated with negative indicators of mental health. Additionally, victimization online, like harassment and threats, were associated with symptoms of anxiety, depression, and loneliness (Bezinović et al., 2015). The authors recommended that a longitudinal study be created to observe the long-term effect of internet use and mental health (Bezinović et al., 2015).

Research has also been done examining the mental health of students in different academic programs. Suldo et al. (2008) sampled 322 students in both the International Baccalaureate (IB) program and an academic, but a non-IB program to research the link between stress and the IB program. Participants were given scales designed to measure mental health (Suldo et al., 2008). The students in the IB program scored significantly higher on the perceived stress scale than those not enrolled in the IB program, and perceived stress was negatively correlated with positive mental health factors like academic self-efficacy and life satisfaction (Suldo et al., 2008). The students tested in this study were chosen using a convenience sample, a biased sampling technique, and the sample was relatively small, meaning that the IB students sampled may not be representative of all IB students in America (Suldo et al., 2008).

The findings presented in these studies provided the information and context needed to have a better understanding of the current state of student mental health, allowing for the creation of interview ques-

tions that centred around the factors affecting student mental health and how to address those factors meaningfully.

Teacher Perceptions of School Mental Health Programs and the Mental Health of Students

In trying to examine how principals perceive their own school's mental health programs, it is necessary to understand how teachers view such issues.

Cushman, Cleland, and Hornby (2011) surveyed teachers from 1,000 primary and secondary schools in New Zealand. The study concluded that 43% of the respondents from secondary schools identified mental health issues as something affecting their students, compared to the 18% of respondents from primary and intermediate schools (Cushman, Cleland & Hornby, 2011). Mental health issues were more prevalent in schools with wealthier students rather than in schools with less wealthy students (Cushman, Cleland & Hornby, 2011). However, this study only managed to sample 12% of all schools in New Zealand and did include a variety of school types (primary, elementary, and secondary), so the findings may not apply to high schools specifically (Cushman, Cleland, and Hornby, 2011).

Reinke et al. (2011) surveyed 229 primary and elementary school teachers, and when asked if they felt that schools should have a role in addressing student mental health issues, 38% of the teachers reported that they strongly agreed and 51% reported that they agreed. The top four barriers the teachers reported in supporting the mental health of their students were an insufficient number of school mental health professionals, a lack of training to deal with the mental health needs of students, and a lack of funding for mental health services at school (Reinke et al., 2011). Only primary and elementary school teachers were sampled, which is not representative of the experiences of high school principals.

A study conducted by Loades & Mastroyannopoulou (2010) tested 113 primary school teachers, assessing their ability to identify and rate the severity of descriptions of children with emotional and behavioural disorders. The participants were required to read the descriptions of the children and complete questionnaires (Loades & Mastroyannopoulou, 2010).

The teachers were able to identify the severity of the behavioural and emotional disorders accurately; however, they were less concerned for the children with emotional disorders than the ones with the behavioural disorders (Loades & Mastroyannopoulou, 2010).

Teacher experiences and perceptions of student mental illness not only provide valuable insights into the mental health of students and related programs, but they also present a gap in the research of the experiences of principals that this study addressed. Additionally, the responses of the teachers sampled provided a point of reference for the creation of interview questions as both positions play a role in managing and promoting the interests of students.

School-Based Mental Health Programs

Effectively framing questions relating to mental health programs at schools requires an understanding of mental health programs that have already been adopted at schools and the success of those programs in treating the mental health of students.

In 2013, Metz et al. sampled students from two suburban high schools in Philadelphia to assess the effectiveness of a mindfulness program on emotional regulation among adolescents. All students sampled completed self-reports and assessments before and after the program to assess its effects (Metz et al., 2013). Participants in the program reported a reduction in psychosomatic symptoms (mental health symptoms related to physical illness) and an improvement in their self-regulation (Metz et al., 2013). Metz et al. (2013) found there were decreased levels of reported stress, an increase in regulation strategies, and increased emotional awareness and concentration among the participants in the program. The study only sampled students from two high schools, which may limit the application of its findings to other settings (Metz et al., 2013).

In Italy, Veltro et al. (2017) conducted a study to measure the effectiveness of teaching a modified version of a mental health handbook on 12-16-year-olds using a series of questionnaires. The study found that the classes which taught the handbook allowed the high school participants to manage negative emotions better, improve their goal-setting skills, express more positive feelings, and decrease their cigarette use (Vel-

tro et al., 2017). The study is limited because it only sampled one group, instead of comparing those sampled with a control group (Veltró et al., 2017). Since this study is uncontrolled, its findings are not entirely transparent because a baseline is not provided (Veltró et al., 2017).

Shoshani et al. (2014) assessed the longitudinal effects of a school-based positive psychology program in an Israeli middle school where results were measured through tests completed by the students. Participants in the program reported a decrease in general distress, symptoms of depression, symptoms of anxiety, and interpersonal sensitivity, whereas the control group reported significant increases (Shoshani et al., 2014). Shoshani et al. (2014) found there were significant increases in self-esteem, self-efficacy, and optimism among participants in the program as well. Since the study relied on self-reporting, its results may be biased or inaccurate (Shoshani et al., 2014).

Nabors et al. (2000) conducted a study assessing the pros, cons, and outcomes of an extended mental health program (EMS) at three high schools in Baltimore. This study measured outcomes by questioning focus groups about their experiences with the program (Nabors et al., 2000). Nabors et al. (2000) found that the participants reported that the EMS program improved their academics, personal skills, and attitude. The administrators of the program reported an improvement in family coping strategies and stress reduction as benefits of therapy for the participants (Nabors et al., 2000). Using focus groups comes with its shortcomings. The participants may have felt uncomfortable in a group setting (Nabors et al., 2000). They may have responded in ways that they thought would be beneficial to research rather than saying what they felt or wanted to look better to other members of the group (Nabors et al. 2000).

The outcomes of previously implemented school-based mental health programs indicate what models are successful in promoting and protecting student mental health. Successful programs in this section of the literature review provided an understanding of why these programs are used and guided the formation of the interviews conducted in this study.

Summary

Much research has been done in the field of student mental health, including the factors affecting the mental health of students, teachers' perceptions of school mental health programs, and the effectiveness of different school-based mental health programs. However, the experiences of high school principals in Southern Ontario in dealing with student mental health is yet to be researched. Filling this gap provides recommendations to school leaders and policymakers in Southern Ontario on how to manage adolescent mental health better, which will improve academic and emotional outcomes. In order to research this perspective, two methods were employed: semi-structured interviews and thematic analysis.

Methodology

To uncover the experiences of the five high school principals in dealing with the mental health of their students, this study used semi-structured interviews, which were followed up by thematic analysis of the responses given by the principals. Several questions were sent to the principals (see Appendix A), and informed consent was obtained by having the principals sign a consent form (see Appendix B). To maintain requested confidentiality, the names of principals and their schools are not mentioned in this study. Such methods were chosen because researchers commonly use them in this field of study. For example, Faithfull et al. (2019) used interviews and thematic analysis to study the experiences of 19 mental health researchers in partnering with youth to conduct mental health research.

For the current study, four of the interviews were conducted using Zoom. This software allows users to conduct digital interviews and allows for audio interview files to be saved on a computer. One of the interviews was conducted in person. The interview questions were sent to the principals beforehand, so they were able to formulate detailed responses. During the interviews, the principals were asked six structured questions, and one follow up question (see Appendix A). On average, the interviews lasted 30 minutes. In this study, out of the five high school principals chosen, two were from single-sex schools (one from an

all-boys school, the other from an all-girls school), and three were from co-ed schools. The schools were chosen to eliminate any confounds caused by gender. Gender differences in mental health among adolescents do exist, as concluded in a study conducted by Keppens, Spruyt, and Van Droogenbroeck (2018), who found that girls scored significantly higher on assessments measuring anxiety, psychological distress, and depression when compared to boys.

After each interview was completed and the data was recorded, a thematic analysis of the data was conducted. The analysis method was modelled off one described by Clarke & Braun (2013). First, each interview was initially analyzed after its completion, and quotes related to the research question were selected. Preliminary labels (codes) were created to describe the content of the quotes selected after each interview. Conceptual patterns that occurred in the quotes and codes across all five interviews that were relevant to the research question became the themes. The themes were then named based on the content of quotes and codes they represent. Four thematic-analysis tables were then created (see Appendix C), one for each theme, which include the codes relating to each theme and the quotes relating to each code. The tables were also compared to the research question to determine if each theme and the quotes referenced answered the research question. This method was used to answer the research question, “what are the experiences of five Southern Ontario high school principals in dealing with the mental health of their students?” The themes created represent the experiences of all the principals interviewed in their broadest form. The themes were built from conceptual patterns in the codes and quotes of each of the five interviews, meaning that they are the universal experiences of all five principals. In the findings section, “themes” and “experiences” are used interchangeably. After analyzing the interviews, four main themes and ten codes appeared.

Findings

In all five interviews, the experiences that came up the most were student anxiety and loneliness. The principals thought that out of all the factors that affect the mental health of their students, anxiety was the most prevalent. The principals discussed anxiety in

two ways: academic anxiety and social anxiety/loneliness. The cause of their students’ academic anxiety was the large workload, the success-driven work ethic of their students, and their students’ participation in a wide variety of extra-curricular activities. For social anxiety and loneliness, factors such as pressure coming from parents and parents’ expectations of success in subjects that their children were not interested in were discussed by the principals. An interesting observation was the influence of social media on adolescent mental health, specifically how it creates a false sense of reality about how people live. Principals also felt that social media puts adolescents’ actions under the microscope and leads to feelings of isolation. One principal believed “there’s an Instagram culture of perfection, and that is something we have to work really hard against. It gives people the wrong idea about the way people are living and who is having a better time than you are, and I think it creates a culture of envy.”

