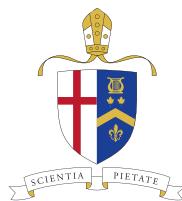


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Table of Contents

- 5 Language Revitalization and Historical Trauma:
A Historical Analysis of the Chickasaw and Chikashshanompa'
Margaret Goodin
- 16 Colorism and Its Correlation with Implicit Racial Stereotyping:
An Experimental Action Research Study
Calla Reed
- 27 National Football League Concussions from 2009 – 2015:
A Secondary Data Analysis
Ethan Kelly
- 37 Examining Portrayals of Female Protagonists by Female Screenwriters Using
Feminist Critical Discourse Analysis
Brooke Shapiro
- 48 Immune Cell Responses to Amyloid-Beta Proteins: What is the Extent and
Implications of Amyloid-Beta Induced Cytotoxicity in Microglial Cells and
Peripheral Blood Mononuclear Cells?
Annie Cao
- 57 My Teacher, My Peers, or Myself?
Hollyn Saliga
- 78 Determining Stress Management Activities for Various Myers-Briggs
Personality Types
Jensen Ghidella
- 99 Operative Utilization of Agricultural Wastes for Amending Pyrolysed
Carbonaceous Feedstock, or Biochar, in a Simulated Unindustrialized
Agricultural Setting
Palmer Short

- 108 An Evaluation of Mental Health Stigma Perpetuated by Horror Video Gaming
Elizabeth G. Dickens
- 118 Is Oklahoma's State-Mandated Minimum Teacher Salary Sufficient? Evidence from 90 Oklahoma Districts
Lia Martin
- 129 An Investigation into the Short Term Effects of Music Therapy for Patients with Probable Alzheimer's Disease or Another form of Dementia
Owen Clute
- 139 Computer Simulation of Genetically Modified *Aedes aegypti* Release Methods
Gregory Schwartz
- 146 Motivation in Pursuing Advanced Degrees in STEM Fields Among Domestic and International Students
Pranshu Adhikari
- 156 Copy Number Variation in Salivary Amylase: A Participant-Based Study on Genetic Variation
Elizabeth Phillips
- 167 Twelve Shades of Green: Contrasting the Environmental Effectiveness of Power Generation Methods in 12 Developed Countries through the Lens of the Electric Vehicle
William Deo
- 176 Comparing Traditional AP Classes to Portfolio AP Classes in Effectiveness of Measuring Knowledge
Leanne Olona
- 194 Contributors, Faculty and Advisors to Contributors, Editors of the Journal, Guidelines for Contributors

Editorial

The Young Researcher holds one belief to be undeniably true: that the pursuit of academic excellence can be achieved despite factors such as age or background. Through a passion for knowledge, determination for improvement, and an adherence to rigorous research processes, young researchers can contribute outstanding work and enhance understanding in an abundance of fields. The purpose of *The Young Researcher* 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. Furthermore, *The Young Researcher* hopes to inspire young scholars to discover their voice, and through a process of diligent research and inquiry, make an impact on society.

Many different fields are represented in this journal, including life sciences, humanities, and social sciences. In these areas of study, *The Young Researcher* is proud to present academic studies held to a peer-reviewed standard. Directly fostered and encouraged are important research questions, rich examination of relevant literature, and nuanced methodologies to satisfy these inquiries. Negative, positive, and inconclusive findings are welcomed by the journal; the most important philosophy being that the researcher has inspected the issue with a dedicated and thoughtful approach.

In an age where truth and integrity appear increasingly difficult to find, *The Young Researcher* is proud to include papers from a community of students who engage in an open dialogue of pertinent issues. When the passion of youth can be combined with a quest for truth, truly remarkable discussions arise.

Please enjoy the papers, and we thank you for engaging in a community that values academic excellence and genuine enthusiasm in the pursuit of improvement.

Welcome to *The Young Researcher*.

The Editors

Isaac Boloten
Owen Clute
Alex Forgay
Owen Holland
Jeffrey Hugessen
Ethan Kelly
Julian Russell
Jesse Wilson

Language Revitalization and Historical Trauma: A Historical Analysis of the Chickasaw and Chikashshanompa'

Margaret Goodin

The Chickasaw experienced many difficulties that hampered their ability to survive as a culturally significant group of people. This paper seeks to examine the connection the Chickasaw have with their unique language and how this strong connection allowed for them to begin a revitalization process to overcome culture destroying hardships. A historical analysis provides a lens for examining the impact of Indian Removal and the boarding school era on the Chickasaw. This research illustrates that resilience and pride for their culture allowed for the language revitalization process to begin. Through this process the Chickasaw have maintained a vibrant culture. However, this research only touches on one aspect of cultural survival. To fully understand this issue it is advisable to analyze other cultural traits that have remained significant despite the historical trauma endured by the tribe.

Keywords: language, Chickasaw, Indian Removal, revitalization, historical trauma, survivance.

Introduction

The loss of language and its impact on culture was one of the most critical of the many trials and tribulations experienced by Native American tribes in the United States during the nineteenth and twentieth centuries. However, many tribes have overcome the difficulties that hindered their continuance. The story of the Chickasaw is one of great sorrow and loss, but also great pride in their heritage and strength as a Nation. This story is passed down from elders to the younger members of the tribe through their traditional language. The language, despite its importance, encountered unforeseen challenges that threatened its existence. This paper serves to highlight how interactions with the federal government would result in many negative implications for the tribe. Additionally, this paper attempts to analyze how the Chickasaw were able to maintain and revitalize their language despite the overwhelming push to rid

the Chickasaw Nation of their tribal characteristics. Because the United States was developing a primarily Eurocentric culture, the culture of Native peoples was frowned upon. Nevertheless, the ongoing spirit of Chickasaw pride has allowed for the continuance of their culture. For many reasons, the Chickasaw Nation was able to remain culturally significant and maintain their unique language through their strong sense of resilience in order to continue the traditions of their ancestors.

Background

The Chickasaw Nation is one of the Five Civilized Tribes, which include the Cherokee, Choctaw, Chickasaw, Seminole, and Creek. Although the Chickasaw is the smallest tribe within this group, they are a thriving tribe that once occupied areas of Mississippi, Alabama, Tennessee, and even small parts of

LANGUAGE REVITALIZATION AND HISTORICAL TRAUMA

Kentucky.¹ However, much of the research shows that the center of this civilization was primarily in Mississippi. Similar to many other tribes in the United States, Chickasaw men were hunters and protected the tribe from harm while the women took care of things around the home and tended to the gardens.²

The Chickasaw had lived in the Mississippi Valley area for many years before they came in contact with European settlers as early as the 16th century when the Spanish explorer Hernando de Soto came to explore the Mississippi Valley.³ After the unconquerable Chickasaw had driven out the Spanish explorers they came in contact with new Europeans. A number of studies have shown that when the French and the English came to the Chickasaw homeland disputes arose between the Chickasaw, who allied with the English, and the Choctaw, who allied with the French.⁴ The hostility that developed between the two allied forces ultimately erupted into attacks on the Chickasaw by the French and the Choctaw. The Chickasaw were able to defend themselves against the French and Choctaw alliance due to the large amount of firepower that was given to them by their English allies.⁵ Despite the numerous raids on the Chickasaw Nation, they remained unscathed and “unconquered.”⁶ The sense of unity and pride resulting from defending their tribe marks the resilience of the Chickasaw, which is a major theme discussed later on in this paper.

Pertinent to the research surrounding Native Americans is the relationship that they developed not only with the European invaders, but also their relationship with the federal government after the formation of the United States. The federal government and Native American tribes developed a hostile attitude

towards one another that had detrimental consequences for Native peoples that have continued into the present. This hostile environment was caused by the large “cultural gap between the two groups [that] was too wide to inspire confidence and trust.”⁷ Basically, Native peoples and the federal government had competing ideas on what they needed and wanted. The United States, at this point, was predominantly white and Christian and perceived itself to be civilized compared to Native Americans who were seen as savage and uncivilized peoples. Because of this, the federal government wanted to acculturate and assimilate Native peoples into American culture. This marked a major shift in the way of life of the tribes considering that the federal government would implement policies causing a great deal of harm to them in the years to come. Central to the implementation of policies that were aimed at erasing Native Americans was the Indian Removal Act of 1830, which is discussed in more detail throughout this paper.

Historical Trauma

The policies imposed on Native American tribes manifested into the historical trauma that affected them in many negative ways. Historical trauma can be described as the “cumulative emotional and psychological wounding, over the lifespan and across generations, emanating from massive group trauma experiences.”⁸ This definition is a crucial idea that is mentioned throughout the scholarly conversation surrounding Native American tribes and what they have endured. The Chickasaw experienced a great deal of historical trauma beginning with their relocation to

1 Brady Davis, Joseph Smith, and Brad R. Lieb. “Chisha’ Tálλaa’ and the Chickasaw Preserve.” *The Journal of Chickasaw History and Culture* 17, no. 1 (Spring, 2015): 30-41.

2 Monte Ross Lewis. “Chickasaw Removal: Betrayal Of The Beloved Warriors, 1794-1844.” Order No. 8208103, University of North Texas, 1981.

3 Ibid. 5.

4 Lewis, “Chickasaw Removal: Betrayal Of The Beloved Warriors, 1794-1844,” 5. Wendy St. Jean. “Trading Paths: Mapping Chickasaw History in the Eighteenth Century.” *American Indian Quarterly* 27, no. 3 (Summer, 2003): 758-780.

5 St. Jean., “Trading Paths: Mapping Chickasaw History in the Eighteenth Century,” 761.

6 Lewis, “Chickasaw Removal: Betrayal Of The Beloved Warriors, 1794-1844,” 6.

7 Vine Deloria Jr. and Clifford M. Lytle. *American Indians, American Justice* (Austin: University of Texas Press, 1983), 6.

8 Maria Yellow Horse Brave Heart. “The Historical Trauma Response among Natives and Its Relationship with Substance Abuse,” *Journal of Psychoactive Drugs* 35, no. 1 (2003): 7.

LANGUAGE REVITALIZATION AND HISTORICAL TRAUMA

Indian Territory. Removal was a crucial component of the historical trauma experienced by the Chickasaw because they were being separated from the land their creator “granted them for their preservation and use.”⁹ Another experience contributing to the trauma the tribe endured were the attacks on their language and identity. The Dawes Act 1887 called for the allotment of tribal lands in Indian Territory.¹⁰ This policy required the creation of tribal rolls and, because the Dawes Commission was in charge of these tribal rolls, the Chickasaw “lost one of their most basic rights--the right to decide their own membership.”¹¹ Because this system was based on the amount of “Indian blood” one possessed, it became evident that the Chickasaw people were being judged based upon “how Chickasaw a person was.”¹² This set a precedent for non-Native people to judge the ethnic identity of Native peoples. Other attacks on the Chickasaw culture included the desire to get rid of the language the Chickasaw spoke to continue to force assimilation so they would fit into the predominantly European culture.

Indian Removal

As noted previously, one of the biggest attacks on Chickasaw culture occurred in 1830 when the Chickasaw Indians, along with other tribes occupying lands east of the Mississippi, were subjected to the terms of the Indian Removal Act, which was implemented by President Andrew Jackson.¹³ This Act called for the removal of all the tribes that occupied lands east of the Mississippi so that the land could be settled by European colonizers. The tribes would be moved to western lands that had been obtained by the United States with the Louisiana Purchase in the early 1800s.

This transfer to new lands caused a great deal of harm to tribes that occupied those lands. The Indian Removal Act of 1830 stated that:

it shall and may be lawful for the President of the United States to cause so much of any territory belonging to the United States, west of the river Mississippi...to which the Indian title has been extinguished...to be divided into a suitable number of districts, for the reception of such tribes or nations of Indians as may choose to exchange the lands where they now reside, and remove there.¹⁴

Importantly, the Act never directly stated that forced removal of Native American tribes was lawful, meaning that the forced removal of the tribes can be seen as an “abuse of presidential power”¹⁵ on Andrew Jackson’s part. As a result of this abuse of power, the Chickasaw, as well as other tribes that occupied land in this area, experienced a great deal of loss that would result in a downward spiral for their culture.

It is important to note, however, that the Chickasaw removal did not occur right when the Indian Removal Act was enacted. It was not until the Treaty of Pontotoc in 1832 that the Chickasaw officially ceded all of their lands to the federal government.¹⁶ The reason for the delay in the removal of the Chickasaw was because they had no desire to leave behind lands that meant so much to them culturally and spiritually.¹⁷ Many Native American tribes have strong connections with the lands they occupy because they have sacred value. This value derives from the idea that the Chickasaw were put in the places they were for a reason as defined within their creation stories. Because the land contributed to a major part of Chickasaw culture, their separation

9 Blue Clark. “Chickasaw Colonization in Oklahoma.” *Chronicles of Oklahoma* 54 (1976): 44–59. Accessed November 13, 2016: 49.

10 “Dawes Act (1887).” www.ourdocuments.gov. November 27, 2015.

11 Amanda J. Cobb. *Listening to Our Grandmothers’ Stories: The Bloomfield Academy for Chickasaw Females, 1852-1949* (Lincoln: University of Nebraska Press, 2000), 69.

12 Ibid., 71.

13 Kari A. B. Chew. “Family at the Heart of Chickasaw Language Reclamation.” *The American Indian Quarterly* 39, no. 2 (04, 2015): 154.

14 “Indian Removal Act: Primary Documents of American History.” Library of Congress. Accessed Dec. 6, 2016

15 Alfred A. Cave. “Abuse of Power: Andrew Jackson and the Indian Removal Act of 1830.” *The Historian* 65, no. 6 (2003): 1330-1353. Accessed November 13, 2016: 1332.

16 Jon T. Kilpinen. “The Supreme Court’s Role in Choctaw and Chickasaw Dispossession*.” *Geographical Review* 94, no. 4 (10, 2004): 484-501.

17 Clark, “Chickasaw Colonization in Oklahoma,” 49.

LANGUAGE REVITALIZATION AND HISTORICAL TRAUMA

from this land was a critical blow to their physical and emotional survivance. Cultural survivance, as it is used here, can be defined as “moving beyond basic survival in the face of overwhelming cultural genocide” to promote revitalization of a culture.¹⁸ This term was developed by Gerald Vizenor in 1999 to characterize the way indigenous peoples struggled to persevere amidst the push toward a predominantly white culture under colonialism.¹⁹

Another reason for the Chickasaw wanting to stay where they were was due to not having been offered land of sufficient value to justify leaving their homeland. Nevertheless, they agreed to do so when they were offered the western portion of the land that the Choctaw lived on in Indian Territory or in what is now present day Oklahoma.²⁰ The Chickasaw relocated to Indian Territory in 1837 in a trek that was known as the “Chickasaw Trail of Tears.”²¹ Because of the trauma that removal imposed on the Chickasaw, small parts of their culture began to dissipate as they lost ties to parts of their traditional culture that had defined them as unique peoples for so many years. Once the Chickasaw tribe arrived in Oklahoma they encountered unforeseen difficulties that continued the harm caused by removal. As indicated previously, these difficulties included encountering resistance to their language and their way of life.

Boarding Schools and Language

An issue of great importance when studying the Chickasaw is looking into the boarding school era and its effect on the tribe. When the Chickasaw arrived in Indian Territory they created their own boarding schools. One such school was known as the Bloomfield Academy for Chickasaw Women, which was run by the Chickasaws with the help of mis-

sionaries.²² Tribal control of the school represented an extreme act of “self-determination” despite living in an era when the federal government had been attempting to rid the United States of Native American cultures while also “threatening their sovereignty.”²³ The notion of Chickasaws running their own schools illustrates how they were trying to better themselves because they knew that being literate would not only make living in Indian Territory much easier but would also help with their survival as a unique group within the United States.²⁴ Despite this attempt by the Chickasaw to make living in Indian Territory easier, they faced much greater problems as the federal government continued the push toward erasing Native American culture by taking over their schools. This culminated in a direct attack on the Chickasaw language resulting in a huge cultural shift.

The cultural shift was due to the Chickasaw language (Chikashshanompa') being seen as a detriment to the survival of the tribe in Indian Territory by both the Chickasaw and the federal government. After struggling with financial disparities, the Chickasaw-run boarding school was taken over by Protestant missionaries who promoted the idea that “English was superior to Indigenous languages.”²⁵ As mentioned previously, this was one of the biggest hardships that the Chickasaw encountered in Indian Territory. Importantly, forbidding the use of indigenous languages is a critical facet of acculturation and assimilation because of the role it plays in cultural erasure. The damaging effects of not being able to speak their traditional language at school or at home are clearly illustrated in the following personal accounts from members of the Chickasaw tribe. One example is from an elder who stated “[w]hen I was young I wasn’t allowed to speak the Chickasaw language even in my own home. That was forbidden. When

18 Chew. “Family at the Heart of Chickasaw Language Reclamation,” 161.

19 Gerald Robert Vizenor. *Manifest Manners: Postindian Warriors of Survivance*. Hanover: Wesleyan University Press, 1994.

20 John Michael Paul. “Collective and Collected Memories: The Construction and Maintenance of Chickasaw Identity.” Order No. 3094071, Oklahoma State University, 2003.

21 Christopher John Aducci. “Itti’at Akka’ Wáyya’Ahookya Ikkobaffo (Trees Bend, but Don’t Break): Chickasaw Family Stories of Historical Trauma and Resilience Across the Generations.” Order No. 3567217, Kansas State University, 2013.

22 Cobb. *Listening to Our Grandmothers’ Stories*, 52.

23 Kari A. B. Chew. “Chikashshanompa’ Ilanompolachi.” *The Journal of Chickasaw History and Culture* (Fall, 2014): 26-29: 29.

24 Cobb. *Listening to Our Grandmothers’ Stories*, 6.

25 Chew. “Family at the Heart of Chickasaw Language Reclamation,” 242.

you went to school you [were] forbidden to speak any other language beside English.”²⁶ Another elder expressed a similar sentiment explaining that “[y]ou had to speak English. They really tried to lose it. Even though we were an Indian school, they tried their best to get rid of all the Indian aspects. They were trying to modernize us.”²⁷

The belief in the superiority of English over traditional tribal languages was not the only reason for the Chickasaw language falling out of popularity among the Nation’s people. A recurring theme throughout the literature expressed how learning English would make the members of the tribe better off politically, economically, and socially.²⁸ This idea spread throughout much of the tribe causing many members to become bilingual, which severely disrupted the passing down of Chikashshanompa’ while also making many Chickasaw children English speakers only.²⁹ Another reason the Chickasaw lost control of their boarding schools was the desire of white settlers to exert influence over all areas of Native life that they possibly could. This occurred as the federal government continued to promote policies that completely took away Indian lands so settlers could move onto those lands once occupied by tribes.

This push came in full force in 1898 with the passage of the Curtis Act, which sought to bring tribal governments to an end.³⁰ In 1906 the Chickasaw lost complete control of their boarding schools and finally realized they were fighting “a battle they had no hope of winning.”³¹ Once tribal governments had been eliminated and boarding schools were controlled by missionaries and the federal government, full assimilation and acculturation seemed imminent. The fact that some boarding schools, such as the Carlisle

Indian Boarding school, adopted the mantra “kill the Indian, save the man”³² speaks to this issue. This continued to cultivate the idea that Native Americans were inferior to the white population while also explaining why the European society sought to destroy everything Native Americans had built as culturally significant bodies of people. Hence, a common theme acknowledged among many researchers examining the boarding school era is that the federally-run boarding schools represented the creation and maintenance of a “white supremacist settler society.”³³ This form of Eurocentric society continues to cause difficulties for Native Americans and hampers their ability to survive even today.

Method

In order to gain a better understanding of how the Chickasaw were able to maintain a unique culture despite their trauma, conducting a historical analysis of the tribe was crucial. Choosing an aspect of the Chickasaw culture in which there was continuity and maintenance was important for my research and, ultimately, lead me to research surrounding the Chickasaw language.

A similar study was conducted by Dr. Amanda Cobb³⁴ who looked at the boarding school era. Specifically, she looked at the Bloomfield Academy for Chickasaw Females and compiled stories from the women who attended while also discussing what happened historically. Cobb’s study was a good model because it used historical analysis as well as providing information useful for my own research. Overall, her study gave my study a starting point and provided

26 Aducci. “Itti’at Akka’ Wáyya’Ahookya Ikkobaffo (Trees Bend, but Don’t Break), 66.

27 Ibid, 66.

28 Chew. “Chikashshanompa’ Ilanompolachi.” Jenny L. Davis. “Language Affiliation and Ethnolinguistic Identity in Chickasaw Language Revitalization.” *Language & Communication* 47, (03, 2016): 100. Ivan Camille Ozbolt. *Community Perspectives, Language Ideologies, and Learner Motivation in Chickasaw Language Programs*. PhD diss., University of Oklahoma, 2014.

29 Davis. “Chisha’ Tálla’á and the Chickasaw Preserve,” 102.

30 Cobb. *Listening to Our Grandmothers’ Stories*, 115.

31 Cobb. *Listening to Our Grandmothers’ Stories*, 67.

32 Lindsay Peterson. “Kill the Indian, Save the Man,” *Americanization through Education: Richard Henry Pratt’s Legacy*. Master’s thesis, Colby College, 2013. 1-104: 86.

33 Michelle Malathi Iyengar. “Not Mere Abstractions: Language Policies and Language Ideologies in U.S. Settler Colonialism.” *Decolonization: Indigeneity, Education & Society* 3, no. 2, 33-59. Accessed November 6, 2016: 36.