The importance of student voice is another theme that emerged during the interviews. Instilling a culture of openness and acceptance was important to the principals and is one of the codes under the student voice theme. The principals emphasized the importance of creating a safe environment where students could talk about what was going on in their lives while also educating parents on mental health issues that are prominent among adolescents. It was the opinion of a principal that their school should have a “safe place for students to talk about what’s going on in their lives. That sometimes looks like a social worker, that sometimes looks like mental health awareness week. I think most of the time actually, it looks like making sure everyone has an adult that they feel connected with.” The importance of relationships is another part of the student voice theme, as the principals saw relationships and related experiences as a way for students to find purpose and meaning. Finally, the principals thought that student input in operational functions at school was necessary, specifically on issues such as the school timetable and uniform. Referring to the timetable, one principal wanted to ensure “there are points in the day where kids can kind of relax from class to class.”

The link between physical and mental health, specifically in regard to student physical activity and sleep schedule, was a collective concern among the principals interviewed. A principal thought, “when you can

be outside and active, I think it helps you manage your emotions and helps you resolve conflicts.” Some principals wanted to start their high school later in the day so that their students could have time for both exercise and sleep. One principal believed “the perfect school day for students would start much closer to 11 am. I think teenage sleep rhythms are different from adult sleep rhythms.”

The last theme to come out of the interviews is the importance of school intervention in student mental health. Principals recognized that to have a successful student body, they need a mentally healthy student body and prioritized student mental health over academics. Providing students with a holistic education that goes beyond academics is important to the principals as well. Ideas were proposed, like providing mental health boosts throughout the year, creating time for joy and laughter, and teaching students the “great books,” which address the struggles people face, and teaching students how to be more resilient. When touching on the importance of high school students reading the great books, one principal thought, “many of those great writers address many of these issues about what it is to be a human being. How to control your emotions, how to lead a meaningful life, what does it mean to lead a meaningful life?” Lastly, teacher and specialist involvement in student mental health were also discussed. Such involvement included bringing in a mental health expert to give recommendations, increasing teacher involvement and training on how to handle student mental health issues, and teaching teachers how to take care of their own mental health so they can better deal with student mental health issues.

Principals identified student anxiety and loneliness, the importance of student voice, the link between physical and mental health, and the importance of school intervention when dealing with the mental health of their students. The current body of research supports the experiences of the principals interviewed.

Discussion

To uncover the experiences of the principals in this study in dealing with the mental health of their students, five semi-structured interviews and a thematic

analysis of the participants’ answers were conducted. Student anxiety, loneliness, the importance of student voice, a link between physical and mental health, and the importance of school intervention were the main experiences of the principals sampled. The analysis of the experiences of the five principals interviewed in this study provides insight into how schools deal with student mental health. The findings should also be considered by larger institutions like the Toronto Public School Board, Canadian Accredited Independent Schools, and the Toronto Catholic District School Board.

Student Anxiety and Loneliness

Previous research discusses the prevalence and impact of mental health issues among students and the need for schools to play an active role in student mental health (Cushman, Cleland & Hornby, 2011; Reinke et al., 2011). These findings are supported by the results of this study as the principals frequently discussed the issues of student anxiety and the importance of school intervention in mental health. Additionally, many popular studies like Metz et al. (2013), Bezinović et al. (2015), and Shoshani et al. (2014) measure the effects of certain behaviours and programs on people’s mental health by testing the impact they have on the anxiety of their participants. Using anxiety as an indicator of mental health shows its prevalence, further supporting the principals’ experiences with student anxiety and loneliness.

The Importance of Student Voice

Since many principals considered students using their voice and being heard at school important to student mental health, a possible policy is to implement a standardized communication channel between students and administrators for students to make suggestions on their school’s operational pieces. A study by Mitra and Gross (2009) analyzed cases from Australia and the United States and found that giving students a voice allowed for pressing issues to be dealt with and led to significant changes in areas that needed to be addressed at the school.

The importance of student voice theme is also supported by the findings of other research conducted in the field of student mental health. For example,

Riekie et al. (2017) found that student well-being was improved by greater school connectedness, an idea brought up several times by the principals sampled in this study.

The Link Between Physical and Mental Health

A measure that could improve student mental health is starting school later in the day, an idea raised by a few of the principals interviewed. Research done by Wahlstrom (2002), found that when seven Minneapolis public schools changed their start time from 7:15 to 8:40 am., students slept in class less and reported fewer symptoms of depression. These findings support the principals' experiences, as the principals understood the importance of students getting a good night's sleep and the differences between teenage and adult sleep rhythms.

The Importance of School Intervention in Student Mental Health

Having more programs to maintain physical health and having more opportunities to form strong relationships with other students and teachers could be worthwhile, especially for students already dealing with mental health challenges. Abraczinskas et al. (2016) found that youth in a mental health program in the United States reported increased intrapersonal skills and internalized problems less when they participated in extracurriculars more frequently. Implementing annual, mandatory student mental health training for teachers and including mental health service in the Ontario Ministry of Education's school inspections could improve the administrative handling of high school student mental health. Improving the ability of school staff to deal with student mental health, specifically teachers was raised by the principals interviewed. The model used by Woods (2014), which involved teachers participating in a mental health workshop, improved the teachers' ability to support, identify, and educate students with anxiety and depression.

Additionally, previous studies emphasized the importance of school-based mental health programs (Metz et al., 2013; Veltro et al., 2017; Shoshani et al., 2014; and Nabors et al., 2000).

This was reinforced by the principals' discussion of school intervention techniques like holistic education and teacher and specialist involvement in high school student mental health.

Limitations

Since only five principals were interviewed, more research is needed to determine if the experiences of the principals in this study are true for a larger sample size of high school principals. All of the principals sampled were from private and independent schools, which is not representative of all education demographics. Additionally, the lack of ethnic and socio-economic diversity in the students of the schools sampled in this study may have altered the results. Research conducted by Shim et al. (2009) found that African Americans were more willing to seek mental health treatment and reported having less embarrassment about using mental health services compared to other populations. Perhaps if the study had a more diverse sample of student bodies, the principals' experiences might be different. While the experiences of the principals supported previous findings, a small sample size, the type of school studied, and a lack of diversity in the student bodies of the schools sampled may have skewed the results.

Conclusion

Through the use of interviews and thematic analysis of the experiences of five Southern Ontario high school principals, four common themes were identified: student anxiety and loneliness, the importance of student voice, the connection between physical and mental health, and the importance of school intervention in student mental health. Existing research supports the experiences of the principals interviewed regarding the factors that affect student mental health, teacher perceptions of student mental health, and effective school-based mental health programs. The findings of this study help bridge the gap in student mental health research as they expand on the existing literature and provide various recommendations to high school administrators on what type of mental health policy should be implemented. Recommend-

ed policy includes implementing a channel of communication between students and administrators to encourage student input on school programs, starting school later in the day to allow students to sleep more, and having more programs to maintain physical health. Mental health is an issue that affects everyone. As the body of mental health research continues to grow, the findings of this study will not only benefit students and school staff in Southern Ontario but assist further research on student mental health.

Considering the limitations of this study, it would be beneficial for future research to incorporate a much larger sample size of principals from different regions of Canada and around the world. Further research should be done using a more diverse sample of both schools (independent, private, and public) and student bodies to see if a broader sample size supports the findings of this study. Studies targeting the experiences of a variety of high school members like administrators, mental health experts, and teachers in dealing with high student mental health would also be beneficial to increase the body of research in the field. If the proposed research is conducted, and the findings support those in this study, there would be a clear direction of what high school mental health policy should include. Lastly, it is important for future research to address the effectiveness of programs related to the experiences brought up in the interviews in this study, and how those programs can improve.

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Appendix A

1. From your experience, what are the main factors affecting the mental health of your high-school students?

2. What types of mental health issues do you see as most prevalent among your high-school students?

3. From the time you became principal to the present, what are the most significant changes that you have seen in the way your school has dealt with high-school student mental health?

4. Referencing your experience, what role should high schools play in dealing with and promoting the mental health of their high-school students?

5. What types of policies or actions would you like to implement that would better the mental health of your high-school students?

6. What are the main barriers or problems you see in providing mental health services to your high-school students?

If you have any additional comments on any of the topics touched on during this interview, please make them.

Appendix B

Consent to Participate in Interview-Based Study The Experiences of Five Toronto High-School Principals in Dealing with the Mental Health of Their Students: A Qualitative Study

Researcher

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Description:

You are being asked to participate in a 30-45 minute video interview where you will answer questions about your experiences in dealing with the mental health of your students. The interviews will be conducted on a website called Zoom. I will be sending you an email on the day we have decided on to conduct the interview, and in that email, there will be a link to download the Zoom application. Download and open the application and connect to the audio-conference.

Risks and Benefits:

There are no apparent risks in participating in this study. The outcomes are based exclusively on what you say during the interviews. While there will be no direct benefits, your willingness to participate in the study will show that you and your school are active in learning about and promoting mental health policy.

Confidentiality:

If you are willing to have both your name and school be mentioned in the study, sign the first and second lines. If you want your name and school to remain confidential throughout the study, sign the first and third lines.

Right to Withdraw:

In signing this form, you acknowledge that you will be able to withdraw as long as a week after consenting to participate in this study. The date and time you are available to be interviewed are negotiable after consenting.

IRB Approval:

This study has been reviewed and approved by the Royal St. George's College Internal Review Board (IRB).

Statement of Consent:

I have read, understood, and accept all of the information as stated above. I have been given a copy of this form. I have been allowed to ask questions, and those questions have been answered.

I consent to participate in this study.

Signature of Participant

Confidentiality Option #1

Confidentiality Option #2

Appendix C

Table C1

Theme #1: Student Anxiety and Loneliness

Themes (Experiences)	Codes	Quotes
Student anxiety and loneliness	Academic anxiety Student anxiety and loneliness	<p style="text-align: center;">Academic anxiety:</p> <p>“Anxiety in its broadest form has the most significant impact on student mental health because these are high achieving students who want to do well, and anxiety plays a big part in achieving their goals.”</p> <p>“I think having a significant workload, wanting to participate in many different activities. Students want to exercise and to sleep and rest and to do the other things that cause optimal mental and physical health.”</p> <p>“The rates like the type of anxiety that people feel today in the 1950s, they would have been hospitalized for.”</p> <p style="text-align: center;">Social anxiety and loneliness:</p> <p>“There’s an Instagram culture of perfection, and that is something we have to work really hard against. It gives people the wrong idea about the way people are living and who is having a better time than you are, and I think it creates a culture of envy.”</p> <p>“Exhaustion of carrying on, or even hiding real problems or pretending you don’t have real problems or hiding who you actually are. There is loneliness in that.”</p> <p>“We see a lot of pressure from parents. It’s parents’ expectations for their children that are affecting kids in a negative way. I’m finding that parents don’t always want what is best for their child or not what their child would be good at”</p>

DEALING WITH STUDENT MENTAL HEALTH: A QUALITATIVE STUDY

Table C2

Theme #2: The importance of student voice

Themes (Experiences)	Codes	Quotes
The importance of student voice	<p>Culture of openness and acceptance</p> <p>Building relationships and their importance</p> <p>Student input in school-decisions</p>	<p>Culture of openness and acceptance:</p> <p>“We need to make sure we have a safe place for students to talk about what’s going on in their lives. That sometimes looks like a social worker, that sometimes looks like mental health awareness week. I think most of the time actually, it looks like making sure everyone has an adult that they feel connected with.”</p> <p>“We do a better job of educating parents. We have parents into the school to talk to psychologists or to learn more about eating disorders or to learn about suicide or to learn about depression. These were not topics schools engaged in with parents when I first started.”</p> <p>Building relationships and their importance:</p> <p>“It is really important as a habit every day, learning how to build relationships. A search for purpose or meaning right and providing students with these experiences and then explaining why those things are important.”</p> <p>Student input in school-decisions:</p> <p>“What we’ve been talking about is trying to create a timetable where there are points in the day where kids can kind of relax from class to class.”</p> <p>“The places where student voice I think is always most wanted is around operational pieces. So, it is around the uniform. it is around the time that school starts.”</p>

DEALING WITH STUDENT MENTAL HEALTH: A QUALITATIVE STUDY

Table C3

Theme 3: *The link between physical and mental health*

Themes (Experiences)	Codes	Quotes
The link between physical and mental health	<p>Physical activity</p> <p>Sleep schedule</p>	<p>Physical activity and diet:</p> <p>“Starting high school days later in the morning and maybe going later in the afternoon. I think ideally it would even be a 10 o’clock start in the morning and finish school at five o’clock in the afternoon. The other aspect would be a mandatory daily physical activity of at least half an hour.”</p> <p>“I think when you can be outside, and active I think that it helps you manage your emotions and helps you resolve conflicts like it’s just better for you all around.”</p> <p>Sleep schedule:</p> <p>“We know that is a biological function and or product of exercise or sleep in, you know because we also know that the teenage biological clock is geared towards late nights and late mornings.”</p> <p>“The perfect school day for students would start much closer to 11:00 a.m. I think teenage sleep rhythms are different from adult sleep rhythms.”</p>

DEALING WITH STUDENT MENTAL HEALTH: A QUALITATIVE STUDY

Table C4

Theme #4: Importance of school intervention in student mental health

Themes (Experiences)	Codes	Quotes
<p>Importance of school intervention in student mental health</p>	<p>Prioritization of mental health</p> <p>Holistic education</p> <p>Teacher and specialist involvement</p>	<p>Prioritization of mental health:</p> <p>“I think schools should play a very active role. I mean at (blank) well-being is the first pillar of our strategy, it actually comes ahead of academics because our feeling is if you’re not well, you can’t actually engage in academics successfully.”</p> <p>Holistic education:</p> <p>“Taking what we do in mental health awareness week and making sure that we periodically are having a booster on that during the rest of the day. I think remembering that’s as important in April as it is in January. So sometimes throw in the extra sleep-in day or give the extension on the paper.</p> <p>“Remembering that joy and laughter are hugely important, so build in time for joy and laughter.”</p> <p>“I believe there should be a reading of the great books, and by that, I mean a traditional liberal arts education. Many of those great writers address many of these issues about what it is to be a human being. How to control your emotions, how to lead a meaningful life, what does it mean to lead a meaningful life?”</p> <p>“I know schools think a lot about teaching about the positive elements of failure and I think we’re trying, but I think we have a long way to go with helping people be more resilient.”</p> <p>Teacher and specialist involvement:</p> <p>“I’m a fan of finding the person who’s really smart, bringing them in for a couple of weeks, and have them say here’s what I understand about what you’re doing, you should think about (blank), another school is trying (blank) with great success, and get those recommendations and implement them.”</p> <p>“I’d like a policy where we have annual training of teachers on how to handle mental health issues.”</p> <p>“You can explicitly teach mental health first aid, but I also think you can teach teachers how to take care of themselves and to be relational, and then I think that takes care of a lot of student mental health (issues).”</p>

Engineering a Low-Cost, Non-Invasive Corrosion Monitoring System

Demos Negash

Corrosion is one of the most costly global expenditures. In recent years, a multitude of Non-Destructive Testing (NDT) methods to detect early corrosion in rebar have been developed. However, there are several issues that prevent their wide-scale application. Thus, the goal of this project is to create an accurate, low-cost corrosion monitoring system by using the voltage via an electrical current from a solar cell using an engineering design process. The final device was programmed by an Arduino Uno to export data to a Google Sheets cell. In all the trials, as the cross-sectional cut of the rebar samples increased, the voltage output in the rebar samples decreased, and statistical significance was later shown. In addition, the transfer time of the voltage readings to a Google Sheets cell was seen to be relatively quick. This system costs roughly \$61, making it 51% more economical compared to other Arduino-based monitoring systems.

Keywords: corrosion, electrical current, solar cells, non-invasive, monitoring system, Arduino

Introduction

One of the most costly global expenditures is corrosion costs, totaling approximately \$2.5 trillion every year [1]. This value encompasses, but is not limited to, corrosion repair and prevention. Additionally, thousands of lives have been lost due to corrosion-related incidents [2]. Over time, although these numbers have only risen, efforts to reduce them have been made. In the United States, infrastructure spending over the past decade has shifted toward maintenance spending, opposed to capital spending [3]. This reallocation of spending has led to many benefits, including reduced infrastructure damage and reduced man-

agement costs [4]. However, current efforts have not shown significant progress, as the American Society of Civil Engineers ranked overall infrastructure a D+ in a comprehensive report in 2017 [5].

Corrosion

Corrosion is a unique occurrence in metals that develops over various periods of time. Existing in various forms, corrosion consists of a redox reaction at the surface of the material. Upon oxidation, ions and electrons are created that are later used in the reduction reaction. Seen in Figure 1 is an illustration that highlights the electrochemical process at an atomic level.

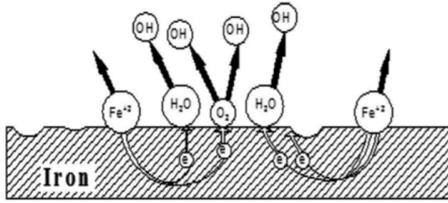


Figure 1: Electrochemical Process of Corrosion [6]

As a result, rust starts to form over the surface of the metal. Multiple studies have shown that once corrosion has occurred, the product continues to amass, reaching a larger volume than the actual metal itself [7] [8]. Essentially, this allows for corrosion-inducing agents to further penetrate the steel, rapidly accelerating the process. Consequently, stress builds up in the rebar, creating cracks and spalling that causes serious infrastructure deterioration [9]. The combination of the loss of tensile strength and fracture toughness in the rebar within concrete has been identified by structural engineers as one of the leading causes of infrastructure failure [10]. In effect, the costs to repair the infrastructure skyrocket. Societal consequences also exist, because the safety and health of the public is put at risk [11] [12].

Non-Destructive Testing (NDT)

In recent years, non-destructive testing (NDT) has widely proven to have potential for civil engineers. NDT is a field of engineering analysis technique that enables inspection methods to predict corrosion without causing damage to the structure, allowing for the structure to maintain its integrity [13]. These methods have become more abundant over recent decades. A review of NDT methods conducted by Zaki et al., researchers at the Department of Civil Engineering at University of Malaya, in 2015 found that these methods are critical to providing the necessary detection and monitoring for the evaluation of the condition of reinforcing steel structures [14].

Furthermore, NDT methods provide many crucial benefits. Due to the ability for rapid data collection through several methods, early detection of corrosion is feasible. In effect, costs associated with corrosion damage significantly decrease. When discussing

the impacts of early corrosion detection, Anita Augustyniak, PhD in Material Science at the University of New Hampshire, stated, “further material damage would be prevented by providing maintenance on an as-needed basis when it is relatively inexpensive” [15]. Additionally, Larry Summers, former Secretary of the Treasury writes, “not only does prolonged corrosion make the bridge weaker, but it makes fixes much more expensive.” [4].

Although NDT methods provide promising insight on corrosion detection, there are several key limitations preventing their application on a much wider scale. Multiple reports have shown that commercially available NDT equipment is beyond the reach of many researchers due to the cost, with the cheapest NDT equipment averaging around \$1000 per unit [16]. Furthermore, the costs of equipment in widely-used NDT methods have not seen a significant reduction in prices over time [17].