34 Cobb. *Listening to Our Grandmothers’ Stories*

LANGUAGE REVITALIZATION AND HISTORICAL TRAUMA

direction for determining what sources I would need to answer my research question pertaining to the significance of language to Chickasaw survivance.

Considering the fact that my research was qualitative, it was imperative for me to gather primary documents that would help shape my research. For the purposes of my study, this meant looking into the Indian Removal Act of 1830, which allowed me to understand when the issue with the loss of Chickasaw culture first arose. I also spent time looking through other treaties and acts, such as the Curtis Act and the Dawes Act.³⁵ In addition to consulting these primary documents, I looked through firsthand accounts of members of the Chickasaw Nation who spoke the Chickasaw language or had been around other people who spoke the language. These accounts were an integral part of my research for several reasons. They allowed me to understand not only the historical context surrounding the loss of language and its impact on culture, but also how members of the tribe felt about revitalizing their language to assure the persistence of their culture. Such a focus was crucial for my research since it provided a unique perspective that could not be found in secondary sources with their broader analysis of the historical situation surrounding the Chickasaw.

After gathering several sources that analyzed firsthand accounts, I examined sources that analyzed historical trauma and the boarding school era. This allowed me to connect the firsthand accounts with the bulk of the research on my topic. The purpose of my study was to continue the larger discussion on the Chickasaw and their culture and explain *how* they were able to maintain such a unique language and preserve their culture despite the attacks and trauma imposed on them.

Sources critical to this research were accessed using tools from Norman High School and the University of Oklahoma. The information was important in elucidating the relationship that the Chickasaw Nation developed with Europeans and the federal government and how interactions impacted Chickasaw culture. Most of my primary documents came from academic search engines, such as EBSCO and

ProQuest, as well as books that were gathered from the Western History Collection at the University. Usage of databases, such as EBSCO and ProQuest, allowed for scholarly peer-reviewed information to be collected with great ease. Because my research was historical, it was inevitable that there would be some amount of bias present within the research. However, the use of academic search engines allowed for the collection of sources that looked at my topic from multiple perspectives, which provided some balance albeit not eliminating bias altogether. Bias was very important to recognize because historical research often comes from a western perspective, thus sources that offer dissenting opinions, including Native voices, are needed to create a broader understanding of cultural survivance.

Discussion

The concept of cultural survivance is not unique to the Chickasaw. Rather, it is a recurring theme throughout many Native American tribes. The Chickasaw Nation is one of many tribes that exhibit the traits of cultural survivance in a country where their culture was deemed unacceptable and frowned upon by many. But even in the face of Indian Removal and the boarding school era, the Chickasaw have maintained a unique culture that was aided by the revitalization of their language and the creation of programs to help it grow. The majority of the research supports the claim that the Chickasaw have a unique culture today, but there is a lack of information regarding how this maintenance took place during a shift toward a white settler society.

Recall that cultural survivance means more than surviving; rather it speaks to overcoming issues such as forced acculturation and assimilation in order to preserve and revitalize a culture.³⁶ This is relevant when discussing the Chickasaw because, before being uprooted and moved to Indian Territory, they defined themselves as “fierce defenders of their homeland” and believed that they were “unconquered peoples.”³⁷ This idea illustrates the massive amount of resilience

35 “Dawes Act (1887).” Cobb. *Listening to Our Grandmothers’ Stories*. 115.

36 See note 18 referring to cultural survivance as defined by Gerald Vizenor.

37 St. Jean Remaining Chickasaw in Indian Territory, 1.

LANGUAGE REVITALIZATION AND HISTORICAL TRAUMA

that is present among the Chickasaw people. Defending their culture and revitalizing their language shows how the Chickasaw were able to maintain their culture. Though resilience has been a common theme throughout much of the research, the connection between it and the ability of the Chickasaw to revitalize their unique language has not been made. But in order to understand how the Chickasaw were able to revitalize their language against daunting odds, this connection must be made.

Because of the trauma that was forced upon the Chickasaw Nation by Indian Removal and the boarding school era, the disappearance of culture became a threat that loomed above them. However, despite the threat of disappearance, the Chickasaw exerted a strong sense of pride and familial strength in order to move past the detrimental effects of the aforementioned issues. There have been many studies conducted that serve to analyze the state of the Chickasaw culture. One such study involved interviews of members of the Chickasaw Nation who said that despite the attacks made by “mainstream U.S. culture” that were intended to wreak havoc on their tribe, their “pride in their heritage” has not diminished.³⁸ Pride in their culture is not something that is entirely unique to the Chickasaw, much like the concept of cultural survivance is not unique to them. However, the significance of their resilience and pride does not stem from its uniqueness. Rather it is highlighted by the fact that despite their experiences, they have maintained a bustling culture and made it known that their people have been here for generations and they are going to continue to uphold the values of their traditional culture.³⁹ They have remained a culturally significant body through their resilience and resistance against the white culture being thrust upon them.

The resilient nature of the Chickasaw goes hand and hand with their identity and how they choose to define themselves and their culture. Their culture stems primarily from their unique language,

Chikashshanompa’. As mentioned earlier, the boarding school era posed a very large threat to the language because Chickasaw boarding schools were being taken over by European missionaries. This meant that the predominance of English as a first language would take over. This is something that cannot be ignored when looking at the Chickasaw Nation because “language is the vortex from which the Chickasaw culture evolves” and taking that away could cause the identity of the tribe to disappear with it.⁴⁰ Since the Chickasaw had been moved to a land that was completely foreign to them, language was one thing that remained constant. Unfortunately, this was slowly being taken from them as well.

Overcoming the idea that their language and culture was inferior to that of the Europeans was difficult for the Chickasaw because they no longer had as much control over their lives as they had in their homeland. During this time, it became evident to elders that their people were beginning to “[cover] themselves with the security blanket of modern life created by European settlers” in order to have prosperity in the future that they now believed came from speaking English.⁴¹ The elders and ancestors of the tribe, upon whom the descendants rely, were becoming disheartened and frightened with the disappearance of their language and identity as an individual nation that was once separate from that of the European settlers.

Continuing to expand on the identity and language of the Chickasaw, it is of utmost importance to recognize that because a written form of their language did not exist, everything about the tribe was passed down through oral transmission from elders to the youth of the tribe.⁴² If the traditional language was lost, much of the information about the tribe could not be passed down to the younger generations, meaning oral traditions could not be carried on. Essentially, the existence of the Chickasaw culture as a whole was on the verge of diminishing. However,

38 Zermarie Deacon, PhD., Joy Pendley PhD., Waymon R. Hinson PhD., and Joshua D. Hinson M.A. “Chokka-Chaffa’ Kilimpi’, Chikash-shiyaakni’ Kilimpi’: Strong Family, Strong Nation.” *American Indian and Alaska Native Mental Health Research (Online)* 18, no. 2 (2011): 41-63.

39 Mark Francis. “Preservation through Education.” *The Journal of Chickasaw History and Culture* 12, no. 2 (Spring, 2010): 52-61.

40 Ibid, 54.

41 Ibid, 53.

42 Arrell M. Gibson. “Chickasaw Ethnography: An Ethnohistorical Reconstruction.” *Ethnohistory* 18, no. 2 (1971): 99-118.

LANGUAGE REVITALIZATION AND HISTORICAL TRAUMA

this brings back the idea of resilience and the ability of the tribe to continue speaking the language in spite of the overwhelming push to leave it behind and speak English. This, in more ways than one, illustrates an incredible act of resistance against conforming to the beliefs of the European settlers.⁴³ This continues to highlight the connection between the resilience of the tribe and their unique language while also introducing the important influence that the beliefs of the elders have on the tribe and its continuance. Due to the importance of language to Chickasaw identity, recognizing the need to continue speaking their Native language would prove to be a major turning point in terms of language preservation. Specifically, tribal members realized the importance of keeping their language alive as a means for assuring the continuance of a vibrant culture.

This realization helped spark the revitalization process and thus helped save the unique identity of the Chickasaw. This marked a major shift in the lives of many of the Chickasaw as they became aware that as the number of traditional speakers decreased there was a simultaneous decrease in their cultural presence. The Chickasaw Nation discussed how in 1994 it became evident that there were less than 1,000 people who spoke the Chickasaw language fluently and today that number is significantly lower, standing at only 75 speakers, all of whom are elders.⁴⁴ This is something that could not be ignored by the Chickasaw because, as mentioned previously, the Chickasaw language is central to their identity and must be maintained if future speakers of the language will exist to pass on the stories of the ancestors. These frightening numbers spawned the process of language revitalization throughout the Chickasaw Nation.

While not a formal recognition of the need for language revitalization programs, in 1973 the first Chickasaw dictionary was published after the Chickasaw governor, James Overton, realized his people believed that Chikashshanompa' had little value or

significance in today's society.⁴⁵ These views had been present since the boarding school era when speaking of the Chickasaw language was strongly discouraged. While the creation of the Chickasaw dictionary represented a major step in the right direction for the revitalization and maintenance of their unique language, it was not the only way the Chickasaw sought to revitalize their language. Over the years the Chickasaw created programs that would aid the process of language revitalization. However, the need to expedite this process became even more pressing with the recognition of the extensive loss of Native speakers in 1994 as indicated previously. In 2007, the tribe created the Chickasaw Language Revitalization Program that offers a master-apprentice program in which a non-fluent speaker is paired with a fluent speaker who helps them learn how to speak the traditional Chickasaw language.⁴⁶ This was a step in the right direction for the Chickasaw because it has allowed for the creation of more fluent speakers of the language. The Revitalization Program also provides a program known as Chipota Chikashshanompoli or "Youth Speaking Chickasaw," which teaches children to speak their language through traditional means such as song.⁴⁷ This program is very beneficial for the tribe because it allows for the continuance of the Chickasaw culture into future generations. The final revitalization tool open to the Chickasaw Nation is Rosetta Stone, which was made available to the tribe in 2016.⁴⁸ These programs allow for members of the Chickasaw Nation to have a stronger connection to their tribe through Chikashshanompa'.

In addition to the programs offered to members of the Chickasaw Nation, there are programs and tools that non-members of the Chickasaw Nation can use as well. The Chickasaw Nation has created the "Chickasaw Language Basics app" that teaches the Chickasaw language and provides songs and videos that are available to anyone via download or internet access.⁴⁹ Having an app that is open to the public is

⁴³ Chew. "Chikashshanompa' Ilanompolačhi," 26.

⁴⁴ "Language." Language: Chickasaw Nation. February 3, 2016. Accessed March 13, 2017.

⁴⁵ Chew. "Chikashshanompa' Ilanompolačhi," 28.

⁴⁶ "Language." Language: Chickasaw Nation.

⁴⁷ Ibid.

⁴⁸ Ibid.

⁴⁹ Ibid.

important for the Chickasaw because it allows even those who are not part of the Chickasaw Nation to see the value and significance of the culture.

The creation of these programs and revitalization all stem from the resilience of the tribe and their desire to remain significant. People have acknowledged that “the fact that the tribe still has speakers and is trying so hard to preserve its language is inspirational and testifies to the resilience of the Chickasaws.”⁵⁰ This idea is something that rings true for many members of the Chickasaw Nation because, despite the hardships that their ancestors may have endured, they have overcome those difficulties and revitalized a flourishing culture through their resiliency. They believe that they have a responsibility to defend the nation and culture that their ancestors died protecting and it is important to make sure that their culture survives well into the future.⁵¹

Limitations and Future Directions

Understanding the unique connection between language and identity, and Chickasaw resilience was not an easy task. This was because many sources discussed the Chickasaw in relation to other Nations, especially those that mentioned Indian Removal. The Chickasaw, as well as many other Native American tribes in the United States, tend to be grouped together and not looked at separately. This made finding sources solely about the trauma the Chickasaw endured difficult. In addition, some of the sources that could have been beneficial to this research could only be accessed if purchased.

Another limitation within this research is the fact that it was based solely upon written information that was used to make connections about certain ideas, such as the importance of cultural diversity within the Eurocentric society. While this alleviated some of the bias within the research, sources that highlight the cultural presence of the Chickasaw tend to be slightly biased toward the Native Americans and do not excuse the actions of the federal government. Additionally, it is important to recognize personal bias.

Because the researcher is Native American, it is important not to let personal passion for the topic stand in the way. It was imperative that this bias was kept to a minimum throughout the paper.

Nevertheless, this paper serves to add to the ongoing and fruitful conversation surrounding the Chickasaw and their unique culture. Although mentioned throughout much of the research, the connection between the revitalization of their language despite trauma is not explicit. In order to continue this discussion, it is recommended that researchers analyze the continuance of other cultural traits that contribute to the Chickasaw identity. It could also be beneficial for future researchers to attempt to interview tribal members so that the researcher can gain personal accounts for their study. Continuing this conversation will help to highlight the unique culture that the Chickasaw exhibit and the important role they play in preserving the history of the United States.

The implications of this research are that it can open dialogue and encourage others to think about the many ways diverse cultures have helped shape the United States and make it the nation that it is today. Opening up dialogue on this topic could allow for more people to desire to preserve and learn about the Native cultures that make up the United States. This would help to highlight the idea that the United States is dynamic and ever changing based on complex interactions between many different cultural backgrounds.

Conclusion

Research on the Chickasaw and their language highlighted unique connections that are somewhat ignored throughout much of the literature. This paper served to shed some light on how the Chickasaw have maintained their language despite the constant effort of the federal government to eradicate it. Much of what is discussed about Native Americans does not highlight their significant contribution to the culture of the United States today. The purpose of this research was to add to the ongoing conversation surrounding the Chickasaw Nation and their strength

50 Ozbolt. *Community Perspectives, Language Ideologies, and Learner Motivation in Chickasaw Language Programs*. 117.

51 Paul. “Collective and Collected Memories: The Construction and Maintenance of Chickasaw Identity,” 144.

LANGUAGE REVITALIZATION AND HISTORICAL TRAUMA

as a tribe. The revitalization programs started by the tribe have allowed them to take small steps in the right direction toward showing that their presence should not be ignored. Language is only one of many cultural traits that is significant to the identity of the tribe. In order to continue this conversation other cultural traits must be examined. The issues surrounding the Chickasaw Nation are also important to recognize because Native American tribes have helped shape the cultural landscape of the United States and it is imperative that it be preserved. As a final note, despite the tribulations that the Chickasaw have encountered, their resilience and strength has not skipped a beat and will only continue to grow as the tribal members, as well as others, continue to uplift their culture and continue to define not only their Nation, but that of the United States as well.

References

- Aducci, Christopher John. "Itti'at Akka' Wáyya'Ahookya Ikkobaffo (Trees Bend, but Don't Break): Chickasaw Family Stories of Historical Trauma and Resilience Across the Generations." Order No. 3567217, Kansas State University, 2013. <http://search.proquest.com.ezproxy.lib.ou.edu/docview/1519509001?accountid=12964>.
- Cave, Alfred A. "Abuse of Power: Andrew Jackson and the Indian Removal Act of 1830." *The Historian* 65, no. 6 (2003): 1330-353. Accessed November 13, 2016. <http://web.b.ebscohost.com.ezproxy.lib.ou.edu/ehost/pdfviewer/pdfviewer?sid=4af301d2-0ad4-4329-b60c-7b10fdc90567%40sessionmgr102&vid=9&hid=125>
- Chew, Kari A. B. "Chikashshanompa' Ilanompola'chi." *The Journal of Chickasaw History and Culture* (Fall, 2014): 26-29. <http://search.proquest.com.ezproxy.lib.ou.edu/docview/1681428614?accountid=12964>.
- Chew, Kari A. B. "Family at the Heart of Chickasaw Language Reclamation." *American Indian Quarterly* 39, no. 2 (Spring, 2015): 154-179,242. <http://search.proquest.com.ezproxy.lib.ou.edu/docview/1665111789?accountid=12964>
- Clark, Blue. "Chickasaw Colonization in Oklahoma." *Chronicles of Oklahoma* 54 (1976): 44-59. Accessed November 13, 2016. https://works.bepress.com/cblue_clark/10/
- Cobb, Amanda J. *Listening to Our Grandmothers' Stories: The Bloomfield Academy for Chickasaw Females, 1852-1949*. Lincoln, NE: University of Nebraska Press, 2000.
- Davis, Brady, Joseph Smith, and Brad R. Lieb. "Chisha' Tálla'a' and the Chickasaw Preserve." *The Journal of Chickasaw History and Culture* 17, no. 1 (Spring, 2015): 30-41. <http://search.proquest.com.ezproxy.lib.ou.edu/docview/1785283294?accountid=12964>.
- Davis, Jenny L. "Language Affiliation and Ethnolinguistic Identity in Chickasaw Language Revitalization." *Language & Communication* 47, (03, 2016): 100.
- "Dawes Act (1887)." www.ourdocuments.gov. November 27, 2015. <http://www.ourdocuments.gov/doc.php?flash=true&doc=50>
- Deacon, Zermarie, PhD, Joy Pendley PhD, Waymon R. Hinson PhD, and Joshua D. Hinson M.A. "Chokka-Chaffa' Kilimpi', Chikashshiyakni' Kilimpi': Strong Family, Strong Nation." *American Indian and Alaska Native Mental Health Research (Online)* 18, no. 2 (2011): 41-63.
- Deloria, Vine, Jr., and Clifford M. Lytle. *American Indians, American Justice*. Austin, TX: University of Texas Press, 1983.

LANGUAGE REVITALIZATION AND HISTORICAL TRAUMA

- Francis, Mark. "Preservation through Education." *The Journal of Chickasaw History and Culture* 12, no. 2 (Spring, 2010): 52-61. [https://search-proquest.com.ezproxy.lib.ou.edu/docview/635853981?accountid=12964](https://search-proquest-com.ezproxy.lib.ou.edu/docview/635853981?accountid=12964).
- Gibson, Arrell M. "Chickasaw Ethnography: An Ethnohistorical Reconstruction." *Ethnohistory* 18, no. 2 (1971): 99-118.
- "Indian Removal Act: Primary Documents of American History". Library of Congress. Accessed Dec. 6, 2016 <https://memory.loc.gov/cgi-bin/ampage?collId=llsl&fileName=004/llsl004.db&recNum=458>
- Iyengar, Malathi Michelle. "Not Mere Abstractions: Language Policies and Language Ideologies in U.S. Settler Colonialism." *Decolonization: Indigeneity, Education & Society* 3, no. 2, 33-59. Accessed November 6, 2016. <http://decolonization.org/index.php/des/article/view/19559/17835>
- Kilpinen, Jon T. "The Supreme Court's Role in Choctaw and Chickasaw Dispossession*." *Geographical Review* 94, no. 4 (10, 2004): 484-501. <http://search.proquest.com.ezproxy.lib.ou.edu/docview/225329945?accountid=12964>.
- "Language." *Language: Chickasaw Nation*. February 3, 2016. Accessed March 13, 2017. <https://www.chickasaw.net/Our-Nation/Culture/Language.aspx>.
- Lewis, Monte Ross. "Chickasaw Removal: Betrayal Of The Beloved Warriors, 1794-1844." Order No. 8208103, University of North Texas, 1981. <http://search.proquest.com.ezproxy.lib.ou.edu/docview/303171037?accountid=12964>.
- Ozbolt, Ivan Camille. *Community Perspectives, Language Ideologies, and Learner Motivation in Chickasaw Language Programs*. PhD diss., University of Oklahoma, 2014.
- Paul, John Michael. "Collective and Collected Memories: The Construction and Maintenance of Chickasaw Identity." Order No. 3094071, Oklahoma State University, 2003. <http://search.proquest.com.ezproxy.lib.ou.edu/docview/305244748?accountid=12964>.
- Peterson, Lindsay. "Kill the Indian, Save the Man," *Americanization through Education: Richard Henry Pratt's Legacy*. Master's thesis, Colby College, 2013. 1-104. <http://digitalcommons.colby.edu/honortheses/696>
- St. Jean, Wendy. *Remaining Chickasaw in Indian Territory, 1830s-1907*. Tuscaloosa, AL: University of Alabama Press, 2011.
- St. Jean, Wendy. "Trading Paths: Mapping Chickasaw History in the Eighteenth Century." *American Indian Quarterly* 27, no. 3 (Summer, 2003): 758-780. <http://search.proquest.com.ezproxy.lib.ou.edu/docview/216852210?accountid=12964>.
- Vizenor, Gerald Robert. *Manifest Manners: Postindian Warriors of Survivance*. Hanover: Wesleyan University Press, 1994.
- Yellow Horse Brave Heart, Maria. "The Historical Trauma Response among Natives and Its Relationship with Substance Abuse," *Journal of Psychoactive Drugs* 35, no. 1 (2003): 7. <http://dx.doi.org.ezproxy.lib.ou.edu/10.1080/02791072.2003.10399988>

Colorism and Its Correlation with Implicit Racial Stereotyping: An Experimental Action Research Study

Calla Reed

This study examined the correlations between implicit racial stereotyping and colorism and their roles in society. Using Fitzpatrick's Skin typing scale and animated facial software, this study used a mixed method approach to examine participants' reactions to stimuli in the context of colorism and implicit racial stereotyping. In addition, participants offered responses to explicit response open-ended questions concerning colorism and racial stereotyping. The findings revealed that color-blind ideology, exposure, and education displayed participants' knowledge of explicit examples of racial stereotyping, but excluded their knowledge of critical implicit racial stereotyping and colorism. Implications are provided.