However, in the methods that are relatively accessible to researchers, accuracy can often be mediocre. The half-cell potential (HCP) method, the most widely regarded accessible NDT method in the field, generally requires the addition of other methods, rendering the lone technique as unreliable [18]. In addition, Lukas Sadowski, a university professor at the faculty of civil engineering at Wrocław University of Science Technology in Poland, writes, “half-cell potential values merely provide information about the probability of corrosion and not about the rate of corrosion” [19]. Essentially, the corrosion occurring within a structure is indeterminate rather than quantifiable via the HCP method. As a result, many predictions about future deterioration within the structure are flawed. Despite this method allowing for large-scale data acquisition and establishing fundamental corrosion trends between, these drawbacks have led researchers to question the reliability of the technique.

Research has accelerated methods to account for the absence of accurate methods. Ground Penetrating Radar, commonly known as GPR, has progressed the field by accommodating for the spread of more advanced NDT technologies. Through the propagation of different radio frequencies via electromagnetic waves, reflected waves are sent back to a receiving antenna to be recorded and converted into a voltage wave [20]. Istiaque Hasan and Nur Yazdani, professors of civil engineering at the University of Texas at

Arlington, found that within testing, GPR is one of the few methods able to identify localized damage within rebar [21]. For many applicable methods in the literature, rebar is assumed to undergo uniform corrosion. An important facet of GPR is its proficiency to highlight specifically where corrosion has occurred. Figure 2 illustrates an example of the results of a GPR scan.

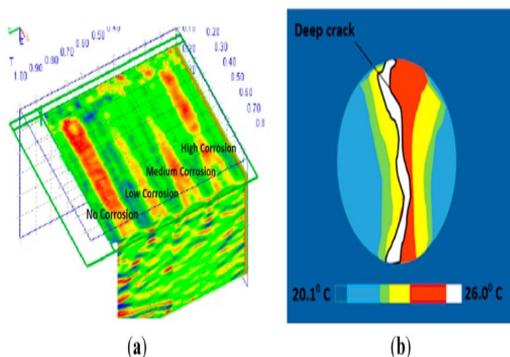


Figure 2: Ground Penetrating Radar [22]

Although this method is capable of identifying localized corrosion, the results scanned are often too difficult to interpret for those without expertise in the field, making them highly susceptible to human error [23]. Moreover, current GPR technology only allows the wide-scale application of GPR containing a qualitative assessment of the results. Ahmad Zaki, PhD in civil engineering from the University of Malaya and one of the most prominent NDT researchers, et. al published a study using GPR that collected quantitative results using wave peaks [24]. The researchers conclude that quantitative assessment of corrosion damage was possible using GPR, addressing a critical gap within the literature surrounding GPR technology. However, since the publication of this study in 2018, GPR equipment still remains very costly. Despite the results in this study, researchers are unable to obtain access to the newest technologies.

Project Goals

Based on the current literature, the end goal of this project is to create an accurate, low-cost corrosion monitoring system by using solar cells. Solar cells are

devices that utilize light energy, primarily from the Sun, and convert it into electricity [25]. Since solar technologies are constantly under innovative research and development (R&D) [26], the end product could be enhanced by researchers in the future. Furthermore, no literature exists concerning the use of solar cells to detect early corrosion. Given that solar cells only require light energy to operate, the end system could enable hands-off corrosion monitoring, therefore allowing resource allocation to be more efficient. This research aimed to investigate the question: Can voltage readings from solar cells be utilized to detect early corrosion in rebar, and if so, how can a non-invasive system continuously monitor these readings? By creating this system, the significant gap in the literature to create a low-cost, accurate corrosion detection methodology could be addressed.

Methodology

In order to achieve the project's goals successfully, this study has two fundamentally different components to the embedded system: the hardware and software. For the hardware, an engineering design process was utilized in order to construct the monitoring system correctly. As explained by Seyyed Khandani, PhD and professor of engineering at Diablo Valley College, the engineering design process is an iterative process that involves defining a problem, generating a solution, and testing and implementing that solution [27]. Due to the design process' flexibility, it allows the researcher to backtrack and enhance the device to meet the goals that were originally set for the product. Given its flexibility, it made this methodology ideal for the construction of this monitoring system. Refer to the project goals section to see the goals for this study.

Furthermore, the same techniques apply to the software portion of this research. The purpose of the software in the device is to allow for user-friendly access and collection of the data. Many of the decisions regarding the software were based on shortcomings with current monitoring systems within the literature. Given that this portion only involved programming the device, a laptop with the Arduino Integrated Development Environment (IDE) installed were the only materials required for this.

Rebar Sample Preparation

The first step in the creation of the monitoring system was to emulate the damage caused by corrosion within the rebar samples. For this experiment, a 4 to 18 mm hydraulic electric rebar cutter was used to reduce the rebar samples to $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ of their cross-sectional depth. Additionally, a rebar sample with no cut served as a control. This process was modeled after a study done by researchers at the University of Kerman, in which an accurate assessment method found that decreasing moment capacity, a direct result of corrosion, is linearly proportional to corrosion [28]. Next, in order to establish a reliable electrical current throughout the rebar samples, stainless steel screws were attached to the ends of the rebar [29]. See Appendix A for a picture of the rebar samples.

Solar Application

For this experiment, an ALLPOWERS 5v solar cell was utilized to send a current through the rebar samples. Due to the scope of this research, the ALLPOWERS 5v solar cell allows for a consistent electrical current to be sent through the steel rebar samples without damaging the voltage regulator of the Arduino UNO. According to Ankem Susheel and S. Selvendran, researchers at the Department of Electronics and Communication Engineering at the CVR College of Engineering in India, because the Arduino UNO is a sensitive device, damage to the system through high heat or voltage can hinder the circuit [30]. Given that this solar cell cannot easily attain these high metrics, it was used as the source of power for the electrical current throughout this study. In addition, this solar cell model costs \$13 dollars. Since equipment cost is a key drawback of current methods, the low cost of this solar cell made it ideal for the device.

Furthermore, alligator clips, which are used to create a temporary electrical connection, were attached to stainless steel screws on the ends of the rebar samples in order to establish this current. The solar cell used in this experiment was soldered to expose the conducting copper, and the other ends of the alligator clips were attached to the positive and negative terminals of the solar cell.

After the electrical current had been established to the rebar and pins on the Arduino UNO, the code to

receive these voltage readings was developed. The pins on the Arduino UNO were programmed to sense the electrical current from the solar cell. It was coded to read the voltage from the electrical current, converting and outputting that value to volts. The code was continually modified once additional code serving different functions was developed. For this code specifically, it can be found in lines 1-13 of the full code in Appendix C.

Cloud Architecture

The final step in the creation of the monitoring system was the implementation of a program to non-invasively monitor these voltage readings on a spreadsheet, rather than the serial monitor on the IDE. The purpose of this step was to allow users of the product to gather information from remote locations. Essentially, in order to monitor the system, cloud architecture enables great abstraction for users that are not in situ [31]. This phase of the development of the monitoring system was modeled after a previous photovoltaic system from Ibrahim Affali, researcher at the Department of Electrical Engineering at Memorial University of Newfoundland, and Tariq Iqbal, professor of electrical engineering at Memorial University [32]. In Affali's design, the results were sent to a Microsoft Excel spreadsheet. By sending the data collected throughout this experiment to a Google Sheets cell, the data could be shared between users.

For the hardware setup of the system during this step, jumper wires, which are used to connect two points on a circuit, were used to transfer the current from the solar cell going through the alligator clips to two separate pins on the Arduino - the negative terminal of the solar cell to the GND pin and the positive terminal of the solar cell to a 5v analog pin. A finalized picture of the monitoring system can be seen in Appendix B.

Next, the code to transfer these voltage readings to a cell on Google Sheets was developed. The device was coded to allow the user to access the Google account of the user by inputting his/her username, password, and the name of the spreadsheet that they are writing to. These were accessed by allowing for the device to import packages from different classes over the Google cloud network. It is important to note that this input is case sensitive, meaning that all charac-

ters had to match the Google information in order for the device to respond correctly. For the spreadsheet, it was coded to create rows that would allow the voltage readings from the serial monitor to be placed in a cell. In addition, the time and date were also recorded, thus allowing the device and users to track any frequencies over time. See Appendix C for the full program. The program was approximately 70 lines of code.

Results and Discussion

When the system was built, 5 trials were run on the different rebar samples to test whether or not differences in voltage could be seen after varying levels of corrosion had occurred. After the electrical current had been applied, measurements on each trial were taken at 10 minutes, 30 minutes, and 1 hour. In all 5 trials for each rebar sample, approximately 5 volts and 1 amps was applied to each rebar sample in order to ensure that no damage was done to the regulator of the Arduino UNO.

In all 5 trials for each rebar sample, there were no issues regarding the transferring of voltage readings to a spreadsheet cell, as indicated from visual observations from a multimeter. Therefore, this signifies that there were no major errors regarding the schematic design of the monitoring system nor the code used to monitor the voltage readings. In order to see trends between the data more precisely, the data is represented in millivolts (mV).

Time	Voltage (mV)	Current (A)
10 minutes	148.0	.996
30 minutes	147.7	.996
1 hour	148.4	.996
Average	148.0	.996

Table 1: Control Rebar Sample

Table 1 shows the voltage output of the control rebar sample as while the current was set to a constant 0.996 Amperes. On average, 148.0 mV was sent

through the rebar sample. A major trend that can be seen is that over time, the voltage readings fluctuated, indicating that the electrical current being sent through was not numerically constant.

Time	Voltage (mV)	Current (A)
10 minutes	132.6	.996
30 minutes	128.4	.996
1 hour	133.1	.996
Average	131.4	.996

Table 2: ¼ Rebar Sample

As seen above in Table 2, one major observation that can be noted is that in comparison to the values found when there was no cut in Table 1, Table 2 shows values of voltage that are proportionately less than that of the rebar at full size without any cross-sectional cuts. At the voltage readings at 10, 30, and 60 minutes for Table 2, each of the values were lower than those in Table 1. In addition, the average voltage for the ¼ cut rebar sample was 12% less than the control.

Time	Voltage (mV)	Current (A)
10 minutes	88.3	.996
30 minutes	93.4	.996
1 hour	89.2	.996
Average	90.3	.996

Table 3: ½ Rebar Sample

In the results shown in Table 3 with a ½ cross-sectional cut, the rebar trend continues to persist of declining voltage as cross-section cut increases. The voltage values had a much more significant reduction from ¼ cut to ½ cut compared to the control. Compared to the control, the average voltage in the ½ cut rebar sample was 39% less. When compared to the ¼

cut, the average voltage was 32% less in the 1/2 cut rebar sample.

Time	Voltage (mV)	Current (A)
10 minutes	55.6	.996
30 minutes	38.7	.995
1 hour	42.9	.996
Average	47.64	.996

Table 4: 3/4 Rebar Sample

The table above shows the results for the 3/4 cut rebar sample. This sample showed to have a significant impact on the value of the voltage being passed through in comparison to no cross-sectional cut. In comparison to the control, the average voltage for this rebar sample was more than 100 mV less, or 64%.

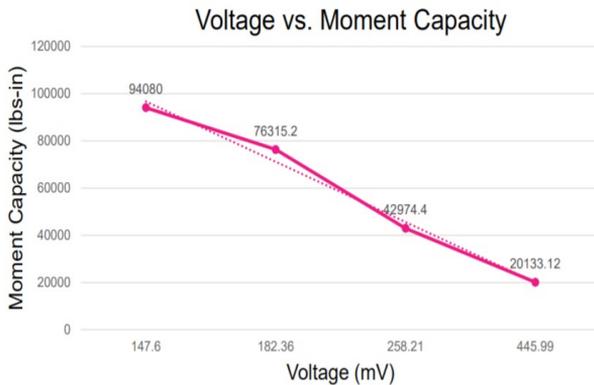


Figure 3 – Voltage vs Moment Capacity

As seen in Figure 3, when the electrical current was sent through the different rebar samples using a solar cell, the moment capacity of the sample decreased as the voltage increased. Based on the trend line seen on the graph, the value between voltage and moment stayed approximately at a 1 to -1 ratio. This meant that if the corrosion had led to a section of 1/10th the rebar, the moment capacity would also de-

crease by 1/10th which is equivalent to 90% the total load it could once hold. These findings are critical to the application of the device at a larger scale, as the voltage readings are relatively proportional with the moment capacity of the rebar. Furthermore, the results shown below reinforce the findings of other studies, with respect to the different instruments used [33] [34].

Source	Sum of Squares	Mean Square
Between-treatments	10789.2027	10789.2027
Within-instead	64367.5842	1399.2953
Total	75156.7869	

Figure 4 - One-Way ANOVA Statistical Test

Given that there were varying cuts within the rebar samples, specifying that there was more than one independent variable, an ANOVA statistical test was done in order to explore whether the data collected was due to random chance. In order to test the significance of the data, the one-way ANOVA statistical analysis was conducted at 95% accuracy. The statistical analysis consisted of 48 samples, 24 for the rebar sample with a 3/4 cut and 24 for the control rebar sample. The mean of the 3/4 size rebar sample was 104.18 mV with a standard deviation of 39.7267, while the mean of rebar the control rebar sample was 134.165mV and the standard deviation was 34.8929.

The greater standard deviation seen in the rebar sample with a 3/4 cut shows larger variation in the data with slightly less accuracy than that of the control rebar sample. Because the p-value is 0.007916 which is less than the p-value of significance 0.05, the downward trend seen in the trials were significant. Moreover, given that the solar cell used during data collection was able to show this significance, the results seen above demonstrate that the voltage readings from an

electrical current using a solar cell was a feasible alternative to other exorbitant NDT equipment.

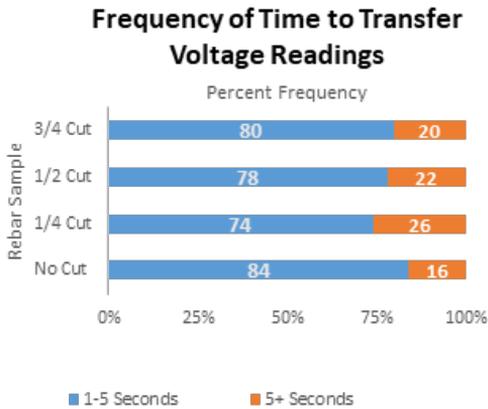


Figure 5 – Frequency of Voltage Readings Transfer

Once trials were conducted on each rebar sample, because the data in the study was transferred through a cloud network instead of an offline source, an additional trial on the frequency of time that it took the device to send voltage readings to each rebar sample was completed. Similar to previous trials, this additional trial was 10 minutes. Approximately 300 voltage readings were gathered during this test. The results can be seen above in Figure 5. As seen from the data, 79% of the voltage readings gathered from the device took between 1-5 seconds to reach a cell on Google Sheets. The longest time it took a voltage reading to reach a Google Sheets cell was 12 seconds.

One key finding in this trial was a large discrepancy between the control sample and the rebar sample with the 3/4 cut. In addition, it can be seen that the frequencies varied between each rebar sample. Based on the data seen in the graph, the standard deviation of the frequencies is approximately 4.16, indicating that the frequency times were varied. Because the IDE software is usually operated offline, in the context of this research, it could be initially assumed that the frequency should stay the same for all samples; however, the results do not align with this assumption. It is important to note that the trials for this study were not all taken on the same date. Given this, a highly probable rationale is that different bandwidth speeds

at the location of the research during the different trials. Because it was sent through a cloud network, the speed of the data reaching Google servers was heavily reliant on internet speeds. However, during these periods of lower internet speeds, the data would quickly send over once the internet speeds were restored to normal levels.

Integrand	Cost
Arduino UNO	\$23
ALLPOWERS Solar Cell	\$13
Arduino Integrated Development Environment	FREE
Multimeter	\$12
Jumper Wires	\$9
USB Cables	\$4
TOTAL	\$61

Figure 6 – Cost Table

Given the cost of all components, the final cost of the product is \$61 dollars. The laptop used to program the Arduino UNO and the rebar samples used were exempt, assuming that users would have access to these materials. Compared to other monitoring systems in the literature, the cost of the product is significantly less. An Arduino-based corrosion monitoring system from the Department of Applied Science and Technology at University of Ferrara priced at approximately \$162 dollars [35]. In addition, researchers from the Polytechnic University of Turin developed a logarithm-based Arduino-based system that cost around \$100 [36]; however, the Arduino-platform used in their study was almost half of that cost. Upon additional review of the costs of these systems, the device constructed in this research was approximately 51% more economical.

Furthermore, this device is simpler compared to other Arduino systems. In this device, it can be concluded that corrosion predictions can be made from the voltage readings displayed; however, in other systems like the aforementioned logarithm-based system from Polytechnic University of Turin, the independent variables were very dynamic.

Conclusion

New Understanding and Significance

When compared to other systems and their limitations, this device improved on many of the aforementioned problems with them. As high equipment costs prevent many researchers from accessing these technologies, this monitoring system proved to be significantly more economical. In this study, one of the most important findings was the strong positive correlation between decreasing moment capacity and voltage. Therefore, as seen in the trials conducted on the rebar samples, along with the one-way ANOVA statistical test, this device was able to produce significantly accurate results between the different rebar samples.

Several electrochemical NDT methods in the literature have successfully used an electric current from a variety of sources within their monitoring systems [37] [38]; however, this device is the first to use the electrical current from a solar cell as an accurate means to detect corrosion within rebar. This is significant for several reasons. As previously mentioned, because solar technologies are constantly under R&D, this system can be enhanced in the future to address any limitations that current solar technologies, specifically solar cells, may contain. Furthermore, constant supervision of the equipment within the monitoring system is not necessary because solar cells only require light energy to operate. Although the cost of monitoring systems is an issue, the costs to have a person continually operate this system and repair it could also become a problem, as seen in other monitoring systems [39]. By allowing for noninterference of the equipment via a solar cell, costs relating to equipment repair can potentially decrease.

In addition, this corrosion monitoring device is the first to use Google Sheets as a means to store data. By allowing for the transfer of data through Google servers, this further reiterates the device's capability to enable hands-off monitoring. In the specific context of corrosion monitoring, this is critical. By allowing researchers to monitor corrosion levels at different locations, the allocation of resources, such as labor and money, can be used more efficiently. As a result, overall corrosion costs and damage can be further mitigated. This directly related to the initial project goals for this research.

The problems regarding corrosion management have persisted for decades, and multiple solutions have been proposed to mitigate the impacts by detecting corrosion early on. For example, the United States Department of Transportation and Tracy Gordon, an economist at the Urban-Brookings Tax Policy Center, suggest that the scope should be moved to local officials [4]. However, the issues regarding the high costs and ambiguous exactness of corrosion detection are still present in current technologies. This device assists to fill that gap in the current literature regarding these technologies.

Limitations

Although this low-cost monitoring system successfully gathered data that could give insight on corrosion levels within reinforcing steel, there are several limitations of the device that were not addressed during this study. The two main limitations of this study were the corrosion modeling in the rebar and the dependency on internet speeds.