Keywords: colorism, racial stereotyping, implicit response, color-blind ideology, education, exposure

While explicit forms of racism have been the focus of many academic and socio-progressive movements, such as the Civil Rights Movement, implicit forms of racism are also prevalent and harmful in our society. Once used as a socio-economic tool to categorize slaves, enforce racial etiquette, and support segregation laws, implicit forms of racism, especially colorism and implicit racial stereotyping, are forms of racism that often go unknown and unnoticed by the general public (Arboleda, 2011; Exhibit, 2016; Greenwald, Banaji, & Nosek, 1998). Colorism, defined as the "Prejudice or discrimination against individuals with a dark skin tone, typically among people of the same ethnic or racial group" ("Colourism", n.d.), and racial stereotyping, defined as "a standardized mental picture that is held in common by members of a group and that represents an oversimplified opinion, prejudiced attitude, or uncritical judgment" ("Stereotype", n.d.)

can both be found between and within racial/ethnic groups, making implicit racism a prevalent issue in our society. This implicit racism often negatively affects an individual's emotional, economic, and social status (Duke & Berry, 2011; Norwood, 2014; Hunter, 2005), leading to the following inquiry: How and in what ways are colorism and implicit racial stereotyping correlated in a multicultural society such as the United States?

Literature Review

Implicit Racism

Significant evidence suggests that implicit forms of racism, such as colorism and implicit racial stereotyping, are currently more socially prevalent and seen as more socially acceptable than explicit forms of

COLORISM AND ITS CORRELATION WITH IMPLICIT RACIAL STEREOTYPING

racism. Danel (2012), Walker (2008), and Stepanova (2009) each examined implicit responses and stereotyping in reaction to varying racial phenotypicality and skin tones. The results found that Polish and Scottish participants strongly preferred phenotypicality which resembled the features present in their own ethnic population (Danel, 2012), while South Asian and European American participants both preferred European Americans' phenotypicality over South Asians' phenotypicality (Walker, 2008). Similarly, both European American and African American participants negatively stereotyped African American phenotypicality and skin tones when it was compared to Eurocentric phenotypicality and skin tones (Stepanova, 2009). These studies assert that colorism often relates negatively to implicit racial bias and stereotyping, both within and between various racial and ethnic groups.

Polyhart (2004), Kelly (2004), and Breland (1998) each examined the implicit perceptions and stereotypes associated with African Americans while administering a basic knowledge test. The results of the study found that out of African American and European American participants, the African American participants scored higher on average but were perceived by both the European Americans and themselves as scoring lower (Polyhart, 2004). Concerning African American participants of varying skin tones, the African American participants with darker skin tones were perceived as doing worse than the African American participants of lighter skin tones (Kelly, 2004). A separate study found similar results, reasserting the claim that African American participants of darker skin tones were perceived as having lower intelligence than African American participants of lighter skin tones (Breland, 1998). These studies found that negative implicit stereotypes are not only seen in interracial colorism, but also prevalent within ethnic and racial communities, especially between individuals with varying skin tones.

Correlations within Implicit Racism

While the majority of studies focus only on examining explicit racism or implicit racism, few studies address the direct correlations between implicit aspects of racism. McLallen et.al (2006) examined color bias and its influence over implicit racial bias, by ex-

amining implicit responses to an Implicit Association Test of binary colors (black and white) and an Implicit Association Test of ethnic and non-ethnic names (popular African American and European American names). The results of the study found that racial bias and racial preferences are connected to an implicit, learned preference for lighter colors over darker colors - the definition of colorism. Some evident limitations of the study are that it only includes European Americans in its final results, despite the fact that varying minorities participated in the study. Another limitation of the study is that it only discussed the implicit racial and color biases concerning black and white binary colors or European Americans and African Americans.

Even fewer studies directly address colorism and racial stereotyping. Clark & Clark (1947) conducted a series of experimental surveys from the 1930s—1950s, which showed the effect of colorism on young children, who continually chose the lighter doll as opposed to the darker doll. When they were asked why, the children made statements that supported their associations between the negative, explicit racial stereotypes, which were rampant in society at the time, and the darker skin tone of the doll. One limitation with the study that arises when applying it to modern society is that children were the sole participants, which allowed for only a restricted number of questions and procedures to take place. Another limitation is that there was a severe limitation of two skin tones that were tested, with only a pale white doll and a dark brown doll used as stimuli, as opposed to the various shades of skin tones present in our modern, and increasingly diverse, society.

Present Research

In summary, although explicit forms of racism are still being combated and reduced, implicit forms of racism, especially concerning colorism and implicit racial stereotyping, are prevalent and also need to be addressed as an issue in our society, in part by increasing awareness. The current study is a modern adaptation of the Clark and Clark (1947) study, in order to re-examine the problem of implicit racism in our society, and does so by examining implicit responses to colorism and racial stereotyping in working-age adults.

Method

Implicit Response

Having chosen a mixed, action research method in order to effectively examine the correlation between racial stereotyping and colorism, the current study primarily collected implicit reactions, emotions, and comments in a survey format. Implicit response was examined, as opposed to explicit response, because, “implicit bias is tested as a less controllable measure of other-race attitudes” (Walker & Hewstone, 2008), stating that implicit biases, especially those concerning sensitive and stigmatized topics, such as race, are more revealing of the individual’s true opinions than explicit attitudes and biases. To create implicit responses, participants were timed at 12 minutes, for the survey, which had a total of 33 questions. I decided to utilize QuestionPro survey software, once I was given a student research scholarship, in order to administer the survey.

Data Collection

I collected data determining if there is a preference for lighter skin tones over darker skin tones (while accounting for the variable of the participants’ race/ethnicity), and I also collected data stating that the bias for skin tones has a correlation with implicit racial stereotyping. Due to the ethical concerns regarding studies with human subjects, I received approval from the Institutional Review Board. Participants will also be asked to explicitly discuss their experiences and feelings of being racially stereotyped or concerning colorism, and this will help assert that colorism and racial stereotyping continue to be prevalent in society. The Clark Doll Experiment shares similar goals as the present study, which is to examine the correlations between colorism and negative stereotypes (Clark & Clark, 1947).

Baseline Test

The baseline test was created in order to compare the implicit results to a set standard. This test was inspired by a study in *Black and White: The Role of Color Bias in Implicit Race Bias*, where the “color names were judged, from positive to negative, as white, yel-

low, red, brown, and black, and evaluations of racial categories made a separate group of participants were ordered similarly from positive and negative as Caucasian (White), Oriental (Asian), American Indian (Native American), Asian Indian, and Negro (Black)” (McLallen et al., 2006).

The baseline test consists of six varying skin tones from the Fitzpatrick skin-typing test (Figure 1) which is a modern scale of skin tones used by dermatologists to determine the amount of SPF (Sun Protection Factor) needed, due to ultra-violet light exposure and the level of melanin present in the skin (“Know your Skin Type”, 2016). Participants were asked to implicitly rate each skin tone on a scale, ranging from ‘Strongly Dislike’ to ‘Strongly Like’. Each participant was matched to a skin tone on the Fitzpatrick skin-typing test by the researcher in order to allow for additional correlations between the individual’s skin tone and their views on other skin tones. The skin tone categories are defined as the following: Light skin tones (Types I and II), medium skin tones (Types III and IV), and dark skin tones (Types V and VI) (Figure 1).

Animated Faces Test

The Animated Faces Test was created in order to examine implicit racial stereotyping using realistic stimuli. The current study was inspired by an experiment in *Making of a Face: Role of Facial Physiognomy, Skin Tone, and Color Presentation Mode in Evaluations of Racial Typicality*, where the researchers “controlled and modified the variables of skin tone, slight facial feature variations, and color presentation in a panel of Eurocentric faces, low facial variation of Afrocentric faces and high facial feature variation of Afrocentric faces; this concludes that color perception plays an important role in facial categorization and is critical to the study of prejudice and stereotyping” (Stepanova & Strube, 2009, p. 69). Using MakeHuman software, an open source software program that creates realistically animated faces, I created animated facial stimuli that have slightly varying ethnic features and a dark, medium, and light skin-tone for each animated face. Each animated face varied, with 1.1-1.3 (Figure 2) possessing completely African features and 75% male features, 2.1- 2.3 possessing completely African features and 75% female fea-

tures with a thinner nose width, and with 3.1-3.3 possessing African, Asian, and Caucasian characteristics with a smaller lips and a smaller forehead.

Each facial series had all of the three varying skin tones, with 1.1, 2.1, and 3.1 possessing the light skin-tone; 1.2, 2.2, 3.2 possessing the medium skin-tone, and 1.3, 2.3, 3.3 possessing the dark skin-tone. All of the animated faces were defaulted at twenty-five years of age, and without facial hair and eyebrows. Additionally, the default eyes for all the faces are a light-brown color, as this eye color is prevalent across the majority of races and ethnicities, and each face had a neutral expression. These features were chosen because these facial aspects have been known to significantly influence the results of studies regarding race. The participants were each shown the animated faces and asked to associate one of the eight adjectives, four negative and four positive, from the Project Implicit Skin-tone Implicit Association Test (Greenwald, Banaji & Nosek, 1998) with the animated face. Participants also had the option to give their own adjective to accurately describe the face.

Hypotheses

For the Baseline Test, which examines participants' response to skin tone stimuli in order to simulate colorism, I hypothesized that the majority of adult participants will associate the darker skin tones (Types V and VI) with negative adjectives, despite the individual's racial or ethnic background and personal skin

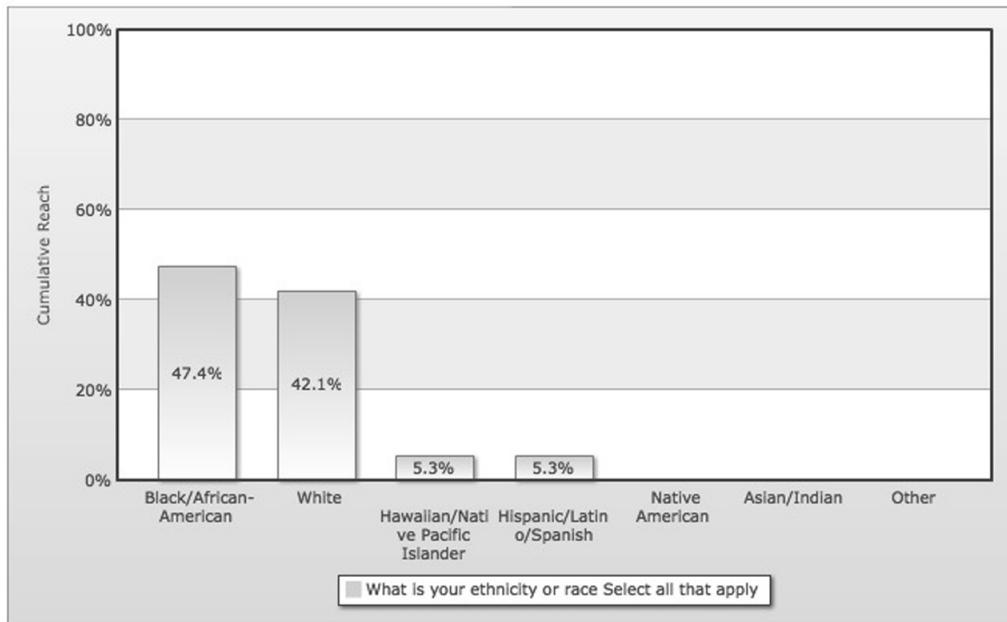
Fitzpatrick Skin-Typing Scale



tone; due to learned stereotyping and the burdens that those who are affected by colorism, those who possess darker skin tones, have in society and would associate the lighter skin tones (Types I and II) more positively,



Animated faces 1.1, 1.2, and 1.3 respectively



with a positive linear association from the darker skin tones to the lighter skin tones.

For the Animated Faces Test, which examines participants' response to animated faces in order to simulate implicit racial stereotyping, I hypothesized that the participants who are of ethnic or racial backgrounds will associate the faces possessing darker skin tones with more positive adjectives, while European-American participants will associate the same faces with more negative adjectives.

Participant Questions

The participant question section was created so participants could fully and explicitly express their feelings on colorism and racial stereotyping. This section was included in order to aid in the discussion of implicit racial stereotyping and skin-tone bias, while assisting in promoting future research.

Participants

My scope of eligible participants were working-aged adults, 25 to 65 years in age, in the general public from a South-Midwest mid-sized urban city

in the US. This age group was chosen due to the fact that their implicit formation of stereotypes and reactions to various skin tones directly impacts the social values of the general population of the United States. Participants possessed a variety of racial/ethnic backgrounds (European-American, African American, Hispanic American, and Native Pacific Islander). Nineteen voluntary participants were tested in the present study. The participant demographics consisted of ten females and nine males, with eight participants being of African-American descent and eight participants being of European-American descent; along with one Hispanic participant, one Native Pacific Islander participant, and one participant of both European-American and African-American descent.

The demographic chart (pictured above), illustrates the amount of influence each racial and ethnic group had over the overall survey results, with African-American participants having the most influence.

Although I administered every survey in person, each participant was stripped of any identifying information in order to remain anonymous. Participants also had the option to discontinue the survey or omit a survey section if they were experiencing emotional stress.

Results

Baseline Test

African Americans were the group who rarely positively associated the lighter skin tones (Types I and II), with only one African-American participant preferring the lighter skin tones. In addition, this group also rated the medium Fitzpatrick skin tones (Types III and IV) as the most positive, however, they were also the group that negatively associated the darker Fitzpatrick skin tones (Types V and VI) the most.

European-Americans were the group who positively associated the lighter Fitzpatrick skin tones (Types I and II) the most when compared to other groups. This group also preferred the medium skin tones (Types II and IV), although not as strongly as the lighter skin tones. None of the participants from this group preferred the darker skin tones (Types V and VI).

A Native Pacific Islander participant was neutral across all skin tones. A Hispanic participant, however, strongly disliked both the lighter skin tones (Types I and II) and the medium skin tones (Types II and IV) when compared to the strongly preferred darker skin tones (Types V and VI). One participant, who was of both African-American and European-American descent, significantly preferred the lighter skin tones, while also strongly preferring the darker skin tones.

I had initially hypothesized that the overall result would be a positive linear association from the darker brown skin tones to the lighter pale skin tones, with the paler skin tones being the most positively associated. However, there was a pattern resembling a bell-curve of positive association, with the tan and mid-brown skin tones being the most positively associated with more “Strongly Like” or “Like”, while the palest white skin tone and the darkest brown skin tone were the most negatively associated with more “Dislike” and a few “Strongly Dislike”.

Animated Faces Test

For African Americans, the majority preferred the African Female animated face. However, the results of the African Male face and the Various face were inconclusive, with participants positively and negatively associating each face with adjectives.

For European Americans, the African Female and African Male were both preferred in equal numbers, but, overall, were preferred less than the Various face. A small percentage of participants from this group also could not associate the faces with adjectives in the context of simulated racial stereotyping, and would therefore give a ‘neutral’ result, which were not related to the context of race.

The Native Pacific Islander participant strongly preferred the African Female face and somewhat preferred the African Male face and Various face. In contrast, the Hispanic participant was not able to associate the faces with adjectives within the context of simulated racial stereotyping, and therefore provided a ‘neutral’ result in this section of the survey. Concerning the participant who was of both African American and European American descent, the African Female and the African Male face were both preferred over the Various face.

I initially hypothesized that the participants who are of ethnic or racial backgrounds will associate the faces possessing darker skin tones with more positive adjectives when compared to European-American participants, and my study confirmed this, although there were more participants who were of an ethnic or racial background who participated in the study.

Spearman's Coefficient Correlation Analysis

Using Spearman’s rank correlation coefficient, it was determined that the average correlation between the implicit judgments of the skin tones present on the Fitzpatrick skin typing test and the implicit attitudes expressed concerning the Animated Faces Test accurately highlight the correlation between implicit colorism and implicit racial stereotyping.

The overall participants’ responses rating for the Fitzpatrick Skin Typing Scale Type I skin-tone were compared to the overall responses from the Animated Faces Test using a correlation analysis, by utilizing Spearman’s rank correlation coefficient, as seen in Table 1.

The “Types” in the chart are designated as the Fitzpatrick skin-typing scale skin-tone types, I through VI. The numbers in the brackets are the individual correlations between the responses concerning im-

COLORISM AND ITS CORRELATION WITH IMPLICIT RACIAL STEREOTYPING

Type I	Type II	Type III
7 (1) and 8 [-0.22]	7(2) and 8 [0.01]	7(3) and 10 [-0.25]
7(1) and 16 [0.12]	7(2) and 16 [0.25]	7(3) and 14 [0.08]
7(1) and 22 [0.09]	7(2) and 22 [-0.11]	7(3) and 18 [-0.22]
Avg: -0.003	Avg: 0.05	Avg: -0.13
Type IV	Type V	Type VI
7(4) and 10 [-0.19]	7(5) and 12 [0.38]	7(6) and 12 [-0.08]
7(4) and 8 [0.01]	7(5) and 20 [0.17]	7(6) and 20 [0.25]
7(4) and 18 [0.01]	7(5) and 24 [0.17]	7(6) and 24 [0.44]
Avg: -0.06	Avg: 0.24	Avg: 0.20

plicit racial stereotyping from the Animated Faces Test, and the responses concerning colorism from the Baseline Test. For skin-types III, IV, and I the average results showed a negative agreement between the ranking of the skin-tone type and the responses concerning the animated facial stimuli. In contrast, for the skin-types II, V, and VI the average results depicted a positive agreement between the skin-tone type and the responses concerning the animated facial stimuli. The total average of all skin-tone correlations was 0.05.

Open Response Discussion

When asked to give possible solutions to decreasing colorism and racial stereotyping in our society, ten participants cited exposure, nine participants cited education, and two participants cited colorblind ideology as the solution or a part of the solution.

Discussion

Baseline Test

African-Americans had the highest rate of negative association concerning the darker skin tones of the Fitzpatrick scale (Types V and VI), which accurately portrays the prevalent issue of colorism within the African-American community, with darker skin tones being ‘strongly disliked’ and tans and mid-browns be-

ing ‘strongly liked’. This prevalence of colorism within the African-American community is not a recent development, but most likely a continued systematic consequence of the adversities, such as racism, discrimination, and second-class citizenship, which this racial group has to confront. This hierarchy of skin tones within the African-American community can be seen explicitly in even modern contexts, such as “In the early 1990s, the EEOC [Equal Employment Opportunity Commission] typically received less than 500 complaints of color-bias per year. By 2002, the number had nearly tripled to 1,400 complaints of color-bias” (Hunter, 2005). This leads to darker-skinned African-Americans being given fewer opportunities in both the African-American community and our society, as they combat both colorism and racism simultaneously. In addition, for African-American participants to rarely positively associate the lighter skin tones (Types I and II) accurately illustrates the perceived tension between these two racial groups. However, this result was also somewhat unexpected due to European Americans being on top of the social hierarchy, as articulated by sociologist Maxine Leeds, where she “describes her [women] interview participants as able to see the beauty in traditionally black identities.... But it seems as if they have not completely released the power of the white ideal of beauty. They stand outside of a white cultural ideal, yet they have internalized it” (2005). This internalization of beauty ideals standardized by European-Americans is due to European Americans having increased influence and

COLORISM AND ITS CORRELATION WITH IMPLICIT RACIAL STEREOTYPING

positive representation in the media, which would have set this group as the ideal standard.

For European-Americans to have the highest rate of positive association concerning lighter skin tones (Type I and II) accurately depicts the benefits that these skin tones, mainly held by European-Americans, have in our society, such as white college graduates being chosen more often for high paying positions of leadership over their black college graduate peers, all of whom possessed the same credentials (Harrison & Thomas, 2009). Similarly, for European-Americans to prefer the medium skin tones (Types III and IV) as opposed to the darker skin tones (Types V and VI) justifies the assertion that European-Americans historically and continually give more privileges and rights to those who share this group's physical features, traits, and characteristics and thus, those who had a skin-tone closer to their own. None of the European Americans preferred the darker skin tones (types V and VI), which accurately portrays the aforementioned continued stigmas our society holds against those who possess a darker skin tone, also known as colorism, as opposed to stigma against a specific race, which is racism. Similarly, for this group to also have the most neutral responses asserts the common perception that European-Americans are more prone to being uncomfortable discussing skin tones, and race in general. This is specifically seen when one European-American participant stated "because I am white [it is assumed that] I have racial feelings towards other skintones", when, in actuality, the vast majority of individuals, despite race, possess bias towards skin tones.

For the Native Pacific Islander participant to be positive across all of the skin tones accurately supports the assertion that exposure to a larger range of skin tones, many of which are present on the diverse Pacific islands, could increase the individual's rate of positive association related to a wider variety of skin tones.

Meanwhile, the Hispanic participant strongly preferred the darker skin tones (Types V and VI) over both the lighter skin tones and the medium skin tones, which was an unforeseen result. This is due to the prevalence of colorism also present in the Hispanic community, which tends to be more explicit. This can be seen in a 2002 court case where "the EEOC [Equal Employment Opportunity Commission] sued the

owners of a Mexican restaurant in San Antonio, Texas for color-based discrimination. A white manager at the restaurant claimed that the owners directed him to hire only light-skinned staff to work in the dining room" (Hunter, 2005). Despite this and various other cases of explicit colorism in the Hispanic community, for the Hispanic participant to prefer the darker skin tones conveys a strong variation of opinions on skin tones within the Hispanic community, and can be further examined in future research.

For the participant of both African-American and European-American descent to strongly prefer the darker skin tones (Types V and VI) and prefer the lighter skin tones (Types I and II) over the medium skin tones (Types III and IV) was also an unexpected result, due to the prevalence of medium skin tones in the growing community of individuals who are of both African-American and European-American descent, such as the participant. This result can best be explained by a quote from the participant, stating, "As a biracial person, I have never been black enough or white enough". Hopefully, this phenomenon can be examined further in future research.