As stated in the rebar sample preparation section, in order to emulate corrosion, slits were made into the center of the rebar. The reasons for this are twofold. First, given the time frame for this research, attempting to create these conditions using corrosive liquid would likely not be efficient. In addition, importing corroded rebar is an option, but price would likely become an issue. Although this was grounded and modeled from other researchers, it is not an exact representation of the real world. The same patterns seen in the data collected in this study would likely be seen; however, conclusions cannot be made that solidify the device's capability in real world situations.

Furthermore, another key limitation was the dependency on internet speeds. Although the device is able to send the voltage readings over various speeds, the bandwidth of the user has a large impact on the time it takes for data to reach them. For example, if the voltage readings are sent from an area of higher internet speeds to one of significantly lower speeds, this potentially could drastically hinder coordination to address the problem. Regardless, the device shows promising solutions to civil engineers attempting to rapidly gather information on the amount of corrosion that has occurred within a structure.

Future Directions

There are a multitude of paths that researchers could take to look further into the field. Based on the limitations, the future directions for this research focus on enhancing the system in order to further achieve the goals that were set originally. First, coordination with local governments to implement the device on different structures would allow insight on the scope to which the monitoring system is feasible. In order to accomplish this, modifications would likely have to be made to the solar cell used in the monitoring system due to the physical nature of current infrastructure. Furthermore, while the program that was developed in the monitoring system was concluded to enable researchers to obtain data at various locations, the frequency of receiving that data is highly reliant on internet speeds because it was sent through Google servers. The incorporation of a phone application component to notify users if a problem occurs could mitigate the issue regarding the various internet speeds of users. By allowing for large amounts of data to reach users these speeds, actions by local transportation officials could be taken at a much faster rate, further reducing costs and damage, and increasing public safety.

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Appendix A – Rebar Cuts



Rebar Sample: No Cut (Control)



Rebar Sample: 1/2 Cut

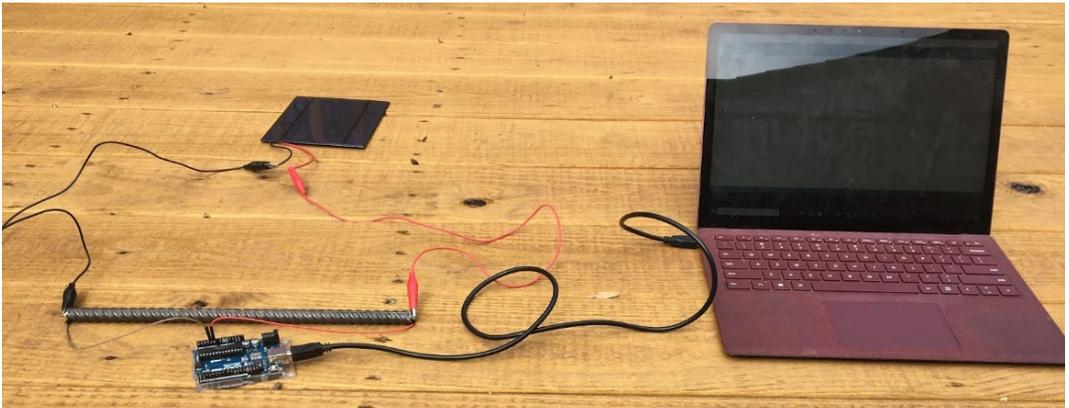


Rebar Sample: 1/4 Cut



Rebar Sample: 3/4 Cut

Appendix B – Final Monitoring System



Appendix C – Final Code for Monitoring System

```

const float referenceVolts = 5.0;
const int SolarPin = 0;
void setup()
{
  Serial.begin(9600);
}
void loop()
{
  int val = analogRead(SolarPin);
  float volts = (val / 1023.0) * referenceVolts;
  Serial.println(volts);
  delay(500);
}
import com.google.gdata.client.spreadsheet.*;
import com.google.gdata.data.*;
import com.google.gdata.data.spreadsheet.*;
import com.google.gdata.util.*;
import java.net.URL;
import processing.serial.*;
String uname = "xxx";
String pwd = "xxx";
String spreadsheet_name = "sensorlog";
int spreadsheet_idx = 0;

Serial port;

int oldTime;

int reportingInterval = 2000;
void transmitData(float val) {
  String date = day() + "/" + month() + "/" + year();
  String time = hour() + ":" + minute() + ":" + second();
  try {
    ListEntry newEntry = new ListEntry();
    newEntry.getVoltageReadings().setValueLocal("date",
date);
    newEntry.getVoltageReadings().setValueLocal("time",
time);
    newEntry.getVoltageReadings().
setValueLocal("reading", Float.toString(val));
    URL listFeedUrl = worksheet.getListFeedUrl();
    ListEntry insertedRow = service.insert(listFeedUrl,
newEntry);
  } catch (Exception e) {
    println(e.getStackTrace());
  }
}
}
}
service = new SpreadsheetService("test");
try {
  service.setUserCredentials(uname, pwd);
  URL feedURL = new URL("http://spreadsheets.google.
com/feeds/spreadsheets/private/full/");
  SpreadsheetFeed feed = service.getFeed(feedURL,
SpreadsheetFeed.class);
  for (SpreadsheetEntry entry: feed.getEntries()) {
    if (entry.getTitle().getPlainText().equals(spreadsheet_
name) ) {
      break;
    }
    SpreadsheetEntry se = feed.getEntries().
get(spreadsheet_idx);
    worksheet = se.getWorksheets().get(0);
    println("Found worksheet " + se.getTitle().getPlain-
Text());
  } catch (Exception e) {
    println(e.toString());
  }
}
}

```

Contributors

Abigail Bohn attends DuPont Manual High School, located in Louisville, Kentucky. Serving as a Varsity captain, she is an avid cross country and track runner. In the future, Abigail hopes to attend medical school with aspirations of becoming a surgeon.

Alyssa Gaylard is a high school senior at Appleby College in Oakville, Ontario. Next year, she will be attending the University of California, Irvine to study political science. In high school, Alyssa was the Director of the Debate Club, the Secretary General of the Model United Nations Club, and the Politics Editor for an independent student-led newspaper. In addition to this, she also enjoys participating in community service events and social justice campaigns. In her spare time, Alyssa loves writing poetry and making short films.

Lydia Guertin is currently published by the Tennessee Academy of Science for her work on Dielectric Elastomer Actuators, but chose to study the impacts of sexual assault awareness movements after her own experiences with sexual assault. She is an avid soccer player and musical theater performer in her free time, and will be attending Haverford College in the fall, where she intends to double-major in Mathematics and Astrophysics.

Sawsan Haider will be a student at Queen's University to study health sciences in the fall. She is passionate about the intersection between health and technology and has worked on projects like designing an app that uses retina scans to detect Alzheimer's and creating a machine learning algorithm to detect diseases in CT scans.

Ella Hilton is passionate about gaining momentum for the computer science field while encouraging all students, regardless of gender, that they can pursue whatever it is that interests them.

Nanyi Jiang is a Capstone student at Appleby College, Ontario, Canada. Her work focuses on business, economics, and entrepreneurship.

Asha Kalapatapu lives in the Houston suburb of Katy. She became interested in the topic of support needed for caregivers based on her family's experience. A member of the Seven Lakes HS Class of 2021, Asha undertook this research project as part of the AP Capstone program. She serves as editor-in-chief of the school yearbook, is an officer with the Hospital Missions organization and National Charity League, and is also a member of the Superintendent's Leadership Circle.

Pragyat Khanal is a high school senior at Newark Charter School in Newark, Delaware. He is planning on majoring in biomedical engineering at Duke University.

Rakshita Kota is a current Junior in High School and is a 17 year old ambitious girl with big dreams and aspirations. While not in school or doing school work, Rakshita spends most of her time participating in extracurricular activities and community service. A significant portion of her time goes towards coaching math and science topics online and running a competitive math and science team at her former Elementary school. In fact, Rakshita was recently awarded the President's Volunteer Service Gold Award for her dedication to the club. She also serves as an officer in both the Math and Science National Honor Societies at her school. Outside of school, Rakshita also tutors students and donates the money earned to provide English teachers to economically disadvantaged students in a rural village in India. Additionally, for the past 12 years, Rakshita has been passionately and committedly learning classical Indian dance and music as hobbies.

Alistair Langhorne is a grade 12 student attending Royal St. George's College in Toronto, Canada.

Siyu (Elaine) Liu is a Grade 12 student at Appleby College in Oakville, Ontario. She is a math enthusiast and fervid community advocate. Her paper—“Not a Children’s Game: Misogyny in the Online Gaming Community”—was conducted as part of the AP Capstone program at school. Elaine is interested in gender studies, cryptography, machine learning, and linguistics. She plans to study mathematics at Massachusetts Institute of Technology in the fall and apply her quantitative skills in addressing social inequalities. During high school, Elaine works to promote equal gender representation in the mathematics community by starting a Math Club at her school. Having represented Canada at the 2020 and 2019 European Girls’ Mathematical Olympiad, she hopes her participation will encourage more aspiring female mathematicians to pursue their passion. When not busy, Elaine likes to spend her time reading 20th century literature, skateboarding, and stargazing.

Madeline McWatters is a rising senior at Newark Charter High School in Newark, DE. The following research paper was written for an AP level research class.

Demos Negash is a 17 year old student at duPont Manual High School in Louisville, Kentucky. Over the years, Demos has developed a strong passion for research. For the past two years, he focused computational chemical structures for solar cells to find a feasible alternative. This knowledge provided him with a strong background when he worked a monitoring system using solar cells. Demos is involved in Y-Club, where he currently serves as the Secretary General of the largest youth government conference in the United States, and is the head captain of his school’s Congressional Debate team. In the future, he aspires to explore and write in the world of academia pertaining government and international relations, hoping to use the skills learned from his STEM research and pass them onto others.