Baseline Test Hypothesis

For the baseline test to be a bell-curve positive association, where the medium skin tones (Types III and IV) were the most positively associated, and the lighter skin tones (Types I and II) and darker skin tones (Types V and VI) were the least favored, instead of the linear positive association I had initially hypothesized, effectively illustrates the gradual change in our societal beauty standards. Although beauty standards are still centered on European-American traits and features (Hunter, 2005), the recent increase in the general population of ethnic backgrounds has begun to diversify the media and change traditional beauty ideals.

Animated Faces Test

For African-American participants to significantly prefer the African Female animated face as opposed to the African Male face and the Various face can be attributed to the fact that the African Female animated face was physically smaller and had 'softer' features

than the other animated faces, in order to convey its gender appropriately, and was therefore the most easily recognizable as ‘friendly’ and ‘non-threatening’ by participants.

For European Americans to strongly prefer the Various face can be correlated to the current rise in the number of children from various races and ethnicities parented by the participant age range (“Multiracial in America”, 2015). These children would be represented by and somewhat resemble the Various animated face, resulting in a higher rate of positive association.

For the Native Pacific Islander participant to strongly prefer the African Female face can be attributed to the aforementioned phenotypical variation that this face had from the other two faces, however, for him not to strongly prefer the African male face and the Various face was an unforeseen result, due to the expectation that the participant would have had more exposure to various ethnicities and skin tones while living on the diverse Pacific Islands. Therefore, it would be assumed the participant would have the most positive association with the Various face. Hopefully this phenomenon can be examined further in future research.

For the Hispanic participant to have a ‘neutral’ result accurately support the aforementioned division of opinions on colorism in the Hispanic community.

For the participant of African American and European American descent to prefer both the African male face and the African Female face as opposed to the Various face, which was meant to represent individuals from multiple racial and ethnic backgrounds, was an unexpected result, because it was inferred that the participant would have most positively associated the Various face.

Spearman’s Coefficient Correlation Analysis

Referring to the previous chart, for skin types III, IV, and I the average results effectively illustrates that the three aforementioned skin types and the animated facial stimuli correlate in a negative linear association, with the Baseline Test results negatively affecting the results in the Animated Faces Test. In addition, for the skin-types II, V, and VI, the average results depicts that the three skin types and the animated facial stimuli correlate in a positive linear association, meaning that the Baseline Test results positively affected the

results in the Animated Faces Test. Overall, this indicates that as skin types III, IV, and I were ranked the highest on average, the animated facial stimuli that followed was ranked negatively in comparison; as skin types II, V, and VI were ranked the lowest on average, the animated facial stimuli that followed was ranked positively in comparison. This resulted in a significant positive correlation between racial stereotyping and colorism in implicit response, revealing that these factors can function simultaneously in the formation of implicit racial bias.

Open Response Discussion

The three most common themes in the open response discussion section were exposure to various cultures and minorities, the promotion of colorblind ideology, a concept where individuals choose not to acknowledge race and ethnicity, and education in our schools and in our society concerning various cultures, ethnicities, and races.

The exposure to different cultures and the interaction with various races within our society, in order to decrease racism and its various forms and outlets (such as racial stereotyping and colorism) is a commonly discussed solution, and has been proven to be effective in certain settings; such as in a 2004 study that examined levels of negative racial biases and stereotyping on college campuses, which found that “stereotypes can be overcome with relatively superficial contact under the right conditions” (Dixon & Rosenbaum, 2004). However, it is a widely contested solution, due to the lack of a variety of minorities in certain rural areas of the United States, and the continued socio-economic housing divide in large urban areas, where the majority of minorities are forced into and kept in poorer neighborhoods, due to phenomena such as ghettoization and redlining.

The promotion of ‘colorblind ideology’, a term used to describe how individuals choose to ignore the races and ethnicities of other individuals in an effort to avoid acts of discrimination and racism, is a commonly denounced solution throughout academia. Therefore, it is more effective to embrace various races and ethnicities, as opposed to ignoring their existence and the contribution they make to our multicultural society.

Education in our schools and in our general society is widely acknowledged as the most effective solution in combating racism and its diverse forms and outlets, due to its easy access ad lasting effect on children. This can be seen in a recent mixed method study concerning child development, where 75 European American children (ages 4-9) were told three stories stereotyping the actions of African American classmates and three stories with non-stereotypical stories concerning the actions of African Americans classmates, and it was found that "stereotypic stories were remembered better ($M = 5.0$, $SD = .9$) than counterstereotypic stories ($M = 4.2$, $SD = 1.4$)" (Bigler & Liben, 1993). However, increased education on what stereotyping is and how it contributes negatively to society, and hinders the individual being stereotyped, was proposed as a possible solution to combat these higher rates of acceptance concerning the stereotypical stories, justifying the need for education on racism and how our society can prevent it.

Conclusion/Future Research

The current study examines colorism and its role in the formation of implicit racial stereotyping, with the focus being between analyzing the correlation between the two variables. A statistically significant and positive correlation was discovered between the two variables, and justifies the hypothesis that colorism and racial stereotyping do correlate with each other. A limitation of the current study is that these results cannot be generalizable, due to the nature of the study as a mixed method with a qualitative analysis. Future research would need to be conducted on the specific ways that colorism and racial stereotyping operate in our society and how this correlation hinders various minority populations.

References

- Arboleda, T. (Adapter). (2011). *RaceOff* [Video file]. In *Entertaining Diversity*. Retrieved November 2, 2016, from <http://entertainingdiversity.com/raceoff-live.html>
- Bigler, R. S., & Liben, L. S. (1993). A cognitive-developmental approach to racial stereotyping and reconstructive memory in Euro-American children. *Child Development*, 64(5), 1507-1518. doi:10.1111/1467-8624.ep9402220358
- Breland, A. M. (1998). A model for differential perceptions of competence based on skin tone among African Americans. *Journal Of Multicultural Counseling & Development*, 26(4), 294-312.
- Clark, M. P., & Clark, K. B. (1947). Racial identification and preference in Negro children. *Readings in Social Psychology*, 169-178. Retrieved October 28, 2016, from <http://i2.cdn.turner.com/cnn/2010/images/05/13/doll.study.1947.pdf>
- «Colourism, U.S. Colorism». (n.d.). Retrieved November 30, 2016, from <https://en.oxforddictionaries.com/definition/colourism>.
- Danel, D. P., Fedurek, P., Coetzee, V., Stephen, I. D., Nowak, N., Stirrat, M., & ... Wright, J. (2012). A Cross-cultural comparison of population-specific face shape preferences (*Homo sapiens*). *Ethology*, 118(12), 1173-1181. doi:10.1111/eth.12022
- Dixon, J. C., & Rosenbaum, M. S. (2004). Nice to know you? Testing contact, cultural, and group threat theories of anti-black and anti-Hispanic stereotypes. *Social Science Quarterly (Wiley-Blackwell)*, 85(2), 257-280. doi:10.1111/j.0038-4941.2004.08502003.x
- Greenwald, T., Banaji, M., & Nosek, B. (1998). Project implicit. Retrieved September 21, 2016, from <https://implicit.harvard.edu/implicit/aboutus.html>
- Hall, R. E. (1992). Bias among African-Americans regarding skin color: Implications for social work practice. *Research on Social Work Practice*. 2. 479^86.
- Harrison, M. S., & Thomas, K. M. (2009). The hidden prejudice in selection: A research investigation on skin color bias. *Journal Of Applied Social Psychology*, 39(1), 134-168. doi:10.1111/j.1559-1816.2008.00433.x
- Hunter, M. L. (2005). *Race, gender, and the politics of skin tone*. Rutledge: Taylor & Francis Group.
- Kelly, S. (2004). Underlying components of scores assessing African Americans' racial perspectives. *Measurement & Evaluation In Counseling & Development (American Counseling Association)*, 37(1), 28-40.
- Know Your Skin Type. (2016). Retrieved December 29, 2016, from <http://www.dermatology.ca/skin-hair-nails/skin/photoaging/know-your-skin-type/>

COLORISM AND ITS CORRELATION WITH IMPLICIT RACIAL STEREOTYPING

- Maddox, K. B. (2004). Perspectives on racial phenotypicality bias. *Personality & Social Psychology Review* (Lawrence Erlbaum Associates), 8(4), 383-401.
- McLallen, A., Johnson, B. T., Dovidio, J. F., & Pearson, A. R. (2006). Black and white: The role of color bias in implicit race bias. *Social Cognition*, 24(1), 46-73. Retrieved September 21, 2016, from <http://research.pomona.edu/sci/files/2011/09/PDF5.pdf>
- Multiracial in America. (2015, June 11). Retrieved October 28, 2016, from <http://www.pewsocialtrends.org/2015/06/11/multiracial-in-america/>
- Ployhart, R. E., Ziegert, J. C., & McFarland, L. A. (2003). Understanding racial differences on cognitive ability tests in selection contexts: An integration of stereotype threat and applicant reactions Research. *Human Performance*, 16(3), 231-259.
- Russell, K. Y, Wilson, M., & Hall, R. E. (1992). The color complex: The politics of skin color among African Americans. New York: Harcourt Brace Jovanovich.
- Stepanova, E. V., & Strube, M. J. (2009). Making of a face: Role of facial physiognomy, skin tone, and color presentation mode in evaluations of racial typicality. *Journal Of Social Psychology*, 149(1), 66-81.).
- “Stereotype”. (n.d.). Retrieved November 30, 2016, from <http://www.merriam-webster.com/dictionary/stereotype>.
- Trytten, D. A., Lowe, A. W., & Walden, S. E. (2012). “Asians are good at math. What an awful stereotype”: The model minority stereotype’s impact on Asian American engineering students. *Journal Of Engineering Education*, 101(3), 439-468.
- Tukachinsky, R., Mastro, D., & Yarchi, M. (2015). Documenting portrayals of race/ethnicity on primetime television over a 20-year span and their association with national-level racial/ethnic attitudes. *Journal Of Social Issues*, 71(1), 17-38. doi:10.1111/josi.12094
- Walker, P. M., & Hewstone, M. (2008). The influence of social factors and implicit racial bias on a generalized own-race effect. *Applied Cognitive Psychology*, 22(4), 441-453. doi:10.1002/acp.1382

National Football League Concussions from 2009 – 2015: A Secondary Data Analysis

Ethan Kelly

In recent years, the National Football League (NFL) has made an effort to lower the prevalence of concussions, partially by enacting rule changes designed to limit contact to the head. This study aims to determine whether NFL rule changes from 2009 – 2015 have resulted in a decrease in the number of reported concussions through analyzing publicly available injury reports, which were compared with rule changes for each season. A second component of the study aims to determine whether teams are underreporting the number of concussions suffered by gathering concussion data for each team. This study found that there was a general increase in the number of concussions from 2009 – 2015 and it is not possible to determine whether rule changes are effective in decreasing head impact exposure. This study also found that certain teams reported a significantly low number of concussions throughout the years analyzed, and underreporting is likely occurring.

Keywords: concussion, underreporting, National Football League, rule changes

Introduction

Throughout the twentieth century, various studies were published regarding the detrimental effects of concussions. It was not until 2005, when Dr. Bennet Omalu published his research on Chronic Traumatic Encephalopathy in deceased National Football League (NFL) players, that concussions became one of the greatest concerns facing sports players, parents, and multi-billion dollar leagues.

While often criticized for disregarding these findings, the NFL has increased its effort in the research and prevention of concussions by recently investing \$100 million in concussion research and by consistently implementing rule changes designed to prevent concussions since around the time of Omalu's findings (Belson, 2016). While there have been vast amounts of research performed on the effects of concussions

in NFL players, there is a lack of research determining whether or not the NFL's concussion prevention strategies are indeed protecting the players. From approximately 2009 onwards, the NFL has implemented several new penalties varying in punishment from five to fifteen yards, as well as possible fines and suspensions. When a penalty is enforced, the penalized team will have the football moved back by the corresponding number of yards to that particular penalty. With these punishments, a negative incentive is placed to discourage players from acts that could cause concussions, and this study attempts to determine whether these negative incentives are working. A second portion of the study seeks to address the issue of the underreporting of concussions by NFL teams. This issue has been discussed in the media and by former players but has yet to be analyzed in an academic study. Thus, the question that will be explored is: are the recent National Football League rule changes designed to limit

brain trauma achieving their desired effect of lowering the prevalence of concussions and are NFL teams accurately reporting these concussions?

This study analyzed National Football League injury reports from 2009 – 2015 in order to determine whether the rate of concussions has been decreasing in unison with the rule changes. This study also tracked the number of concussions reported by every NFL team in order to determine whether teams have been underreporting concussions. Since the research has already been gathered by an outside source, a secondary data analysis was used to present the findings. The goal of this study is to provide a greater level of clarity to a growing issue of concern in the sport of football.

Literature Review

There has been extensive research on the effects and dangers of concussions in the National Football League (NFL), as well as in other football leagues. In the famed 2005 study conducted by Dr. Bennet Omalu which inspired a Hollywood film, Chronic Traumatic Encephalopathy (CTE) was first discovered in a former NFL player. Omalu investigated the case of former NFL player Mike Webster, by performing an autopsy on his brain. Omalu's discoveries were shocking, as he found grey matter on the brain of the player, which showed extensive damage to the brain. What further made this discovery noteworthy was that Webster had no recorded concussions throughout his career (Omalu, 2005). Omalu then proposed that the grey matter found on the brain was a result of repetitive, non-concussive, hits to the head. Over time, while there may have not been great force on the hits, the sheer number of hits resulted in extensive damage to the brain. Omalu then named this condition Chronic Traumatic Encephalopathy (Omalu, 2005). This study is particularly noteworthy as an autopsy had never been performed on the brain of a former NFL player (Omalu, 2005). One major limitation of this study was that due to the nature of the procedure, it could only be performed on deceased players (Omalu, 2005). So while Omalu's findings caused great concern and outrage among the medical and football communities, there was still no way of diagnosing CTE in living players (Omalu, 2005). New methods

of investigating brain injury were attempted, and in 2008, a study involving Omalu used a technique called Positron Emission Tomography (PET) scanning, and the results were encouraging (Small et. al, 2008). In this investigation, five retired NFL players aged 45 to 73 years were compared with a control group of similar age and body characteristics. The results found that signals were much higher in the experimental group, particularly in regions of the brain known to produce tau deposits, which Omalu had discovered in his 2005 study. This development was noteworthy, as the PET scanning successfully filled a gap in the ability to identify traumatic brain injury in living humans. Despite this encouraging breakthrough, more research is necessary to fully comprehend CTE and its possible treatment and identification options (Tator, 2014).

It is essential to outline in this paper a definition for what constitutes a concussion. According to the *British Journal of Sports Medicine*, they state:

Sport related concussion is a traumatic brain injury induced by biomechanical forces. Several common features that may be utilised in clinically defining the nature of a concussive head injury include: SRC may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head. SRC typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, signs and symptoms evolve over a number of minutes to hours. SRC may result in neuropathological changes, but the acute clinical signs and symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies. SRC results in a range of clinical signs and symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive features typically follows a sequential course. However, in some cases symptoms may be prolonged. The clinical signs and symptoms cannot be explained by drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction, etc) or other comorbidities (eg, psychological factors or coexisting medical conditions) (McCrory et al., 2017).

As can be interpreted from this definition, concussions have a wide array of symptoms, which could lead to the possibility of some teams having different interpretations of what classifies a concussion.

Recent breakthroughs in concussion research have placed a greater focus on the issue of concussion prevention through advances in helmet technology along with rule changes in various sports. When addressing concerns over concussion prevention measures, NFL Commissioner Roger Goodell stated, "Within the NFL, safety-related rules will always be clearly defined and strictly enforced, and we will continue to work with our players, coaches, and others to identify new and safer ways to play the game" (Bachynski & Goldberg, 2014, p. 324). Despite these promises to increase player safety, researchers such as Kathleen Bachynski and Daniel Goldberg (2014) argue that they find "little evidence that these strategies prevent concussive and subconcussive head impacts or significantly reduce the associated long-term risks" (p. 324).

While large sums of money have been invested in concussion research, there has not been a substantial amount of research performed on the effects of the NFL rule changes designed to limit the impact to the brain. In 2015, a study was performed that investigated the effects of the changes to the free kick rules in the 2010 and 2011 seasons on injuries (Ruestow, Duke, Finley, & Pierce, 2015). Ahead of the 2011 season, the free kick was moved from the 30-yard line to the 35-yard line. This rule was designed to limit the number of kick returns, a notoriously dangerous play, by increasing the likelihood the ball will be kicked deep into the opponent's territory. The data was collected from NFL injury reports to determine the number of injuries on special teams plays. The study found that there was a noticeable decrease in injuries on these plays when comparing data from the 2010 season without the rule change to the 2011 season (Ruestow, Duke, Finley, & Pierce, 2015). Although it could not be definitively determined whether the reduction in injuries was caused by the rule changes, some inferences could be made. The authors determined that due to an increase in the number of touchbacks, there were fewer plays run, and therefore fewer opportunities for injury (Ruestow, Duke, Finley, & Pierce, 2015). It is important to note that this study did not distinguish between concussions and other injuries. While this study found an overall decrease in total injuries, it did not claim to find a decrease in the number of concussions.

In 2016, a study was performed that analyzed the effects of limiting full-contact high school practices

on the exposure to head impact. Through performing a cross – sectional study, the researchers determined that limiting full-contact practices resulted in an average of a 42% decrease in head impact exposure (Broglie, Williams, O'Connor, & Goldstick, 2016). Along with the study discussed in the paragraph above, there appears to be a trend that lowering the number of contact plays tends to result in a decrease in the number of injuries. While this study does not take into account how much contact NFL players are exposed to in practices, it is important to note that practice conditions may affect concussion rates.

In a report released by the National Football League, the number of total concussions rose considerably from 2014 to 2015 (Breslow, 2016). According to NFL Senior Vice President of Health and Safety Policy Jeff Miller, the NFL has been attempting to identify what has led to this increase (Breslow, 2016). One hypothesized explanation is that there has been a shift in player behavior. As Miller stated, "We're seeing unprecedented levels of player reporting signs and symptoms of concussions" (Breslow, 2016). If this statement were accurate, an increase in the number of concussions should be expected as it is assumed NFL players have not been consistently reporting concussion-related symptoms in the past. As author Jason Breslow points out, however, the NFL does not track data on the incidence of self-reported concussions, hindering the ability to gather a quantitative account of a possible shift in concussion culture (Breslow, 2016).

There have been many studies regarding concussions in sports; however, the field remains relatively young and requires substantially further research to provide greater understanding and context to the current knowledge on concussions and CTE. Many of the studies analyzed in this review produced inconclusive results, which further reinforces the need for additional studies. Through the research analyzed, a general trend can be seen that in rule changes that result in decreased exposure to contact, a reduction in injury rates has been shown. Due to the current sample size, this trend holds little value and certainly warrants further research. While there have been various studies performed regarding concussions and injuries in the NFL, few have analyzed the impact rule changes have had on the number of recorded concussions.

Method

Publicly available injury reports from the National Football League have been analyzed in order to determine the total number of concussions diagnosed for each season from 2009 – 2015. This data was collected from the websites *Pro Football Reference* and *PBS Frontline: Concussion Watch*. The website *PBS Frontline: Concussion Watch* contains the number of concussions suffered by each position and each team from 2012 – 2015 (Breslow, 2015). The website *Pro Football Reference* contains all of the injury reports from each team of the NFL from 2009 onwards and was used to collect data from 2009 – 2011 (Pro Football Reference, 2017). For data collection from *Pro Football Reference*, the injury reports of each team were thoroughly examined and any injury under the designation *concussion* or *head* were counted in the study. This is the same method *PBS Frontline: Concussion Watch* used for its data collection, which ensures consistency throughout the entire study (Breslow, 2015). The data regarding the numbers of concussions per year was then compared to the rule changes put in place for each respective year in order to determine which rules are achieving their desired effects. Furthermore, the number of concussions suffered by each position was collected in order to determine the possible effects the rule changes had on different positions. The positions that were analyzed were quarterback (QB), running back (RB), wide receiver (WR), tight end (TE), offensive line (OL), defensive line (DL), linebacker (LB), and defensive back (DB). A secondary data analysis research method is most suitable for this study as only one variable is in place, the number of concussions, and this data

has already been collected by *PBS Frontline: Concussion Watch* and *Pro Football Reference*. In a 2013 study, a similar method was used to describe the impact of moving the free kick forward five yards on the total number of injuries in the 2011-2012 NFL season (Ruestow, Duke, Finley, & Pierce, 2013). By analyzing the number of concussions alongside rule changes that penalize certain forms of head impact, this study aims to determine the effectiveness of the rule changes. In order to address the possibility of teams underreporting concussions, this study has counted the number of concussions reported by each team from 2009 – 2015. An average value was then calculated for each season to determine the average number of concussions suffered per team, as well as the average of the total number of concussions suffered over all seven years of the study. Trends have been analyzed from this data set in order to determine whether or not concussions are being accurately reported.

Findings

Overall, 1038 concussions were observed during the seven-year period from 2009 – 2015. The position group that suffered the highest number of concussions were defensive backs with 288 reported concussions, while quarterbacks suffered the lowest number with 50 concussions (Table 1). For each year of the study, all relevant rule changes are explained below. It is important to take into account that not all rule changes impact each position identically. Some rule changes will only have a bearing on the concussion data from certain position groups, which has been identified below.