Esha Patel is a senior in high school at Holy Trinity Episcopal Academy in Melbourne, FL. She is interested in microbiology and has been conducting research at the Florida Institute of Technology as a high school student. She will be attending Duke University next year and will be studying biology and global health, hoping to pursue a career in medicine.

Juliet Pridgen is a recent graduate of Mabank High School, class of 2019. She currently attends Southwestern University in Georgetown, Texas where she is working towards her Bachelor of Science degree in Biology with a minor in Health Studies in hopes of attending dental school in the future. Juliet is also a member of the Southwestern Lady Pirates Soccer team and enjoys spending time with her family and dogs.

Clara Ray is a current high school senior. Beginning in fall 2020, she will be pursuing a bachelor’s degree at Georgia State University in Atlanta, GA. She is an aspiring environmental researcher with specific interests in hydrology and plastic pollution.

Sreevatsa Vemuri is an energetic and passionate student who always strives for exceeding expectations. He delves into numerous volunteering opportunities and does his best to help those impacted by health issues. In his free time, you can find Vatsa playing video games or watching YouTube.

Julia Werner is a student at DuPont Manual High School. She plans on entering the field of engineering in the future.

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Stephanie Bergren earned a BA in Television from Columbia College Chicago in 2005. Following graduation, she worked in documentary and video ethnography. As a favor to a friend, she copy-edited a novel in 2006 and has worked intermittently as a copy editor ever since. In 2016, she began teaching 7th grade English. Since then, she has taught English I, III, IV, and AP Research.

Kenneth J. Broda is a Social Studies teacher at Columbus High School in Columbus, GA. Columbus High School is a college preparatory Liberal Arts Magnet Program that has been ranked as one of the top schools in Georgia and the nation in recent years. Currently, he teaches AP Research and AP Macroeconomics, and he has also taught AP US Government and Politics for 16 years. Mr. Broda has taught for 28 years, with 24 of them being at Columbus High School. Beyond teaching in the normal classroom, Mr. Broda taught 4 years in Georgia's Governor's Honors Program, worked at the AP read for US Government and Politics and Macroeconomics as a reader/table leader for a combined 17 years, and has been an AP workshop presenter for the Georgia Department of Education for 7 years. He received a B.A. from the University of Virginia and a M.Ed. from Columbus State University. Mr. Broda has spent his career teaching students about the humanities and how to reach their full academic and personal potential.

Clay Dion is an AP Capstone teacher at Appleby College, teaching both AP Seminar and AP Research in addition to senior school English classes. He is also the Coordinator of the school's Centennial Scholarship programme. He holds a Master's Degree in English Literature from Western University as well as undergraduate degrees in both English (Western) and Mathematics (Waterloo). Before coming to Appleby, he was a sessional instructor, teaching courses in poetry and 18th Century Literature at

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Michael Duplessis is an AP Biology and AP Research teacher at Page High School in Franklin, TN, where he also serves as the Science Department chair. Michael has had the privilege of teaching at Page for 13 years. Before moving to Tennessee in 2007 he taught Biology classes at John Ehret High in Louisiana for 8 years. He earned his Bachelor's Degree in Science Education at the University of New Orleans and his Master's Degree in Educational Leadership and Doctor of Education in Learning Organizations and Strategic Change from Lipscomb University in Nashville. Michael truly enjoys working with students as they research new ideas, and always enjoys learning what his students can teach him because of their research.

Dawn Heinecken is Professor and Chair of the Department of Women's, Gender and Sexuality Studies at the University of Louisville. Her research focuses on critical cultural analysis of gender/race/sexuality in media with an emphasis on sports and children's literature.

Claire Kelly teaches AP Capstone Seminar and Research, and Senior English at Appleby College in Oakville, Ontario. Additionally, she is the Director, Curriculum & Research at the school, helping to lead curricular innovation and pedagogical research. Claire recently earned her PhD from OISE/UT ('19) in Leadership, Higher, and Adult Education, with a dissertation exploring gender representation in independent school headships. She has presented her research in various contexts, including the American Educational Research Association (AERA), and as a CAIS Leadership Institute Women in Leadership module facilitator. Additionally, she has written three children's books (Rubicon publishing). Claire

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Catherine Koos teaches at Holy Trinity Episcopal Academy, in Melbourne, Florida.

Janet Kurusanather is an AP Capstone and English teacher at Appleby College. She holds a BA (Hons.), BEd (Hons.), and Master's degree from York University, graduating from each programme as a Member of the Dean's Honour Roll. Her Master's research was awarded the Joseph-Armand Bombardier Canada Graduate Scholarship from the Social Sciences and Humanities Research Council of Canada (SSHRC). Presently, Janet is a third-year PhD student at the University of Toronto. Her research interests include ethical philosophy and anti-oppressive education.

Matthew Lohman is an educator at Newark Charter High School in Newark, Delaware. He has taught a variety of high school English courses since 2002, including AP English Language and Composition for the past 13 years. In 2015, he helped to develop the AP Capstone curriculum at Newark Charter High School, the first school in Delaware to implement the AP Capstone program. He has taught AP Seminar since 2015 and AP Research since 2016, taking great pride in his students' laudable success and tremendous growth as writers, researchers, and critical thinkers. He holds a BSEd. in English from West Chester University, a Master's degree in education from the University of Delaware, and he is currently working on a second Master's degree in educational technology.

Shannon Roos is an English and AP Capstone teacher and an instructional coach at Hampton High School in Pennsylvania. She holds a bachelor's degree in English and secondary education from Carlow University and her master's degree in instructional technology from Wilkes University. Through her teaching and coaching she strives to

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- Will Fripp
BA, MA
- Will Fripp is a public affairs and political risk analyst for Canadian and international clients. A B.A. in History and Political Science from Victoria University at the University of Toronto and an M.A. in Intelligence and International Relations from the University of Salford in Manchester, England, he is a historian specializing in intelligence and espionage, and its modern influences. Will anchored www.spiesintheshadows.com, a web based curriculum outlining Canadian foreign intelligence history and its impacts on Canada's national development. An occasional lecturer, Will's writings and review articles appear in peer-reviewed academic journals like *Intelligence and National Security*, and elsewhere.

- Michael Gemar
BSc, BA, PhD
- Michael Gemar received undergraduate degrees in Psychology and Philosophy from Rice University, and a PhD in experimental psychology from the University of Toronto. He has worked as a researcher at the Centre for Addiction and Mental Health, examining the cognitive and neural correlates of mood disorders, and was involved in a landmark study demonstrating the efficacy of mindfulness meditation to prevent depressive relapse. He has co-authored numerous journal articles, and taught for over a decade at U of T. More recently, he has worked in the area of health policy, and is currently at a Canadian non-profit.
- Jennifer Goldberg
BA, BEd, MA
- Jennifer Goldberg holds an M.A. in History from the University of Toronto. Her graduate studies focused on teacher misconduct in 19th century Ontario, and her research is published in *Historical Studies in Education*. She currently leads the English department and teaches at Havergal College, where she has also served as Chair of Teaching and Learning. In this capacity, she has explored the role of feedback in student learning, and has presented on this work at the National Coalition of Girls' Schools and Conference of Independent Teachers of English.
- Margaret S. Herridge
BSc, MSc, MPH,
MD, FRCPC
- Margaret Herridge is a Professor of Medicine and Senior Scientist at the University of Toronto. She is also a senior clinician in Critical Care and Respiratory medicine at University Health Network. Her research focus is on long-term outcomes after critical illness for patients and families and specifically on functional, neuropsychological, healthcare utilization and quality of life metrics. Her graduate studies were in Cell and Molecular Biology at Queen's University where she subsequently obtained her degree in Medicine. After completing her clinical training in Internal Medicine/Respirology and Critical Care at the University of Toronto, she obtained her Master of Public Health in Epidemiology and Statistics from the Harvard School of Public Health.
- Ted Higginbotham
BSc, MSc
(Candidate)
- Ted Higginbotham is a graduate student at The University of Toronto and Hospital for Sick Children. His research is focused on further delineating the role of genomic structural variation in autism spectrum disorder and human disease. Ted is a contributing member of the Clinical Genome Resource (ClinGen), an international consortium working to define the clinical relevance of genes for use in precision medicine and translational research.
- Tim Hutton
BA, MLIS
- Tim Hutton is a teacher-librarian at Royal St. George's College. He has a BA in History and American Studies from the University of Toronto and a Masters in Library and Information Science from San Jose State University. At the secondary level, he has taught courses in the social sciences, humanities and communications technology, including a locally designed interdisciplinary course in urban studies.

Ira Jacobs

Dip Phys Ed, MHK,
DrMedSc

Professor Ira Jacobs became dean of the Faculty of Kinesiology & Physical Education at the University of Toronto on July 1, 2010, and was re-appointed to his current second decanal term. Before assuming this role, Jacobs was chair of York University's School of Kinesiology and Health Science from 2007 until 2010, and a federal government scientist from 1982 until 2007.

Jacobs earned his doctorate in clinical physiology from Sweden's Karolinska Institute, where he specialized in skeletal muscle metabolism. For the next 25 years, he did extensive exercise physiology research in Canada's human sciences laboratory, operated by the Department of National Defence. There, Jacobs rose to the position of chief scientist and led a unique international research group that helped to enhance the performance of military special operations units through their research into physiological, nutritional and pharmacological strategies.

He is a past president of the Canadian Society for Exercise Physiology and the Canadian Council of University Physical Education and Kinesiology Administrators. He is a fellow of the American College of Sports Medicine, an international fellow of the US National Academy of Kinesiology, and in 2016, he was named a Fellow of the Canadian Academy of Health Sciences.

Jacobs' research has led to the publication of more than 200 scientific articles, reports and book chapters about his research interests that include the physiological responses to physical exertion in environmental extremes, performance enhancement through pharmacological and nutritional manipulation of metabolism, and exercise pharmacology.