Table 1

Number of Concussions by Position

Year	QB	RB	WR	TE	OL	DL	LB	DB	Total (by year)
2009	5	13	10	13	12	9	16	23	101
2010	11	9	25	12	17	17	19	36	146
2011	7	15	19	13	19	15	24	41	153
2012	7	18	29	19	24	13	13	45	168
2013	6	15	20	16	21	15	15	43	151
2014	2	11	15	9	20	7	16	42	122
2015	12	11	24	17	34	17	24	58	197
Totals (N = 1038)	50	92	142	99	147	93	127	288	

Note. Data from 2009 - 2011 collected from *Football Outsiders*. Data from 2012 - 2015 collected from *PBS Frontline: Concussion Watch*.

NFL CONCUSSIONS: 2009-2015

2010

There were four notable rule changes implemented in the 2010 season that penalize trauma to the head. The first of these rule changes states that “A player who has just completed a catch is protected from blows to the head or neck by an opponent who launches” (NFL Evolution, 2013). The second states, “All ‘defenseless players’¹ are protected from blows to the head delivered by an opponent’s helmet, forearm, or shoulder” (NFL Evolution, 2013). The third states, “quarterbacks after a change of possession are protected from blows to the head delivered by an opponent’s helmet, forearm, or shoulder, instead of just helmet-to-helmet contact.” (NFL Evolution, 2013). The fourth states, “The ball is declared dead at the spot if a runner’s helmet comes completely off” (NFL Evolution, 2013). All of these rule changes would primarily impact players on offense.

2011

Two rule changes were implemented this season that could have had a bearing on concussion numbers. The first states that “The restraining line for the kicking team is moved from the 30- to the 35-yard line in an effort to increase touchbacks” (NFL Evolution, 2013). This rule could impact players on offense and defense. The second states, “A receiver who has completed a catch is a ‘defenseless player’ until he has had time to protect himself or has clearly become a runner. A receiver/runner is no longer defenseless if he is able to avoid or ward off the impending contact of an opponent. Previously, the receiver who had completed a catch was protected against an opponent who launched and delivered a blow to the receiver’s head” (NFL Evolution, 2013). This rule change would only have an effect on offensive players.

2012

Only one rule change was added in the 2012 season that could impact concussion frequency and it states that “The list of ‘defenseless players’ is expanded to include defensive players on crackback

¹ A *defenseless player* is considered to be a player who is not in a position to be able to avoid contact (Blandino, 2017). A player that is labelled as *defenseless* is protected from hits to the head or neck area (Blandino, 2017).

blocks, making it illegal to hit them in the head or neck area” (NFL Evolution, 2013). This rule change would strictly impact defensive players.

2013

One rule change was implemented this season that seeks to decrease contact to the head. The rule “Prohibits a runner or tackler from initiating forcible contact with the crown of the helmet outside the tackle box” (Goodell, 2013) (p. 2). Both offensive and defensive players would be affected by this rule change.

2014

There were no rule changes implemented this season that sought to decrease the risk of concussion (Goodell, 2014).

2015

One rule change was added in this season that could impact concussion risk and this rule “Gives the intended receiver of a pass defenseless player protection in the immediate continuing action following an interception or potential interception” (Goodell, 2015) (p. 2). This rule change would only affect offensive players.

Concussion Reporting by Team

In addition to collecting concussion data by position, this study also tracked the number of concussions that were reported by all 32 NFL teams from 2009 – 2015 and is shown in Table 2. This table also shows the average number of concussions per team for each season, as well as the average number of reported concussions per team for all seven seasons of data. There was a large range in the total number of reported concussions by team for all seasons of data, with the average number of reported concussions being 32.7 (Table 2). At the low end of the spectrum were the Miami Dolphins, Buffalo Bills, and Atlanta Falcons with 12, 18, and 23 concussions respectively through the seven seasons (Table 2). At the high end of the spectrum were the Cleveland Browns, Oakland Raiders, and Minnesota Vikings with 58, 47, and 46 reported concussions respectively (Table 2).

Discussion

The purpose of this study was to determine whether or not the NFL rule changes designed to limit contact to the head have been effective in reducing the number of concussions, as well as to determine whether some NFL teams have been guilty of under-reporting concussions. While there were not very strong trends relating rule changes to changes in the number of concussions, the data regarding concussion reporting by NFL teams suggests the possibility that some teams have been underreporting concussions. Both aspects of the study will be discussed in this section, as well as the limitations and suggestions for future research.

The Impact of Rule Changes

The NFL mostly saw an increase in the number of concussions from 2009 – 2012 even though rule changes were implemented fairly consistently each season that sought to penalize certain forms of hits to the head. While the number of concussions did recede in 2013 and 2014, the number of concussions then increased substantially in 2015, making it difficult to infer that rule changes had an impact on the low 2013 and 2014 figures. This result seems somewhat counter-intuitive, as one would naturally assume that more penalties penalizing hits to the head would result in fewer concussions due to the negative incentive placed on hitting the opponent's head. One

Table 2**Number of Concussions by Team**

Team	2009	2010	2011	2012	2013	2014	2015	Total (by team)
Arizona Cardinals	4	6	2	4	2	4	3	25
Atlanta Falcons	4	3	6	2	3	1	4	23
Baltimore Ravens	9	7	8	9	3	5	4	45
Buffalo Bills	2	2	1	3	0	4	6	18
Carolina Panthers	5	11	8	3	2	3	6	38
Chicago Bears	1	3	5	5	1	4	7	26
Cincinnati Bengals	2	4	0	4	12	10	4	36
Cleveland Browns	3	9	8	10	7	5	16	58
Dallas Cowboys	3	7	2	7	1	4	6	30
Denver Broncos	2	3	4	4	5	8	3	29
Detroit Lions	3	8	5	5	6	4	6	37
Green Bay Packers	7	3	5	6	5	3	3	32
Houston Texans	3	0	2	4	5	3	8	25
Indianapolis Colts	4	3	4	9	7	3	4	34
Jacksonville Jaguars	3	6	5	9	9	3	5	40
Kansas City Chiefs	2	2	2	9	4	5	9	33
Miami Dolphins	0	2	2	2	3	0	3	12
Minnesota Vikings	5	9	9	5	7	2	9	46
New England Patriots	4	4	5	5	6	4	5	33
New Orleans Saints	2	4	1	4	4	3	6	24
New York Giants	1	3	6	4	3	4	9	30
New York Jets	2	3	3	7	5	3	7	30
Oakland Raiders	5	6	10	12	7	5	2	47
Philadelphia Eagles	3	6	6	5	4	1	8	33
Pittsburgh Steelers	1	6	3	5	5	1	7	28
San Diego Chargers	2	1	5	2	6	7	16	39
San Francisco 49ers	4	4	5	6	4	5	8	36
Seattle Seahawks	3	6	10	3	6	3	4	35
St. Louis Rams	5	5	8	4	6	3	9	40
Tampa Bay Buccaneers	2	1	6	4	4	2	5	24
Tennessee Titans	5	3	4	4	5	5	3	29
Washington Redskins	2	6	3	6	5	5	4	31
Averages	3.2	4.6	4.8	5.3	4.8	3.8	6.2	32.7

Note. Data from 2009 - 2011 collected from *Football Outsiders*. Data from 2012 - 2015 collected from PBS *Frontline: Concussion Watch*.

possible explanation for the increase in the number of concussions is that the NFL altered its concussion reporting policy after the 2009 season (Schwarz, 2009). Prior to the 2010 NFL season, players that suffered hits to the head were allowed to return to the same game if their symptoms weakened (Schwarz, 2009). However, from the 2010 season onward the NFL mandated that players exhibiting significant signs of concussion (this includes amnesia, improper balance, and persistent headaches) would not be allowed to return to games even if the symptoms later subsided (Schwarz, 2009). The imposition of this new guideline for diagnosing and treating concussions makes it reasonable to assume that more concussions would be reported on injury reports, as teams could no longer send a player with concussion-like symptoms back into a game. This assumption lines up with the data found in this study, as the number of reported concussions rose considerably after the 2009 season and never receded back to this low level.

This result of a general increase in concussions aligns with a study published in *The American Journal of Sports Medicine* which analyzed the number of reported concussions in 25 American high schools over an 11-year span (Lincoln et. al., 2011). This study found that the number of reported concussions rose consistently for every year analyzed (Lincoln et. al., 2011). The paper suggests that one possibility for the increase in concussions over the years could be due to greater sensitivity in diagnosing concussions as well as more widespread guidelines in terms of diagnosing and treating concussions (Lincoln et. al., 2011). While the study analyzes data from 12 high school sports instead of only football, the increase in concussions draws a parallel to the results found in the NFL. Another possible reason for the increase in concussions could have been an increase in player awareness about the detrimental effects of concussions. In a 2011 study surveying high school soccer players, it was found that players who had been educated about concussions were more likely to self-report a concussion to their coach than their counterparts who had not received any concussion education (Bramley, Patrick, Lehman, & Silvis, 2011). It is certainly possible that NFL players have become increasingly educated about concussions, which could lead to an increase in self-reporting. The NFL has cited that they believe there has been a shift in the culture surrounding con-

cussions and that increases in self-reporting could be one of the main explanations of the increasing concussion numbers (Breslow, 2016).

Contrarily, there have also been studies that have found a correlation between rule changes and concussion rates, which was not observed in this paper. For example, a 2011 study discussed in the Literature Review portion of this paper determined that alterations to a rule regarding the free kick were likely the cause for an observed decrease in injuries (Ruestow, Duke, Finley, & Pierce, 2015). While the study does find a correlation between a rule change and a decrease in injuries, the paper does not examine the effect of this rule change on the number of concussions. So while a rule change may decrease the risk of other injuries, the paper does not state that rule changes can aid in preventing concussions (Ruestow, Duke, Finley, & Pierce, 2015).

Reporting of Concussions by Team

Through analyzing the number of concussions reported by each NFL team from 2009 – 2011, trends that were found could suggest the presence of under-reporting concussions by some teams. A reasonable assumption to make prior to examining the data would be to assume that the number of concussions reported by each team would be fairly consistent with each other, as there should not be a reason one team should suffer more concussions than another. However, when examining the data collected, there is a very substantial difference in the number of reported concussions amongst all teams. The team that reported the highest number of concussions, the Cleveland Browns, reported 58 concussions over the seven years of the study, which is almost five times greater than the number of concussions reported by the Miami Dolphins, who reported only 12. For reference, the average number of concussions over the seven years in this study was 32.7 per team. While it is reasonable to expect teams to have some years that are outliers with unusually low or high figures, this level of discrepancy was not expected. There is no incentive for a team to over-report the number of concussions; however, a team that underreports their concussions would be able to have players play in games that they would otherwise not be medically cleared for if they were diagnosed with a concussion. Furthermore, it

is not only the low seven-year concussion total that raises concern, but rather the consistency of low numbers of reported concussions throughout each season studied. For example, in all seven years of the study, the Miami Dolphins were below the league average in reported concussions each season, including two years where they reportedly did not suffer a single concussion. The Buffalo Bills, the team with the second least concussions (18), was below the league average in six of the seven years of the study. Given how low these figures are compared to the league average and to teams with high numbers of concussions, it is reasonable to suspect that there may have been cases of underreporting with teams including, but not limited to, the Miami Dolphins and Buffalo Bills.

The suspicion of underreporting that has arisen from this study is not a new topic. While there may not be any formal scholarly papers on the underreporting of concussions, there have been many instances of former players, the media, and the medical community criticizing the NFL for its handling of concussions. One example is the case of Kris Dielman. On October 23, 2011, Dielman, an offensive lineman for the San Diego Chargers, was hit hard during a game and although he was clearly wobbly after getting up, he remained in the game (Mortensen, 2011). Following the game on his team's flight home, Dielman suffered a seizure close to the end of the flight and was later hospitalized (Mortensen, 2011). Four and a half months later, Dielman decided to retire from the NFL due to the concussion he suffered (Wilson, 2012). Clearly, the San Diego Chargers' medical staff made a severe error in allowing Dielman to return to the game; a mistake that cost the player his career. While this anecdotal case does not prove the widespread underreporting of concussions, it does show that underreporting did occur to some extent.

Limitations

While the findings of this study do suggest a possibility of NFL teams underreporting concussions, there are some limitations that must be addressed. Concussions are injuries that have many variables as to how they may be suffered, such as contact from another person or the playing surface, poor equipment, or dangerous tackling techniques. Therefore, it is pos-

sible that a team may have a low number of concussions because they use more advanced helmet technology or they teach safer tackling techniques than other teams. Neither of these factors were considered in the study. Furthermore, the data presented in this study includes concussions suffered during practices. While it can be ensured that each team is subjected to the same rules regarding contact during games, it is possible that certain teams may have a greater number of full-contact practices than others, which is not accounted for in this study.

Suggestions for Further Research

The field of studying concussions is still relatively young and there remains a lot of information to be studied. In particular, one subject that has not been studied thoroughly is the underreporting of concussions in the NFL. In this paper, some suggestions were made that teams may have been guilty of underreporting in the years from 2009 – 2015; however, more studies must be performed on the matter in order to truly comprehend the issue. One suggestion for a study that could address this topic would be to survey NFL personnel such as team doctors, players, and coaches, and attempt to determine from them whether they believe concussions have been underreported. Since no data exists on unreported concussions, a qualitative study would most likely be the most effective way to conduct this type of study.

After the end of the 2015 NFL season, the league imposed a new concussion protocol that designates an independent neurologist to be on the sidelines at each game and handle all brain-related injuries (National Football League, 2016). This is a major advancement for properly diagnosing concussions, as the neurologists would not be pressured to send a player back into a game who may have a concussion, as they are not affiliated with a team. It would be very interesting to analyze the number of reported concussions on each team from the 2016 season onward in order to see whether or not the number of concussions becomes more balanced across all teams with the addition of independent neurologists.

Although neurologists may help identify and diagnose concussions, this is not a preventative measure. In a 2012 study it was suggested that return to play

guidelines, such as the NFL concussion protocol, are not the most effective way in solving the problem of concussions (Johnson, 2012). Instead, this study suggests that measures that help prevent concussions should be explored and utilized (Johnson, 2012). One possible ally for future research that could help prevent concussions is further research into new helmet technologies. In a 2016 study, it was determined that the common helmet manufacturers today all provide a similar level of protection against concussions (Collins et. al., 2016). This means that further research and funding must be invested into discovering new helmet technologies in order to increase player safety.

While this paper analyzes concussion data in the NFL, future research could investigate concussions in high school and college football, which could add a greater level of clarity and understanding to the field.

Conclusion

Due to the general increase in the number of reported concussions from 2009 – 2015, it was not possible to determine whether or not rule changes are affecting the rate of concussions. In the second component of the study, through analyzing the number of concussions reported by individual NFL teams there arose evidence of possible underreporting of concussions. Although these findings suggest certain teams may have been guilty of underreporting concussions, more investigation is warranted to confirm this trend in the gathered data.

References

- Bachynski, K. E., & Goldberg, D. S. (2014). Youth sports & public health: framing risks of mild traumatic brain injury in American football and ice hockey. *Journal Of Law, Medicine & Ethics*, 42(3), 323-333. Retrieved from <http://web.a.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=7b54ffa7-4362-4d35-a13d-82d4bc080c41%40sessionmgr4010&vid=2&hid=4201>
- Belson, K. (2016). NFL to spend \$100 million to address head trauma. *The New York Times*. Retrieved from <http://www.nytimes.com/2016/09/15/sports/football/nfl-concussions-100-million-roger-goodell.html>
- Blandino, D. (2017). NFL Video Rulebook: Defenseless Player. *NFL Operations*. Retrieved from <http://operations.nfl.com/the-rules/nfl-video-rulebook/defenseless-player/>
- Bramley, H., Patrick, K., Lehman, E., Silvis, M. (2011). High school soccer players with concussion education are more likely to notify their coach of a suspected concussion. *Clinical Pediatrics*, 51(4). Retrieved from <http://journals.sagepub.com/doi/abs/10.1177/009922811425233>
- Breslow, J. M. (2015). Concussion watch. *PBS Frontline*. Retrieved from http://apps.frontline.org/concussion-watch/-positions_2012
- Breslow, J. M. (2016). What the NFL's new concussion numbers don't answer. *PBS Frontline*. Retrieved from <http://www.pbs.org/wgbh/frontline/article/what-the-nfls-new-concussion-numbers-dont-answer/>
- Broglio, S. P., Williams, R. M., O'Connor, K., L., & Goldstick, J. (2016). Football players' head-impact exposure after limiting of full-contact practices. *Journal of Athletic Training*, 51(7), 511-518. doi: <http://dx.doi.org/10.4085/1062-6050-51.7.04>
- Collins, C. L., McKenzie, L. B., Ferketich, A. K., Andridge, R., Xiang, H., & Comstock, R. D. (2016). Concussion characteristics in high school football by helmet age/recondition status, manufacturer, and model. *American Journal of Sports Medicine*, 44(6). Retrieved from <http://web.a.ebscohost.com/ehost/detail/detail?vid=5&sid=bef6c82d-632f-4d1c-a94a-761342c0df1b%40sessionmgr4009&hid=4107&bdata=JnNpdGU9ZWhvc3QtbgI2ZQ== - AN=115886481&db=a9h>
- Goodell, R. (2013). 2013 official playing rules of the National Football League. *National Football League*. Retrieved from https://www.nfl.info/download/2012mediaguides/2013_nfl_rule_book.pdf

NFL CONCUSSIONS: 2009-2015

- Goodell, R. (2014). 2014 official playing rules of the National Football League. *National Football League*. Retrieved from <http://operations.nfl.com/images/content/rules/2014rulebook.pdf>
- Goodell, R. (2015). 2015 official playing rules of the National Football League. *National Football League*. Retrieved from http://operations.nfl.com/media/1807/2015_nfl_rule_book_final.pdf
- Johnson, L. (2012). Return to play guidelines cannot solve the football-related concussion problem. *Journal of School Health*, 82(4). Retrieved from <http://web.a.ebscohost.com/ehost/detail/detail?vid=6&sid=bef6c82d-632f-4d1c-a94a-761342c0df1b%40sessionmgr4009&hid=4107&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ== - db=a9h&AN=72367650>
- Lincoln, A. E., Caswell, S. V., Almquist, J. L., Dunn, R. E., Norris, J. B., & Hinton, R. Y. (2011). Trends in concussion incidence in high school sports. *The American Journal of Sports Medicine*, 39(5). Retrieved from <http://journals.sagepub.com/doi/abs/10.1177/0363546510392326>
- McCrory, P., Meeuwisse, W., Dvorak, J., Aubry, M., Bailes, J., Broglio, S., ... Vos, P. E. (2017). Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016. *British Journal of Sports Medicine*. Retrieved from <http://bjsm.bmjjournals.org/content/early/2017/04/28/bjsports-2017-097699>
- Mortensen, C. (2011). Safety panel to discuss Kris Dielman. *Entertainment and Sports Programming Network*. Retrieved from http://www.espn.com/nfl/story/_/id/7176056/kris-dielman-concussion-seizure-focus-nfl-nflpa-safety-meet-tuesday
- National Football League (2016). NFL, NFLPA announce policy to enforce concussion protocol. *National Football League*. Retrieved from <http://www.nfl.com/news/story/0ap300000676669/article/nfl-nflpa-announce-policy-to-enforce-concussion-protocol>
- NFL Evolution. (2013). Evolution of the rules: from hashmarks to crackback blocks. *National Football League*. Retrieved from <http://www.nfl.com/news/story/0ap1000000224872/article/evolution-of-the-rules-from-hashmarksto-crackback-blocks>
- Omalu, B. I., DeKosky, S. T., Minster, R. L., Kamboh, M. I., Hamilton, R. L., & Wecht, C. H. (2005). Chronic Traumatic Encephalopathy in a National Football League player. *Neurosurgery*, 57(1), 128-134. Retrieved from <http://www.jeannemarielaskas.com/wp-content/uploads/2015/10/CTE-NFL-part-1.pdf>
- Pro Football Reference. (2017). Injury report. *Pro Football Reference*. Retrieved from <http://www.pro-football-reference.com/>
- Ruestow, P. S., Duke, T. J., Finley, B. L., & Pierce, J. S. (2015). Effects of the NFL's amendments to the free kick rule on injuries during the 2010 and 2011 seasons. *Journal of Occupational and Environmental Hygiene*, 12(12), 875. Retrieved from <http://search.proquest.com/docview/1733197021?accountid=36317>
- Small, G. W., Kepe, V., Siddarth, P., Ercoli, L. M., Merril, D. A., Donoghue, N., ... Barrio, J. R. (2013). PET Scanning of brain tau in retired National Football League players: Preliminary findings. *The American Journal of Geriatric Psychiatry*. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3717700/>
- Schwarz, A. NFL Issues New Guidelines of Concussions. *The New York Times*. Retrieved from http://www.nytimes.com/2009/12/03/sports/football/03concussion.html?_r=1&
- Tator, C. H. (2014). Chronic traumatic encephalopathy: How serious a sports problem is it? *British Journal of Sports Medicine*, 48(2), 81. Retrieved from <http://search.proquest.com/docview/1779358148/fulltext/B7B02051D35491APQ/1?accountid=36317>
- Wilson, B. (2012). Chargers G. Dielman retires due to concussion. *The San Diego Union Tribune*. Retrieved from <http://www.sandiegouniontribune.com/sdut-chargers-g-dielman-retires-due-to-concussion-2012mar01-story.html>

Examining Portrayals of Female Protagonists by Female Screenwriters Using Feminist Critical Discourse Analysis

Brooke Shapiro

This study explores the portrayals of female protagonists by female screenwriters through feminist critical discourse analysis. Specifically, this study examines the female protagonists in the four Academy-Award winning films *Thelma & Louise*, *The Piano*, *Lost in Translation*, and *Juno*. By analyzing the roles and behavior of the female protagonists in these four films, I reveal how these female protagonists each experience the Heroine's Journey, where they transcend their gender constraints and become more independent and empowered. These portrayals by female screenwriters are vital to the off-screen sector of the film industry because of the Social Cognitive Theory of Gender Development and Differentiation, which states that human beings gain knowledge from the messages communicated to them by the media. Therefore, I conclude that the existing gap between female and male screenwriters must be closed to counter the reinforcement of gender roles and stereotypes, as well as ensure that women are inspired, not discouraged, by what they see on screen.

Keywords: feminist critical discourse analysis, feminist film analysis, female screenwriters, male gaze, Heroine's Journey, female protagonists

Introduction

Throughout history, women have struggled to make themselves heard, not just seen. The media has failed to reflect this, as women are vastly underrepresented on all media platforms, especially film. Considering that people's (especially those of younger ages) perceptions of themselves and others are directly affected by media exposure, the absence of women in film (on-screen and off-screen) creates a major issue: presentations of women are distorted and not truly representative of their roles in society.

In terms of screenwriters, only four women have managed to break through the celluloid ceiling: Callie Khouri (*Thelma & Louise*), Jane Campion (*The Piano*),

Sofia Coppola (*Lost in Translation*), and Diablo Cody (*Juno*). They are the only women who have received the Academy Award for "Writing (Original Screenplay)" for a solo-authored script in the 75 years this award has been given. This study investigates how these four writers portrayed female protagonists in their award-winning films — *Thelma & Louise*, *The Piano*, *Lost in Translation*, and *Juno* — in order to determine the value of the female voice in the film industry. By examining the character traits of each female protagonist in these four films and identifying patterns among these characters, a generalization can be drawn about how female screenwriters depict females in their films and whether these portrayals are accurate and representative of the female experience.

Review of Literature

Gender Hierarchy and the Social Construction of Femininity

Gender inequality plays a significant role in how female protagonists are typically portrayed. Part of this is due to the existence of the gender hierarchy, which is described as “an ideological structure that divides people into two classes, men and women, based on a hierarchical relation of domination and subordination, respectively” (Lazar, 2007). The paradigm of gender hierarchy thus restricts the woman’s ability to define and assume her identity. According to N’Guessan (2011), “...gender relations makes the woman a constructed ‘other.’ Overall, as it is well-known because her physique does not allow her to execute some tasks that require the use of force, the woman is wrongly and purposely considered as the weaker sex.” Therefore, a plethora of expectations for women arises out of this assumption that women are weaker and more fragile. These expectations form the basis of traditional feminine ideology, which describes the attributes, behaviors, and roles traditionally and stereotypically associated with girls and women.

Without truly understanding the female experience, male screenwriters might adopt traditional feminine ideology when portraying females, restricting them to traditional gender roles. Thus, it is important to understand what those traditional feminine norms are when interpreting portrayals of female protagonists. In a broad sense, two different sets of expectations exist related to women: behavioral and physical. Various normative messages associated with femininity include “be nice, focus on relationships, be attractive, be thin, nurture others, be silent, defer to men, and be domestic” (Mahalik et al., 2005). In terms of their behavioral roles, women are often described as “homemakers and careers of the family, dependent on men, or as objects of male attention” (Kangas, Haider, Fraser, & Browne, 2014). Women’s traditional roles also tend to be related to nurturance, passivity, and dependence (Bem, 1993).

Physically, the cultural image of women emphasizes a slender body with trim hips (Mazur, 1986). Additionally, sexual characteristics of young women include “general roundness rather than angularity, fleshiness rather than flaccidity, unblemished and

smooth rather than saggy skin, and symmetry” (Mazur, 1986). However, the current societal standards for women, especially the beauty standard of thinness, are unrealistic and pervasive (Heinberg, 1996).

Some suggest that media is the most potent communicator of such sociocultural standards (Thompson & Heinberg, 1999). This is partly due to the “ready accessibility and universality of today’s print and electronic media,” and the fact that “print and electronic media images blur the boundaries between a fictionalized ideal and reality” (Thompson & Heinberg, 1999). Media promotes an unbalanced vision of the roles of women and men in society (Kangas et al., 2014), as it falsely implies that men are the cultural standard and that women are unimportant or invisible (Wood, 1994).

Women in Film (On-Screen)

Females are underrepresented in films, relative to men, in their numbers, roles, and views. Particularly, female protagonists in films are vastly outnumbered by male protagonists. In Dr. Martha M. Lauzen’s study of 2,500 characters in the top 100 films of 2015, titled “It’s a Man’s (Celluloid) World: Portrayals of Female Characters in the Top 100 Films of 2015,” she reports that females comprised only 22% of protagonists in the top 100 films of 2015. Another study found similar results: “Inequality in 800 Popular Films: Examining Portrayals of Gender, Race/Ethnicity, LGBT, and Disability from 2007-2015” reports that out of 4,730 speaking characters, 68.6% were male and 31.4% were female in the 100 highest grossing films of 2015 (Smith, Piper, & Choueiti, 2016). Therefore, recent films lack strong female roles and instead tend to showcase men.

Meanwhile, female characters are portrayed in accordance with traditional feminine ideology. In films, women are usually dependent on other characters, overemotional or sensitive, and are restricted to low-status jobs (Bussey & Bandura, 1999). Female characters often spend their time improving their appearances and taking care of homes and people (Wood, 1994). The reason for this portrayal is posited by the feminist film theorist Laura Mulvey in her essay “Visual Pleasure and Narrative Cinema” (1974). Mulvey states, “In their traditional exhibitionist role women are simultaneously looked at and displayed, with their appearance coded for strong visual and erotic impact

EXAMINING PORTRAYALS OF FEMALE PROTAGONISTS

so that they can be said to connote to be-looked-at-ness.” Thus, Mulvey argues that the use of females in films is to provide a pleasurable experience for male viewers, which she terms the “male gaze.” Mulvey provides this quote from Budd Boettichier:

What counts is what the heroine provokes, or rather what she represents. She is the one, or rather the love or fear she inspires in the hero, or else the concern he feels for her, who makes him act the way he does. In herself the woman has not the slightest importance.

Mulvey characterizes a typical film as beginning with the female protagonist displayed as the object of both the audience and the male protagonists in the film, as she is isolated and sexualized. This is supported by the study “Inequality in 800 Popular Films: Examining Portrayals of Gender, Race/Ethnicity, LGBT, and Disability from 2007-2015,” which found that females were over three times as likely as males to be shown in sexually revealing clothing or nude in the 100 top-grossing films of 2015 (Smith et al., 2016). Mulvey further explains that the female protagonist falls in love with the male protagonist and becomes his property throughout the narrative.

Women in Film (Off-Screen)

In part, the reason that females are misrepresented and underrepresented is because of the lack of females in the off-screen sector of film. Of the 1,365 directors, writers, and producers of the 100 top grossing films of 2015, 81% were males and 19% were females (Smith et al., 2016).

According to Dr. Martha M. Lauzen’s study titled “The Celluloid Ceiling: Behind-the-Scenes Employment of Women on the Top 100, 250, and 500 Films of 2016,” women comprised 17% of all directors, writers, producers, executive producers, editors, and cinematographers who worked on the top 250 domestic grossing films of 2016, representing a decline of two percentage points from 2015. The same study found that 77% of the 250 films lacked female writers. In another study by Lauzen titled “Women and the Big Picture: Behind-the-Scenes Employment on the Top 700 Films of 2014,” 80% of the top 700 theatrically released films of 2014 had no female writers.

Consequently, the lack of female writers in the film industry translates to the number of awards bestowed on female writers. The Women’s Media Center study titled “WMC Investigation: 10-Year Analysis of Gender & Oscar Nominations” found that 86% of those nominated for the Writing (Original Screenplay) award from 2006-2015 were men, while only 14% were women. In this category, no more than two female writers were nominated each year during the period studied (except in 2007), which contrasted the fact that the number of male writers in this category “never falls below four in each year.” In 2009, 2012, and 2014, no female writers were nominated at all. Between 2009 and 2015, only one woman won in this category (*Diablo Cody, Juno*). In total, only four female screenwriters have won an award in this category in the history of the Academy Awards.

Theoretical Framework

Two theories lay the foundation for understanding the implications of inaccurate portrayals of females in film: Social Cognitive Theory of Gender Development and Differentiation and Objectification Theory. The Social Cognitive Theory of Gender Development and Differentiation provides insight into the ways in which humans develop ideas about their gender identities. Bussey and Bandura (1999) wrote:

Children develop the stereotypic conceptions of gender from what they see and hear around them. Once they achieve gender constancy- the belief that their own gender is fixed and irreversible- they positively value their gender identity and seek to behave only in ways that are congruent with that conception.

According to Bussey and Bandura’s theory, individuals base their own behavior on behaviors they have observed in memory. Thus, adolescents’ perceptions of the world are affected by the media they are exposed to and the stereotypes they communicate, as “younger viewers with few of their own experiences to compare against may come to view these representations as cultural norms and form unrealistic relationship beliefs and expectations accordingly” (Johnson & Holmes, 2009). “As children gain mobility and

EXAMINING PORTRAYALS OF FEMALE PROTAGONISTS

competencies to act on the environment they begin enacting behavior that is socially linked to gender and experiencing social reactions" (Bussey & Bandura, 1999). By age five, children have already developed clearly defined ideas of what is considered appropriate behavior for men and women (Mahalik et al., 2005). Therefore, inaccurate portrayals of women in film and media reinforce gender roles and communicate those gender roles to children.

Bussey and Bandura also posit that gender development is a fundamental issue to humans because "the talents they cultivate, the conceptions they hold of themselves and others, the sociocultural opportunities and constraints they encounter, and the social life and occupational paths they pursue are heavily prescribed by societal gender-typing." Therefore, reinforcing gender stereotypes to females through media affects their outlook, as well as the choices they make.

Objectification Theory also reveals how inaccurate portrayals of females can have long-lasting impacts on the females exposed to such portrayals. This theory, proposed by Fredrickson and Roberts, aims to highlight the "lived experiences and mental health risks of girls and women who experience sexual objectification" (Fredrickson & Roberts, 1997). Fredrickson and Roberts state, "This perspective on self can lead to habitual body monitoring, which, in turn, can increase women's opportunities for shame and anxiety, reduce opportunities for peak motivational states, and diminish awareness of internal bodily states." Therefore, displaying females as objects can create mental health risks for women, such as eating disorders, sexual dysfunction, and unipolar depression (Fredrickson & Roberts, 1997). It is clear that a lack of female screenwriters to provide accurate portrayals of females can be extremely detrimental to the lives and wellness of girls and women.

Based on the literature and theory presented above, the following questions are proposed to determine how female protagonists are portrayed by female screenwriters.

RQ1: How do the female screenwriters of *Thelma & Louise*, *The Piano*, *Lost in Translation*, and *Juno* portray female protagonists?

RQ2: Are these portrayals of female protagonists accurate portrayals of the female experience?

H1: Because these films were written by females, the portrayals of female protagonists will be accurate and representative of the female experience.

Method

In this research, I performed a qualitative analysis of the four films to receive the "Writing (Original Screenplay)" Academy Award solo-authored by females to evaluate the portrayal of female protagonists by their female screenwriters. These four films were chosen to represent films written by females over other female-authored scripts because of their recognition by the Academy of Motion Picture Arts and Sciences as the best examples of writing in the year they received the award.

Because this research is of an exploratory nature, a qualitative analysis of female protagonists in these four films is appropriate. In The SAGE Handbook of Qualitative Research (1994), Dr. Yvonna S. Lincoln and Norman K. Denzin define qualitative research as interpretative and "guided by the researcher's set of beliefs and feelings about the world and how it should be understood and studied" (p. 22). I am interested in feminism and media portrayals of females, therefore the interpretations I make while researching this topic are influenced by these interests and my own beliefs. Thus, I fully recognize my bias while investigating the portrayals of female protagonists in these films.

Feminist critical discourse analysis constitutes the framework for analyzing the four films. According to Michelle M. Lazar (2007), feminist critical discourse analysis aims to "show up the complex, subtle, and sometimes not so subtle, ways in which frequently taken-for-granted gendered assumptions and hegemonic power relations are discursively produced, sustained, negotiated, and challenged in different contexts and communities" (p. 142). Thus, Lazar explains that the task of feminist critical discourse analysis is "to examine how power and dominance are discursively produced and/or (counter-)resisted in a variety of ways through textual representations of gendered social practices, and through interactional strategies of talk" (p. 149). Therefore, I will be analyzing the interactions between characters within each film and determining what these interactions reveal about the roles and behaviors of female protagonists.

The four films, *Thelma & Louise*, *The Piano*, *Lost in*

EXAMINING PORTRAYALS OF FEMALE PROTAGONISTS

Translation, and *Juno*, were selected by reviewing the Oscars website (OSCARS.ORG), and looking at the winners of the “Writing (Original Screenplay)” award each year beginning in 1941, when it was first awarded according to the Oscars website. After completing the review, it was determined that *Thelma & Louise*, *The Piano*, *Lost in Translation*, and *Juno* were the only four films to have received this award and been solo-authored by female writers. The four films were obtained from the iTunes Store and Amazon Video.

This study began with a viewing of each film and a qualitative examination of the female protagonist(s) in each film. The female protagonists were evaluated for certain elements: the role each female protagonist played (in relation to men and their occupation) and how they reacted to their role, how their role compared to stereotypical portrayals of females and traditional feminine ideology (as presented in the above “Review of Literature”), and how the protagonists were displayed (in a sexual manner or nonsexual manner). Field notes were taken in the table below to record any observations made (stated in “Findings & Analysis”).

The films were then viewed for a second time, searching for specific examples of the elements that were to be observed during the first viewing. This second viewing ensured continuity and consistency, as well as validated initial observations. Similarities and patterns between female protagonists were also

identified to find a common thread and theme among portrayals of females by female screenwriters.

Prior to the second viewing of each film, the screenplays were obtained from the internet to assist in the identification of specific examples of the elements that were to be observed during the first viewing. Field notes were written directly on each screenplay. Each screenplay was obtained by searching the title of each film followed by the word “screenplay.” To ensure that these screenplays were accurate, being that they were not obtained from a verified source, each screenplay was read carefully while the film was playing to make sure that the lines written in the screenplay matched those in the film. Following the second viewing, each screenplay was read twice. Quotes were pulled from the screenplays.

Findings and Analysis

This study analyzes the portrayals of female protagonists in *Thelma & Louise*, *The Piano*, *Lost in Translation*, and *Juno*. Using feminist critical discourse analysis, I explored the roles and behavior of the female protagonist in each film. Specifically, I watched each film twice and took field notes during each film to record my observations and interpret the texts that were presented in the films. I also further examined

Table 1
Field Notes

Character/Actress	Film	Observations
Thelma (Geena Davis)	<i>Thelma & Louise</i>	
Louise (Susan Sarandon)	<i>Thelma & Louise</i>	
Ada McGrath (Holly Hunter)	<i>The Piano</i>	
Charlotte (Scarlett Johansson)	<i>Lost in Translation</i>	
Juno MacGuff (Ellen Page)	<i>Juno</i>	

EXAMINING PORTRAYALS OF FEMALE PROTAGONISTS

the portrayals of female protagonists by reading the screenplays of each film twice.

To better understand the findings of this research, I have provided brief synopses of each film. *Thelma & Louise* (1991), written by Syrian-American screenwriter Callie Khouri, is the story of two friends who embark on a road trip to escape their lives at home. Their trip soon becomes disastrous after Louise shoots and kills a man who tries to rape Thelma at a bar, turning the two friends into outlaws.

The Piano (1993), written by New Zealand screenwriter Jane Campion, is set in the 1850s and is about a mute Scotswoman and pianist, Ada, who has been sold into marriage and forced to move to New Zealand with her daughter, Flora. Once they've arrived, Ada becomes intrigued by another man, George Barnes, who she begins giving piano lessons to.

Lost in Translation (2003), written by American screenwriter Sofia Coppola, is about a conflicted newlywed, Charlotte, and a lonely movie star, Bob Harris, who meet in Tokyo. The two form a meaningful bond as they adventure through Tokyo.

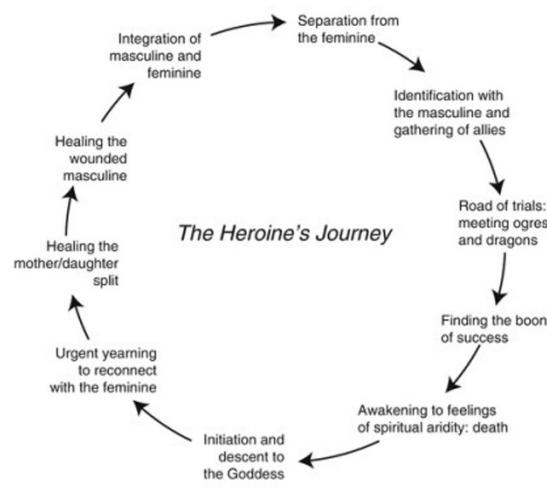
Juno (2007), written by American screenwriter Diablo Cody, is the story of a pregnant teenager, Juno MacGuff, who decides to give her baby to a failed musician and his wife. Complications arise as Juno begins to spend more time with the adoptive father, forcing her to decipher her relationship with this man, as well as the one with her child's actual father.

After viewing the four films, I determined that the female protagonist in each film followed the "Heroine's Journey," a narrative structure created by Maureen Murdock. I noted that each protagonist exemplified male qualities, rather than the characteristics described by traditional feminine ideology, which led me to this model. This model derived from Joseph Campbell's "Hero's Journey" monomyth, a common template for mythology that outlines the different stages of adventure experienced by the hero in a myth or tale (Bronzite, n.d.). The monomyth was clearly designed for male protagonists, which inspired Murdock to create a female-centered version. The Heroine's Journey is about "a heroine who must find balance as she struggles between the sides of a duality," a feminine and a masculine side (Winkle, 2014).

Though the Heroine's Journey was created as a framework for mythology, I will be applying it to contemporary films. Figure 1 provides an overlook of the

Heroine's Journey. This chart was obtained from Maureen Murdock's website.

Figure 1
The Heroine's Journey



The heroine's journey begins with "Separation from the feminine" and ends with "Integration of masculine and feminine."

Murdock's model is specific to mythology, so identifying each phase of the Heroine's Journey in contemporary films is not possible, as each phase is not clearly defined nor present in these four films. However, overlying themes take place within the Heroine's Journey in each of the films.

General Interpretative Findings

After performing feminist critical discourse analysis, I noticed a few common trends among the four films that provide evidence that the Heroine's Journey occurred in each film: a sense of awareness concerning their gender roles and constraints, the presence of masculinity in each female protagonist, their ability to transcend their gender roles, and individualism and choice. These trends are revealed through isolation, rejection of the male gaze, and within their relationships with other characters.

Isolation

In each film, the female protagonist is presented as isolated, which is visible in both her physical and mental state. For example, Ada (*The Piano*), is forced to move from Scotland to a remote part of New Zealand amid an Aboriginal society to live with her new husband in an arranged marriage. Even more isolating is the fact that she is mute. Physical and mental isolation also occurs in *Lost in Translation*, as Charlotte is isolated in both her hotel room and Japan, presenting a significant cultural and language barrier for the young American wife as she accompanies her husband on a business trip. Meanwhile, Juno (*Juno*), is a pregnant teenager which is culturally and socially isolating and seemingly has little family support, forcing her to make major decisions alone. Thelma (*Thelma & Louise*) is isolated within her home, waiting for her neglectful husband to come home so that she may serve him.

However, each female protagonist eventually finds a way to escape this isolation. This is like her “call-to-action,” a key component of the Hero’s Journey. Her transcendence of her isolation signifies the beginning of her journey. For example, Thelma (*Thelma & Louise*) escapes her isolation within her home by leaving town on a road trip with her friend Louise without telling her controlling husband. In *Lost in Translation*, Charlotte decides to make something out of her vacation by going on various adventures with Bob, a man she meets in the bar of her hotel. The ability of these female protagonists to overcome their isolation is where these films differ from the typical film that Mulvey (1974) describes (as presented above in the “Review of Literature”), where she is initially presented as isolated and on display.

Presentation of the Male Gaze and its Subsequent Rejection

Mulvey (1974) describes the typical narrative arc as the female character becoming the property of the male character, allowing the spectator of the film to “directly possess her too.” Not only can this be achieved through the narrative, such as when Ada (*The Piano*) is sold off to an arranged marriage by her father, but can also be accomplished visually through camera angles and shots. For example, close-ups of

Ada’s hands, arms, and bare skin are shown while she is playing piano. Likewise, Charlotte (*Lost in Translation*) is shown sitting in underwear in her hotel room, waiting for her husband to return. The camera pans her body and provides close-up shots of Charlotte’s legs and face, which integrates eroticism into the narrative (Mulvey, 1974). Physically, these female protagonists are built as a female is portrayed culturally, according to Mazur (1986): slender and unblemished.

Eventually, each female protagonist rejects the male gaze, as well as her portrayal as a sexual object. The most explicit example occurs when Thelma (*Thelma & Louise*) begins to resent her role as the subordinate housewife, as seen in Figure 2. In this conversation, Thelma is discussing the fact that she left town with Louise without telling her husband, Darryl. Her dismissal of her position within the household indicates that she no longer wishes to be viewed as an object.