During his term as dean, the Faculty of Kinesiology & Physical Education has been rated as among the top academic programs in the world for kinesiology, physical education, sport and exercise sciences.

John Lambersky

BA, MA, BEd, PhD

John Lambersky is a teacher and head of the Canadian and World Studies department at Royal St. George's College in Toronto, where he leads the AP Capstone program. He has presented his work on teaching practice at the conferences of the International Boys' School Coalition, the National Association of Independent Schools, and the Canadian Accredited Independent Schools. His academic research is focused on school culture as a mechanism for school improvement. His work has been featured in *Leadership and Policy in Schools*, *The Dalhousie Review*, and *The Nashawaak Review*.

Blake Lee-Whiting

BA, MPP

Blake Lee-Whiting is a third year PhD student in the Department of Political Science at the University of Toronto. He received his BA from Queen's University and his MPP from the University of Toronto. He is interested in Canadian politics, public policy, and electoral politics. He is a member of the Policy, Elections, & Representation Lab at the Munk School of Global Affairs & Public Policy where he is currently working on projects related to the health of politicians, electoral success, and electoral candidacy.

- Lori Loeb
BA, MA, PhD
- Lori Loeb is Associate Professor of Modern British history at the University of Toronto. She has a Masters in Museum Studies and a PhD in History. A specialist in the Victorian period, she is the author of *Consuming Angels: Advertising and Victorian Women*. Generally, she writes about things in nineteenth-century Britain. A past Deputy Chair and Associate Chair (Graduate) of the History Department, she is currently MA Coordinator. She teaches courses in nineteenth and twentieth-century British history, Victorian material culture and the English country house.
- Jaime Malic
BA (Hons), MA,
BEd, PhD
- Jaime Malic recently completed her PhD in Educational Leadership and Policy at the Ontario Institute for Studies in Education at the University of Toronto. Her research focused on leadership values and practices in independent schools in Ontario. Jaime has more than ten years of experience as an educator in both independent and public schools. She currently teaches AP Capstone Seminar and senior English courses at St. Clement's School. Jaime has served as both a Reader for AP Capstone Seminar and a writer on the Item-Writing Committee for the Ontario Secondary School Literacy Test. She has written for Independent Teacher and presented on various topics at the Conference of Independent Teachers of English Annual Conference, the Ontario Advanced Placement Administration Conference, and the Advanced Placement Annual Conference.
- William J. McCausland
BAsC, MEng, MA,
PhD
- William McCausland is an associate professor of economics at the Université de Montréal. His research applies Bayesian statistical methods in two main areas. The first is discrete choice, at the interface of economics and psychology, where researchers study how people make choices from a small menu of available options. The second is time series modelling in economics, which has many applications in macroeconomics and financial economics. His undergraduate studies were in Engineering and he received his Ph.D. degree in economics from the University of Minnesota.
- Matt Mooney
BEd (Hons), BEd
- Matt Mooney is currently a secondary teacher in the Canadian & World Studies department at Royal St. George's College in Toronto, where he also serves on the Excellence in Teaching and Learning Committee. Matt earned an Honours BA from The University of Toronto, with a double major in History and Geography and his Bachelor of Education from the Ontario Institute for Studies in Education. Matt has been teaching in Ontario for the last 9 years and has experience with curriculum development, such as his work on the Education Committee for Magna Carta Canada. In 2019-2020, Matt helped to oversee the *The Young Researcher*.
- Gurbir Perhar
BSc, PhD
- Gurbir Perhar received his academic training at the University of Toronto. His Doctoral work focused on mathematically modelling the transmission of highly unsaturated fatty acids in aquatic food chains, culminating in a suite of cybernetic models. His post-doc work saw him consulting for the governments of Canada, USA, South Africa, and China. These days Gurbir runs the Data Intelligence strategy in a multi-billion dollar corporation.

Kate Schumaker
MSW, PhD

Kate Schumaker is the Manager of Quality Assurance & Outcome Measurement at the Catholic Children's Aid Society of Toronto, and holds the position of Assistant Professor (status only) at the Factor Inwentash Faculty of Social Work, University of Toronto. She has worked for over 20 years in child welfare and children's mental health, including front-line clinical positions and 10 years producing and implementing child welfare policy for the provincial government. In 2011-12 she worked for the Commission to Promote Sustainable Child Welfare, supporting accountability framework development, including the establishment of a set of standardized performance indicators for the child welfare sector in Ontario. Her areas of practice and research interest include poverty, child neglect, trauma-informed practice, child welfare decision-making, and evidence-informed policy and practice.

Eva Serhal
BA, MBA, PhD

Eva Serhal is the Director of Virtual Mental Health and Outreach at the Centre for Addiction and Mental Health in Ontario, Canada and Director of the ECHO Ontario Superhub, a collaboration between CAMH and UHN that provides training and implementation support to new ECHO telementoring projects throughout Canada. Eva completed a PhD in Health Services Research at the University of Toronto, with a focus on outcomes and evaluation in virtual models of healthcare. Eva's current research assesses the implementation, adoption and economic factors of virtual care in Ontario. Eva also has significant experience with leadership and governance; she currently co-chairs the Toronto Telemedicine Collaborative and sits as a board member of the Children's Aid Society of Toronto.

Michael Simmonds
BPE, M.A., Dip.Ed.,
MEd, EdD

Michael Simmonds has worked in independent schools for over two decades. He taught science, biology, chemistry, physics, and math before becoming an administrator and Head of School. He earned graduate degrees from both McGill and Columbia universities respectively before receiving his doctorate from the University of British Columbia in Educational Policy & Leadership. His work on accountability synopticism is published in the peer-reviewed, *The International Education Journal: Comparative Perspectives*. He currently works at Havergal College as the VP School Life, Operations & Student Wellness.

Sydney Stoyan
B.A, M.A., Ph.D.

Sydney Stoyan holds a B.A. in French Literature from the University of Toronto, and an M.A. and a Ph.D in English Literature from the University of Ottawa. Her doctoral thesis, "The Widow's Might: Law and the Widow in British Fiction, 1689-1792," won the Governor General's Gold Medal for the Arts in 2002. She has since written freelance and worked as an editor for various publications and projects.

Alumni Editors

Nicholas Bethlenfalvy is a third-year student attending Trinity College at the University of Toronto. He graduated from Royal St. George's College in 2018 after studying under the two-year AP Capstone program. In AP Research, he analyzed the root causes of rising pedestrian fatalities in Toronto. After taking the Ethics, Society and Law stream in the Margaret MacMillan Trinity One Program, Nicholas continues to pursue an undergraduate degree in Economics and American Studies at the Munk School of Global Affairs and Public Policy.

Ryan Hamilton is studying History and Peace, Conflict and Justice at the Trudeau Centre at the Munk School of Global Affairs at the University of Toronto. He is a graduate of the Pearson Stream of the Vic One program at Victoria College. He works on the Pratesi Letters with Dr. Anne Urbancic. He is also a graduate of the AP Capstone program at Royal St. George's College, where his research focused on a Canadian battalion in the First World War.

William Howard-Waddingham is a student at Yale University studying political science. He interns with James and Deborah Fallows, authors of the bestselling book *Our Towns*, with whom he is helping to build the Our Towns Civic Foundation (OTCF). OTCF aims to be a forum for collaboration between American communities to discuss and find solutions to local issues overlooked by the federal government in a time of national disunity and political gridlock. He previously interned at the Yale Law School's Schell Center for International Human Rights as a research assistant to Professor Ryan Thoreson. William is interested in international relations, criminal justice reform, human rights, and journalism. He hopes to pursue a career as a human rights lawyer.

Andrew Pyper is a rising third year at the University of Chicago studying economics and political science. He graduated from RSGC in 2018, where he completed the AP Capstone program. His AP Research study examined the student perceptions of the implementation of formative assessment at RSGC and how it compared to the academic literature. At university he continues his education work by helping students at a South Side high school with their transition to college, he researched suicide attacks for the Chicago Project on Security and Threats, he researches and presents on monetary policy proposals at competitions held by the U.S. Federal Reserve, and he participates in numerous business and finance-related organizations.

Guidelines for Contributors

The Young Researcher is a peer-reviewed journal dedicated to publishing the best original research from secondary school students.

The journal's mission is to provide a larger audience for the original academic research of ambitious secondary students, provide a forum for peer-review, and create a community of young researchers. In addition, the journal strives to advance the quality of academic writing in secondary schools.

The Young Researcher is edited by secondary school students working closely with scholars and active researchers at universities and in the community. The journal operates a blind peer-reviewed review process, following those found in academic research journals.

The journal encourages submissions of original research (including relevant replication studies) from a wide range of academic disciplines within the social sciences, humanities, and sciences.

Submission Guidance:

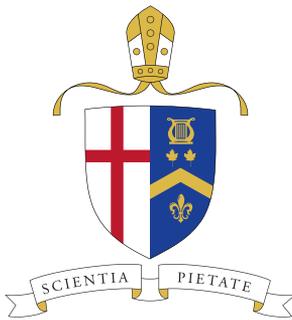
- No more than 5,000 words, excluding references and appendices (in English)
 - Articles should have the following sections or equivalent:
 - Introduction
 - Literature Review
 - Method, Process, or Approach
 - Findings or Results
 - Discussion, Analysis, and/or Evaluation
 - Conclusion and Future Directions
 - References
- Papers should be formatted using discipline-appropriate methods (MLA, APA, and Chicago are acceptable).
- Papers should have an abstract (no more than 150 words) and have 4-6 keywords
- All units of measurement should be in metric wherever possible
- All studies involving human participants must have been approved by a Research Ethics Board

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Please direct any questions to TheEditors@TheYoungResearcher.com



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