Figure 2
Thelma & Louise Screenplay

Thelma: I've never been out of town without Darryl.

Louise: How come he let you go?

Thelma: 'Cause I didn't ask him.

Louise: Aw, shit, Thelma, he's gonna kill you.

Thelma: Well, he'd have never let me go. He never lets me do one goddamn thing that's any fun. All he wants me to do is hang around the house the whole time while he's out doing God only knows what.

Each protagonist’s rejection of the male gaze is accompanied by her discovery of her masculine side. As she rejects the male gaze, she begins to embrace the masculine parts of herself and identify with the men around her.

Use of Relationships to Explore Feminine and Masculine Sides

The final part of the Heroine’s Journey is the “integration of masculine and feminine.” In each film, this occurs in the context of each protagonist’s relationships. Throughout the films, each female protagonist

EXAMINING PORTRAYALS OF FEMALE PROTAGONISTS

uses the relationships present in her life to discover her feminine and masculine sides, unify them and express herself freely, without constraints.

For example, Thelma (*Thelma & Louise*) finally gains the courage to stand up to her controlling husband, exhibiting her masculine side, as seen in Figure 3. This can also be seen in *Lost in Translation*, when Charlotte rejects the role of dutiful wife to spend the rest of her vacation with her new friend Bob. The female protagonist begins to identify with the men around her, not as an object but rather as their equal.

Figure 3
Thelma & Louise Screenplay

Darryl: What in the hell do you think you're doing? Have you lost your goddamn mind?! Is that it? I leave for work and you take complete leave of your senses?

Thelma: Darryl...baby...Darryl, calm down now, honey. Please don't get so mad. I can explain...

Darryl: No you won't. You'll be back today. Now! You get your ass back here, Thelma, now, Goddamnit. Thelma, do you understand me?

Thelma: You're my husband, not my father, Darryl.

However, each female protagonist eventually recognizes the importance of her feminine side, leading her to reincorporate the feminine, which (once again) she accomplishes using her relationships. Although Thelma (*Thelma & Louise*) has departed from her life of subordination and has now entered one of independence, she is still in touch with her feminine side, as she falls for an attractive young man she meets on the road. Additionally, Juno (*Juno*) rediscovers her feminine side by finally accepting the feminine behavior of her step-mother and the mother she is going to give her baby up to for adoption, behaviors that at she had initially rejected.

Upon the reincorporation of her feminine side, each female protagonist discovers that she must find a way to unite the masculine and feminine sides she has learned about throughout her journey. This is presented as a realization or epiphany. For example, Thelma's (*Thelma & Louise*) "union" of her feminine and masculine sides occurs at the end of the film, when she

and Louise are cornered by the police near the edge of the Grand Canyon. Thelma and Louise realize that Thelma could finally be herself, free of gender constraints, as seen in Figure 4. Thelma realizes that she cannot go back to a world of confinement and isolation, as she decides to drive off the cliff into the Grand Canyon. She determines her own destiny, finally.

Meanwhile, Juno's union is the realization she is in love with the father of her child, during a frank conversation with her own father (Figure 5). Juno thus discovers that she is independent while still vulnerable enough to love someone else. While Ada (*The Piano*) initially conforms to her feminine role by submitting to her arranged marriage and allowing herself to serve as a sexual object for her piano client, she comes to realize that she is attracted to her client. She displays her duality by taking equal ownership of the extra-marital relationship. The stage direction from that portion of the script clearly spells out the moment of unity for Ada (Figure 6).

Figure 4
Thelma & Louise Screenplay

Thelma: I guess I went a little crazy, huh?

Louise: No...you've always been crazy. This is just the first chance you've had to really express yourself.

Figure 5
Juno Screenplay

Mac: In my opinion, the best thing you can do is to find a person who loves you for exactly what you are. Good mood, bad mood, ugly, pretty, handsome, what have you, the right person will still think that the sun shines out your ass. That's the kind of person that's worth sticking with.

Juno: I sort of already have.

EXAMINING PORTRAYALS OF FEMALE PROTAGONISTS

Figure 6
The Piano Screenplay

ADA is flushed, shocked, the two face each other at this very moment of profound awareness of each other, profoundly equal. With each new breath, with every moment that their eyes remained locked together the promise of intimacy is confirmed and reconfirmed and detailed until like sleepwalkers who do not know how they came to wake where they did, they are standing next to each other and beginning to kiss each other, the lips, the cheeks, the nose.

Analysis of the Findings

The findings, observations, and interpretations in this study provide insight into the way female screenwriters portray their female protagonists. Specifically, these findings reveal that female screenwriters tend to portray females as empowered and independent individuals. However, this finding is entirely based on interpretation and opinion. Through a postfeminist lens, I interpreted that the discourse within each film revealed that the female protagonists were able to take full control of their situations, choosing their individual courses of action based on their own desires and needs.

The protagonists of each film embody the characteristics of the postfeminist movement, which is “a new form of empowerment and independence, individual choice, (sexual) pleasure, consumer culture, fashion, hybridism, humour, and the renewed focus on the female body” (Adriaens, 2009). Postfeminism rejects the notion that females cannot be feminine or sexual if they want to be independent and empowered. Instead, it focuses on embracing both the feminine and the masculine. This is exactly what each female protagonist does during the Heroine’s Journey. Each female protagonist discovers the unity between their masculine and feminine sides throughout the Heroine’s Journey, learning that they can make their own choices and express themselves while still being in relationships with members of the opposite sex.

Successful female screenwriters, therefore, embrace portions of traditional feminine ideology. Instead of completely rejecting the traditional roles of women, these screenwriters recognize the existence of such roles. Each female protagonist is fully aware of

her place in society, as property and object, but she learns to overcome her position as subordinate and instead take control of how others perceive her. The screenwriter takes the female through a journey of unification, showcasing true female empowerment.

Implications and Conclusion

Upon discovering that there was an overlying trend among the four films analyzed for their portrayals of females, it was concluded that female screenwriters in general portray females as empowered and independent individuals by putting their female protagonists through the Heroine’s Journey. Whether such a portrayal is accurate and representative of all real-life females, as my original hypothesis suggested, cannot be concluded. However, whether or not female screenwriters present female characters in a realistic manner, I believe that they, particularly the writers of the four films examined, are using their female protagonists to inspire viewers to examine and question gender constraints.

This has important implications considering the lack of female screenwriters in the film industry. According to the Social Cognitive Theory of Gender Development and Differentiation, human beings develop their ideas about gender from their environment and the messages communicated to them through media. Therefore, it is crucial that females see empowered women in films and other forms of media to gain an understanding of their full value in society, as more than an object. It is important that women are inspired by what they see on screen, rather than discouraged. Equally important is for males to see empowered and independent females in films, rather than sexualized and stereotypical versions of females, to create understanding and tolerance between the two genders. This must begin with the closure of the gap between men and women in the off-screen sector of film, allowing for the incorporation of the female voice in narrative film. Female screenwriters, as well as directors, producers, and other off-screen occupations, are essential to the film industry because they can provide insight into the female experience and help create a media that teaches understanding and respect among human beings.

Limitations and Suggestions for Future Directions

As stated previously, the results of this research were based solely on interpretation and opinion. Another researcher could have different interpretations of the discourse in these four films, as this research was qualitative. My perspective is different from someone else's perspective; therefore, my interpretation is unique. Perhaps a more quantitative study into this topic could be performed to draw more concrete conclusions, such as a study that quantified specific elements within each female protagonist or used surveys and focus groups to determine the impact of these films and their portrayals of females on real-life women.

My research was also limited in its scope. A key assumption in my research was that these four Academy Award-winning films accurately represent all films written by females. However, I could not adequately research all films ever created by females. For sake of time and quality, I limited my scope to these four award-winning films. Further research could be conducted by looking at a greater range of films written by females, perhaps in different genres or over certain time periods. These films could also be compared to films solo-authored by male screenwriters to determine how portrayals of female protagonists differ between male and female screenwriters. An assumption in my research was that female writers will write most convincingly in a female voice and are more capable of creating empowered portrayals of women. However, male screenwriters could be able to portray females in such a manner. Therefore, further research could be done to confirm the assumption that women are more capable of portraying women in an empowering fashion by examining whether male screenwriters incorporate the Heroine's Journey into films that feature female protagonists.

Despite these limitations, a qualitative analysis of these four films reveals some important trends in the depiction of women by female screenwriters. While it is evident that females are vastly underrepresented both on-screen and off-screen, female screenwriters write from their internal, unique perspective. Female viewers can relate to these writers' depictions of the female experience, one that incorporates the patriarchal expectations set upon women and the duality that exists for females to navigate that world. Those

viewpoints and experiences are distinct to females and while a man is apt to portray the female experience, he is limited by his imagination, rather than his experience. Therefore, authentic female voices must be heard.

References

Primary Sources:

- Campion, J. (Screenwriter & Director). (1993). *The Piano* [Motion picture]. United States: Miramax Films.
- Campion, J. (1993). *The Piano* [Screenplay]. Retrieved from https://sfy.ru/?script=piano_the_ds
- Cody, D. (Screenwriter), & Reitman J. (Director). (2007). *Juno* [Motion picture]. United States: Fox Searchlight Pictures.
- Cody, D. (2007). *Juno* [Screenplay]. Retrieved from <http://screenplayexplorer.com/wp-content/scripts/Juno.pdf>
- Coppola, S. (Screenwriter & Director). (2003). *Lost in Translation* [Motion picture]. United States: Focus Features.
- Coppola, S. (2003). *Lost in Translation* [Screenplay]. Retrieved from <http://www.dailyscript.com/scripts/lost-in-translation-script.html>
- Khoury, C. (Screenwriter), & Scott, R. (Director). (1991). *Thelma & Louise* [Motion picture]. United States: Pathé Entertainment.
- Khoury, C. (1991). *Thelma & Louise* [Screenplay]. Retrieved from <http://www.dailyscript.com/scripts/thelmaandlouise.html>

Secondary Sources:

- Adriaens, F. (2009, November 9). Post feminism in popular culture: A potential for critical resistance? Retrieved from <https://politicsandculture.org/2009/11/09/post-feminism-in-popular-culture-a-potential-for-critical-resistance/>
- Alasutuari, P. (1996). Theorizing in qualitative research: A cultural studies perspective. *Qualitative Inquiry*. Vol 2, Issue 4, pp. 371-384.
- Bem, S. (1993). *The lenses of gender: Transforming the debate on sexual inequality*. New Haven, CT: Yale University Press.
- Bronzite, D. (n.d.). The hero's journey - mythic structure of joseph campbell's monomyth. Retrieved from <http://www.movieoutline.com/articles/>

EXAMINING PORTRAYALS OF FEMALE PROTAGONISTS

- the-hero-journey-mythic-structure- of-joseph-campbell-monomyth.html
- Bussey, K., & Bandura, A. (1999). Social cognitive theory of gender development and differentiation. *Psychological Review*, 106, 676-713.
- Denzin, N. K., & Lincoln, Y. S. (2005). *The SAGE handbook of qualitative research*. CA: Sage Publications, Inc.
- Fredrickson, B. L., & Roberts, T. A. (1997). Objectification theory. *Psychology of Women Quarterly*, 21, 173-206.
- Freeland, C. A. (1996). Feminist film theory. In *Encyclopedia of Aesthetics*. Oxford University Press. Retrieved from <http://www.uh.edu/~cfreelan/courses/femfilm.html>
- Heinberg, L. J. (1996). Theories of body image: Perceptual, developmental, and sociocultural factors. In J. K. Thompson (Ed.), *Body image, eating disorders, and obesity: An integrative guide for assessment and treatment* (pp. 27-48). Washington DC: American Psychological Association.
- Johnson, K. R., & Holmes, B. M. (2009). Contradictory messages: A content analysis of Hollywood-produced romantic comedy feature films. *Communication Quarterly*, 57(3), 352-373. doi:10.1080/01463370903113632
- Kangas, A., Haider, H., and Fraser, E. (2014). Gender: Topic guide. Revised edition with E. Browne. Birmingham: GSDRC, University of Birmingham, UK
- Lazar, M. M. (2007). Feminist critical discourse analysis: Articulating a feminist discourse praxis, *Critical Discourse Studies*, 4: 2, 141-164.
- Lauzen, M. M. (2015). Women and the big picture: Behind-the-scenes employment on the top 700 films of 2014. *The Center for the Study of Women in Television and Film*. Retrieved from http://womenintvfilm.sdsu.edu/files/2014_Women_and_the_Big_Picture_Report.pdf
- Lauzen, M. M. (2016). It's a man's (celluloid) world: Portrayals of female characters in the top 100 films of 2015. *The Center for the Study of Women in Television and Film*. Retrieved from http://womenintvfilm.sdsu.edu/files/2015_Its_a_Mans_Celluloid_World_Report.pdf
- Lauzen, M. M. (2017). The celluloid ceiling: Behind-the-scenes employment of women on the top 100, 250, and 500 films of 2016. *The Center for the Study of Women in Television and Film*. Retrieved from http://womenintvfilm.sdsu.edu/wp-content/uploads/2017/01/2016_Celluloid_Ceiling_Report.pdf
- Mahalik, J. R., Morray, E. B., Coonerty-Femiano, A., Ludlow, L. H., Slattery, S. M., & Smiler, A. (2005). Development of the conformity to feminine norms inventory. *Sex Roles*, 52. doi:10.1007/s11199-005-3709-7
- Mazur, A. (1986). U.S. trends in feminine beauty and overadaptation. *The Journal of Sex Research*, 22(3), 281-303. Retrieved from http://jrsscience.wcp.miamioh.edu/humans_web_04/beauty/feminine.pdf
- Mulvey, L. (1975). Visual pleasure and narrative cinema. *Film Theory and Criticism: Introductory Readings*. Eds. Leo Braudy and Marshall Cohen. New York: Oxford UP, 1999: 833-44.
- Murdock, M. (n.d.). The heroine's journey. In *Encyclopedia of Psychology and Religion*. Retrieved from <http://www.maureenmurdock.com/articles/articles-the-heroines-journey/>
- N'Guessan, K. G. (2011). Gender hierarchy and the social construction of femininity: The imposed mask. *Acta Iassyensis Comparationis*.
- Smith, S. L., Dr., Choueiti, M., & Pieper, K., Dr. (2016, September). Inequality in 800 popular films: Examining portrayals of gender, race/ethnicity, lgbt, and disability from 2007-2015 (Rep.). USC Annenberg. Retrieved from <http://annenberg.usc.edu/pages/~/media/MDSCI/Dr%20Stacy%20L%20Smith%20Inequality%20in%20800%20Films%20FINAL.ashx>
- The Oscars. (n.d.). Retrieved from <http://www.oscars.org/oscars/ceremonies>
- Thompson, J. K., & Heinberg, L. J. (1999). The media's influence on body image disturbance and eating disorders: We've reviled them, now can we rehabilitate them? *Journal of Social Issues*, 55(2), 339-353. Retrieved from <https://pdfs.semanticscholar.org/35e0/110e4ec46edd06fe954c54a5dec02d36be3d.pdf>
- Winkle, C. (2014). Using the heroine's journey. Retrieved from <http://mythcreants.com/blog/using-the-heroines-journey/> WMC Investigation: 10-Year Analysis of Gender & Oscar Nominations (2016). Retrieved from <http://www.womensmediacenter.com/>
- Wood, J. T. (1994). Gendered media: The influence of media on views of gender. *New York University*. Retrieved from <http://www.nyu.edu/classes/jackson/causes.of.gender.inequality/Readings/Wood%20-%20Gendered%20Media%20-%2094.pdf>

Immune Cell Responses to Amyloid-Beta Proteins: What is the Extent and Implications of Amyloid-Beta Induced Cytotoxicity in Microglial Cells and Peripheral Blood Mononuclear Cells?

Annie Cao

Alzheimer's disease (AD) is a neurodegenerative disease with cognitive and physical symptoms. Scientists generally accept the amyloid cascade hypothesis as the defining focus of AD pathology. Past studies have indicated that A β oligomers induced cytotoxicity in immune cells, but the role of A β monomers has remained largely unexplored. The purpose of this study is to confirm the cytotoxicity exhibited by A β oligomer and immune cell interactions, and to discover whether A β monomer interactions will produce a similar response. We used lyophilized A β peptides to generate monomers and oligomers, and then added them into cultured BV2 microglial cells and peripheral blood mononuclear cells (PBMCs). After incubation, we used a Glo-Assay procedure to measure A β induced cytotoxicity based on cell viability. Ultimately, it was found that A β oligomers were more prone to induce cytotoxicity than monomers. The results imply that PBMCs show a greater sensitivity to A β proteins than microglial cells.

Keywords: Alzheimer's disease, amyloid-beta, microglia, PBMCs

Introduction and Lit Review

Alzheimer's disease (AD) is a progressive neurological disease that is marked by cognitive and mental decline. According to the Alzheimer's Association, a leading non-profit healthcare organization in global AD funding and research, it is the most common form of dementia and is the sixth leading cause of death in the United States. As of 2016, over 5.4 million Americans have been diagnosed with AD. By 2050, the number is expected to nearly triple. Along with other forms of dementia, AD treatments cost \$236 billion nationally (Alzheimer's Association, 2016). In terms of both mortality rates and financial costs, AD has proven to be a costly disease. Despite its prevalence in many areas of society, AD is often overlooked, especially when compared to illnesses such as cancer and various cardiovascular diseases.

AD is most prevalent among people above 65 years of age, but symptoms can manifest among younger age groups. Although the primary risk factor associated with the illness, symptoms of the disease differ from those of the natural aging process. In addition to memory loss, chronic memory lapses, delayed cognitive responses, AD patients progressively lose the ability to perform daily functions, and in moderate to severe cases, become dependent upon a caregiver (Mayo Clinic Staff, 2015). AD is burdensome not only to the patient and their loved ones but also to caregivers. It disrupts the daily lives of those affected and presents itself as both an emotional and financial burden. In addition to aging, factors such as genetics and lifestyle choices also play a role in determining an individual's likelihood to be affected by AD. Unlike some illnesses triggered by viruses or bacteria, researchers are not able to define a strict combination of variables

IMMUNE CELL RESPONSES TO AMYLOID-BETA PROTEINS

that stimulate the growth of AD. Because of this inability to identify what causes AD, virtually everyone is at risk to be affected by the disease in one way or another. This is one of the many reasons why AD has is such a complex but necessary issue to explore.

Despite the millions of dollars of annual contributions to AD research, no cure for the disease has yet been found. Currently, the US Food and Drug Administration (FDA) has approved two classes of drug treatments known as cholinesterase inhibitors and memantine to alleviate the cognitive symptoms of AD (Alzheimer's Association, n.d.). According to the National Institute on Aging, a department of the National Institutes of Health (NIH), these drugs regulate neurotransmitters and offer temporary relief for memory and cognitive issues. These medications only address the symptoms that manifest among patients and are unable to eliminate or reverse the damaging effects of the disease. They also cause side effects such as vomiting and nausea, and the effectiveness of each medication can vary greatly from patient to patient (Alzheimer's Association, n.d.). Many clinical trials testing immunization therapies and physical and cognitive training are also being explored (NIH, n.d.). In order for a truly effective treatment to be found for AD, however, it is necessary to target the underlying causes of the disease. In doing so, greater measures can be taken to prevent the first indications of AD from occurring.

The wide variety of factors that may influence an individual's risk of AD are largely debated, but its physiological effects on the brain are more established. Since AD is a debilitating neurological illness, it poses the greatest damage on neurons in the brain. When compared to a healthy brain, an AD-ridden brain is typically smaller in size due to brain atrophy (deterioration of the brain) from a loss of neurons. Abnormal protein deposits known as amyloid plaques and tau tangles have also been found to appear in brain, hindering communication between neurons that later leads to cell death (NIH, 2016). The majority of existing and ongoing AD research is focused on why these deposits form in the brain and what actions can be taken to clear them and possibly lessen the severity of cognitive and physical symptoms.

The most accepted and discussed theory regarding the cause of AD symptoms is the amyloid cascade hypothesis, which defines amyloid-beta (A β) plaques

as the central focus of AD pathology. A β plaques are composed of A β peptides, which are generated from amyloid precursor proteins (APPs). Under some pathological conditions, APPs develop into plaques through what is known as APP processing. The large volume of published papers detailing the process is a significant indicator of the acceptance of the hypothesis in the scientific community. A publication by Richard O'Brien from the Johns Hopkins Bayview Medical Center and Phillip Wong from the Johns Hopkins University School of Medicine (2011) defines APP as a naturally occurring transmembrane protein with a large ectodomain that protrudes past the cell membrane and an intracellular C-terminus. In APP processing, the ectodomain is first cleaved by the protease

alpha-secretase (α -secretase) or beta-secretase (β -secretase). Cleavage by α -secretase results in the soluble amyloid precursor protein-alpha (sAPP α) fragment. The function of the sAPP α is not clear, but many studies have suggested that it has neuroprotective effects in the brain (Chow et. al., 2010). After the sAPP α is cut off, a piece of the original protein called the carboxyl terminal fragment-alpha (CTF α) remains embedded in the cell membrane. The protease gamma-secretase (γ -secretase) then cleaves the CTF α into an APP intracellular domain (AICD), which is believed to play a role in gene transcription and signal transduction, and a soluble P3 peptide, whose role is largely unknown (Zhang et al., 2011). The α -secretase cleaved sAPP α leads to what is known as a non-amyloidogenic, or non-plaque forming, pathway. In the amyloidogenic pathway, as explained in a publication by a team of biomedical researchers from Xiamen University and the Sanford-Burnham Institute for Medical Research (2011), APP is cleaved by β -secretase rather than α -secretase. The product, the soluble amyloid precursor protein-beta (sAPP β), is detached, and the carboxyl terminal fragment-beta (CTF β) is left in the membrane. Like CTF α , CTF β is cleaved by γ -secretase. The resulting fragments are what distinguish the sAPP α non-amyloidogenic pathway from the sAPP β amyloidogenic pathway. An AICD is formed again, but this time, an A β peptide, rather than the P3 peptide, is generated. The A β peptide is longer and more complex than the P3 peptide. Over time, the sticky A β peptides aggregate to form simple, monomeric proteins known as A β monomers. These monomers then combine to form higher isoforms

IMMUNE CELL RESPONSES TO AMYLOID-BETA PROTEINS

called oligomers. As oligomers congregate, A β fibrils form. Groups of A β fibrils are referred to as plaques. With each aggregation, the protein becomes increasingly insoluble. The insoluble A β plaques situate themselves at the synapses between neurons in the brain and block communication between cells. This disrupts the natural course of nerve impulses as they carry signals throughout the brain, leading to mental decline.

Despite the broad acceptance of the amyloid cascade hypothesis, the theory has undergone much criticism. A study by Sanjay Pimplikar from the Lerner Research Institute's Department of Neuroscience (2008) focused on analyzing the shortcomings and gaps of the hypothesis. Pimplikar (2008) noted that although AD progression is typically associated with advanced plaque development, plaque levels do not actually correspond with the severity of mental symptoms. Consequently, as found by a group of neuroscientists from the University of Southampton in a phase I clinical trial, the clearance of plaques has not been shown to reverse or diminish cognitive activity (Holmes et al., 2008). Post mortem brain scans of both human and mouse models have revealed that some patients with impaired memory do not exhibit plaque growth while conversely, other patients were found to have plaque deposits without any implications of mental decline (Pimplikar, 2008). Echoing these concerns, a publication by a group of researchers from the Neuroscience Department of the Garvan Institute of Medical Research (2014) noted that it would not be accurate to label A β plaques as the primary cause of synapse destruction in the brain due to the uncertainties still surrounding the approach. They cite clinical failures and the difficulty of translating data from studies done on mice models to humans as reasons for concern (Morris, Clark, & Vissel, 2014).

While it is evident that the amyloid cascade hypothesis is not a flawless argument, it remains the most heavily supported by numerous publications. Many studies focus AD treatment on the basis of this hypothesis. The abnormality of A β peptides in the brain is a glaring indicator of a compromised immune system (Józwik et al., 2012). Under normal conditions, the human body's immune system is able to combat illnesses ranging from the common cold to severe infections. A feasible explanation for the body's inability to combat the physiological changes brought

by AD is the impairment of the immune system. It has already been established that the A β protein, in its many forms, has noticeable effects on the brain. By observing these and comprehending immune responses from the brain, the path to repairing the immune system may become clearer.

The primary immune cells in the central nervous system (CNS) are known as microglial cells (or microglia). As described by Hiroaki Wake and R. Fields, from the Nervous System Development and Plasticity Section of a human development institute, the cells are responsible for neural development through phagocytic clearance of dead cells and are crucial to the preservation of a healthy brain. Additionally, microglia have been found to possess the potential to respond to virtually any disturbance of the CNS, including the growth of A β plaques (Nicola & Perry, 2015). Like the validity of the amyloid cascade hypothesis, the implications of activated microglia are widely debated. Emerging evidence has raised controversy over whether or not microglial cells have neurodegenerative or neuroregenerative properties. The reason for this controversy may stem from the changing physiology of the immune cells in aging human bodies.

When stimulated by foreign or invasive substances, microglia become "activated." Activated microglia are known to secrete chemokines, cytokines, and inflammatory proteins, which are biological substances that aid in the defense against diseases in the nervous system (Solito & Sastre, 2012). As with a typical immune response, the secretion of these chemicals is intended to yield neuroprotective effects on the CNS. Because the strength of the immune system declines with age, however, these immune responses are sometimes unnecessarily prolonged and eventually show evidence of neurotoxicity.

A comprehensive review of roughly twenty studies by Wake and Fields (2011) has suggested that with increasing age, factors such as oxidative stress and amplified inflammatory responses have been observed. One reference concluded that rather than support the immune system, the cytokine production of older microglia actually decreased cognitive function. This would explain the adverse effects of microglia in AD brains. Due to mitochondrial changes in the cells, the once beneficial agents of immune response had negative impacts in the brain. These progressive observations, far more than accidental data, are supported by

the findings of Egle Solito and Magdalena Sastre from medical and neuroscience-based research institutes in London (2012). In a similar compilation of various resources, Solito and Sastre recognized that the products emitted by microglia in aged and AD patients had altered expressions compared to those from healthy participants in a study. In translating this knowledge to AD, it was hypothesized that in the early stages of the disease, microglia acts as a protector and in some cases reduced the aggregation of A β . As the severity of AD increases, however, microglia eventually are more harmful than beneficial through their release of the previously mentioned cytokines and chemokines. The belief that microglia loses its protective function in AD is known as the “microglial dysfunction hypothesis” and the similar but distinct “neuroinflammatory hypothesis” attributes exaggerated inflammatory responses as the catalyst for AD (Solito & Sastre, 2012). No matter which theory may be more accurate, both exemplify the altered role of microglia in AD. These findings show the need for more research to better determine how and why these CNS immune cells lose their defensive functions with age.

Apart from microglial cells, the human body also houses peripheral blood mononuclear cells (PBMCs), a type of peripheral cell derived from blood. PBMCs contain white blood cells such as lymphocytes and monocytes, which form the main defensive immune system outside of the neuroimmune system (Arosio et al., 2014). The role of PBMCs in the peripheral nervous system (PNS) is comparable to the role of microglia in the CNS. Although PBMCs and microglia are two distinct classes of cells, multiple studies have shown that PBMCs are capable of differentiating into microglial cells. Akiyama et al.’s study referenced by Aaron Lai and JoAnne McLaurin of the Department of Laboratory Medicine and Pathobiology at the University of Toronto (2012) identified that these peripheral cells were able to pass the blood-brain barrier (BBB) and undergo cell differentiation, the process by which the function of a cell becomes specialized or changes (Akiyama et al., 1996). The differentiation of PBMCs into microglia presents the possibility of PBMCs being used as a biomarker, in addition to the already established microglial cells, in studying AD pathology. Even more revolutionary is the suggestion that differentiated PBMCs may be more effective in the phagocytosis of A β deposits than

microglia. The study reported by Lai and McLaurin implied that PBMCs, not microglia, were responsible for the deterioration of A β . Furthermore, Alain Simard and his colleagues the Department of Anatomy and Physiology at Laval University confirmed this speculation through an *in vivo* study and cited that PBMC monocytes are indeed able to cross the permeable BBB and differentiate into microglia. Simard et al. (2006), like Akiyama et al., hypothesize that most of the observed reduction in protein deposits in the brain can be attributed to PBMCs rather than microglia, and even those microglia may likely be differentiated cells rather than resident immune cells.

As shown by the vast array of studies centered on the analysis of microglia and PBMCs, understanding immune reactions to A β deposits is essential to unlocking the mystery behind AD treatment. These findings pointed the focus of this research paper towards the observation of the response of the body’s central immune cells, microglia and PBMCs, to A β deposits, the main obstacle in AD treatment. There was found to be a relative lack of research done on PBMC interactions with A β proteins. Microglial cell responses, on the other hand, have been more thoroughly studied and documented. The goal of this paper is to confirm the cytotoxic effects of A β oligomers on microglial cells, discover if the same effect is induced by A β monomers, and determine if these cytotoxic patterns persist in PBMCs. It is predicted that the findings will support current knowledge of A β -induced toxicity in microglial cells and show the same or greater cytotoxic response from PBMCs induced by A β .

Methods

One publication by Ma et al. (2016), a group of researchers from various biomedical and biotechnological universities around the nation, for example, investigated the neuroprotective effects of a standardized phenolic-enriched maple syrup extract on A β aggregation and also looked at A β induced neurotoxicity and inflammation in microglial cells. The intent of the study was to determine whether or not a compound of maple syrup would reduce A β fibrillation in an animal model. Although the focus of the maple syrup extract as a preventative substance for AD progression is

irrelevant to this research paper, the process by which Ma et al. measured the effects of A β on microglia proved to be inspirational. The researchers observed the BV2 microglial cell response to A β fibrils. For the purposes of this study, A β monomers and A β oligomers were used in place of fibrils. Monomers and oligomers are less developed than fibrils. By replicating a similar experiment with a less complex version of the same protein, more insight will be gained as to during which stage of A β development the protein first exhibits cytotoxicity. Another modification of Ma et al.'s study was the exclusion of oxidative stress, nitric oxide species measurements, and cytokine levels as indicators of cytotoxicity. The measuring of cell viability (amount of living cells) was kept, but a Glo-Assay procedure was to be used in place of the MTT assay. The addition of PBMCs is another change made to the referenced study. Using PBMCs as well as microglia will show which immune cell makes greater contributions to the advancement or delay of A β progression.

Microglial Cell Culture

A combination of different scientific experiments was used in this study. Frozen BV2 mouse microglial cells were used from a previously established cell line. Mice microglia were used rather than human microglia due to lab availability and the commonplace method of using mouse models in science. BV2 cells were used rather than primary microglial cells due to its high cell proliferation and convenience. Primary microglial cells harvested from a living organism is ideal, but doing so would raise ethical concerns and is a more time consuming method. Stored BV2 cells were used due to better characterization of the cells and the ease of data replication. The cells were retrieved from liquid nitrogen storage and were reconstituted in 10mL cell culture solution containing Dulbecco's Modified Eagle Medium (DMEM), 10% fetal bovine serum (FBS) and 1% penicillin/streptomycin (P/S) in a 25 cm² flask. The flask was then incubated in a CO₂ incubator at 37°C for cell proliferation. The cells were observed under the microscope and maintained daily until 80% confluence was reached for adequate cell growth, about 48 hours. The medium was poured out and the flask was rinsed with a trypsin/EDTA solution. About 3 mL of new trypsin/EDTA was added

and the flask was placed back into the incubator for about five minutes until the trypsin had lifted the cells from the surface of the flask. This was determined by observation. The cells were pipetted in and out to ensure even dispersion of the cells in the solution and to detach the cells from each other. Culture medium was added until the total volume of the solution reached 30 mL. The solution transferred to a 50 mL tube. A 10 μ L sample was aliquoted (divided) from the tube and mixed with 10 μ L of trypan blue dye. Gloves were worn and special caution was taken to avoid direct contact with trypan blue, due to its tendency to stain. A hemocytometer was used to count the number of cells in the sample. 100 μ L of the BV2 cell solution at a concentration of 5x10⁵ cells/mL were added into each well of a 96-well plate. The plate was placed back into the incubator overnight.

PBMC Preparation

Blood cells ordered from a blood bank were re-suspended with RPMI-1640 (a culture medium) at a 1:1 volume with the buffy coat. Peripheral blood mononuclear cells (PBMCs) were obtained by Ficoll-Hypaque gradient centrifugation of the re-suspended blood cells. The cells were then placed into vials (1x10⁷ cells per vial) and frozen. To thaw the PBMC vials rapidly, they were placed in a 37°C degree water bath. The contents were then transferred into pre-labeled 50 mL conical centrifuge tubes with 30 mL RPMI-1640 in order to allow the cells to suspend in the buffer as rapidly as possible. The cells were placed in the centrifuge at 1500 rpm for 5 minutes so the contents could conjugate into a pellet. The supernatant (remaining solution at the top of the tube) was decanted and the pellets were un-clumped to be suspended with 10 mL of RPMI-1640 containing 10%FBS and 1% P/S. The cell concentration was counted using a hemocytometer after being stained with trypan blue. The cell concentration was adjusted to 1x10⁶ cells/mL and add 100 μ l to each well of a 96 well plate and keep at 37°C and 5% CO₂ overnight. The cells were treated with 100 μ l of 2x monomeric A β and oligomeric A β at the designated concentrations, the process of which is described in the following Monomeric and Oligomeric Drug Treatment section.

A β preparation

Monomeric A β preparation.

Lyophilized A β_{1-42} peptide (from Biomer Technology, Cat: 1409-rPEP-02) was first thawed at room temperature for 30 minutes to avoid condensation from forming upon opening the tube. The contents of the vial were then suspended in pre-chilled HFIP (1,1,1,3,3,3-Hexafluoro-2-pipanol) solution at 1 mM. The A β solution was kept in a rotator at room temperature for 24 hours until transparent and colorless (or until they were completely dissolved). The solution was placed on ice for 10-15 minutes. 10 μ L of the solution was then quickly aliquoted in pre-labeled, pre-chilled tubes and stored in -80 °C, or centrifuged in Speedvac at 1000g to evaporate all traces of HFIP for future use.

Oligomeric A β preparation.

HFIP pretreated A β_{1-42} peptides prepared from the previous monomeric A β preparation procedure were reconstituted in DMSO solution to a stock concentration of 5mg/ml. They were diluted with PBS to 62.5 ng per reaction in 10 μ L with 1xPBS. A 10 μ L of mixture of drug and A β peptide were held in a low-retention tube and constantly rotated on a rotator in a 37°C incubator for 48 hours.

Monomeric and Oligomeric Drug Treatment

The 96-well plate was retrieved from the incubator from the microglial cell culture procedure. One tube each of prepared monomeric and oligomeric A β_{1-42} peptide were dissolved in DMSO stock (5 mg/mL) and diluted to a concentration of 20 μ mol into new Eppendorf tubes. Each protein was assigned 6 tubes. The proteins then underwent a series dilution from 10 μ mol to 0.156 μ mol. 100 μ mol of the A β from each tube of the varying concentrations was pipetted and mixed into the designated well on the 96-well plate. Three non-treatment controls containing only cell culture medium were set up on each plate. The plate was then incubated for 24 hours. After incubation, 100 μ L of solution from each well was collected and stored in new tubes and placed in -80°C

storage for future analysis. 50 μ L glow assay solution was pipetted into each well and the plate was placed into a plate reader.

This procedure was repeated with the 96-well plate set up and incubated in the PBMC Preparation section. All of the data gathered from the plate reader was plotted using the GraphPad Prism 8.0 software.

Results and Analysis

A β Induced Cytotoxicity In BV2 Cells

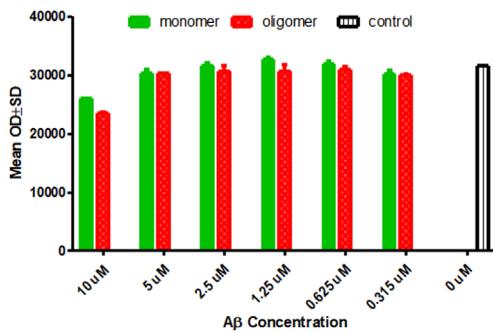


Figure 1. Graph of Glo-Assay results with microglia. This figure displays the results of A β induced cytotoxicity in BV2 cells. OD stands for optical density, which refers to the amount of light absorption of a substance. A higher OD value corresponds with a greater amount of living cells (higher cell viability).

The x-axis of *Figure 1* shows the increasing concentration of A β from the twofold series dilution. The y-axis values represent cell viability. A higher y-axis value corresponds with a higher volume of living cells, while a lower value signifies a larger number of dead cells. The unfilled control bar to the far right of the graph indicates cell viability of the well without A β . Values below the control value, shown with a horizontal line drawn across the graph, was interpreted to indicate cytotoxicity. The results represented in the graph show indications of cytotoxicity for both monomeric and oligomeric A β at 10 μ M ($p < 0.05$) when compared to the control. Between the monomeric and oligomeric A β , the oligomeric A β exhibited a stronger toxicity ($p < 0.05$). At 5 μ M, both isoforms of the protein continued to show toxicity when compared

to the control ($p<0.05$). As the A β concentration decreased, the level of cytotoxicity generally declined. At 1.25 μ M, the monomeric A β was not shown to induce cytotoxicity but the oligomeric form continued to show toxicity compared to the control.

A β Induced Cytotoxicity In PBMCs

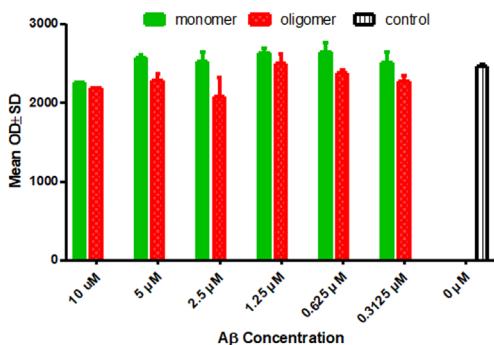


Figure 2. Graph of Glo-Assay results with PBMCs. This figure displays the results of A β induced cytotoxicity in PBMCs. OD stands for optical density, which refers to the amount of light absorption of a substance. A higher OD value corresponds with a greater amount of living cells (higher cell viability).

The graph in *Figure 2* displays the Glo-Assay results of A β induced cytotoxicity in PBMCs. Here, the cytotoxic effects of oligomeric A β compared to monomeric A β are more evident than in *Figure 1*. Similar to the BV2 graph, both forms of the protein indicated toxicity compared to the control well at 10 μ M ($p<0.05$). For the remaining concentrations, the monomeric form showed no indication of toxicity while the oligomers continued to show cytotoxicity, except at 1.25 μ M, which may be attributed to human error in the process of conducting the methods.

Results and Discussion

From the data, it can be concluded that BV2 cells tend to exhibit cytotoxicity to only higher concentrations of both monomeric and oligomeric A β . At low concentrations, a nonexistent or negligible level of toxicity was observed. PBMCs showed a higher

sensitivity to A β . At the highest concentration, both monomeric and oligomeric A β induced toxicity, and oligomeric A β continued to do so at lower concentrations. It can be inferred that at low concentrations, A β can enhance cell proliferation instead of toxicity when reacting to PBMCs.

The data shows that PBMCs are more sensitive to A β proteins, which supports existing findings that PBMCs are more efficient at clearing A β deposits. However, this may have occurred because BV2 is a transformed mouse microglial cell that is resistant to the effects of A β toxicity. PBMC is a primary cell from human blood that has undergone fewer changes and is therefore more inclined to change. Despite these factors, the data suggest that more focus should be centered on the role of PBMCs in AD due to its higher sensitivity to A β peptides. These findings also confirm that in the environment of an AD brain, A β , when formed into oligomers, can induce toxicity to microglia and PBMCs.

The BV2 microglial cells used in this study are representative of the central immune system in the brain. The PBMCs represent the peripheral immune system. Since AD is a disease largely attributed to aging that leads to immunosenescence, or the degradation of the immune system, it is important to analyze the immune system's role in combatting AD. In the peripheral blood system, monocytes from PBMCs possess the ability to migrate into the brain and differentiate into microglial. Therefore, peripheral monocytes may also serve as peripheral blood markers for AD. It is very important to study both microglial and PBMC sensitivity to A β (monomeric and oligomeric). By discovering more about immune cell reactions to abnormal bundles such as A β plaques, scientists can know how to create more effective treatments that will not just alleviate symptoms but eliminate them as well.

Limitations and Future Directions

Due to time constraints, a Glo-Assay procedure measuring cell toxicity was the only procedure run on the BV2 cells and PBMCs. Additional time to develop the project, along with a more extensive background knowledge of AD and immunology and a wider availability of lab resources, would have allowed for a more in-depth and complex study. My lack of education

IMMUNE CELL RESPONSES TO AMYLOID-BETA PROTEINS

concerning the mechanisms of this topic was also a limiting factor on the types of research projects I could pursue.

As stated by Arosio et al. (2014), the role of PBMC in this context is largely unexplored. Microglia and PBMC function remains a grey area that many researchers are still gathering more information about. Contrasting findings have proven that the two types of immune cells have both beneficial and detrimental impacts in AD patients. Further directions for this topic of exploration would be to conduct a more comprehensive study of how immune cells react to A_β peptides. Measuring and comparing the levels of cytokines emitted by activated microglia and PBMCs would indicate which specific substances are responsible for the change of immune cells from beneficial to harmful agents. Studying a greater number of biomarkers to prove A_β induced toxicity can lead to a more complete knowledge of the mechanisms behind AD pathology. This field of immune-based treatment is not just limited to the area of AD research but could also translate to encompass immunotherapy for a broad spectrum of diseases. By unlocking how the immune system reacts to foreign diseases, further steps can be taken to combat these illnesses.

References

- About Alzheimer's Disease: Treatment. (n.d.). Retrieved February 2, 2017, from <https://www.nia.nih.gov/alzheimers/topics/treatment>
- Alzheimer's Disease Fact Sheet. (2016, August). Retrieved February 27, 2017, from <https://www.nia.nih.gov/alzheimers/publication/alzheimers-disease-fact-sheet#changes>
- "Alzheimer's Disease: Unraveling the Mystery." *U.S National Library of Medicine*. U.S. National Library of Medicine, Sept. 2008. Web. 2 Nov. 2016.
- Akiyama H, Kondo H, Mori H, et al. The amino-terminally truncated forms of amyloid beta-protein in brain macrophages in the ischemic lesions of Alzheimer's disease patients. *Neuroscience Letters*. 1996; 219(2):115–118. [http://dx.doi.org/10.1016/S0304-3940\(96\)13197-9](http://dx.doi.org/10.1016/S0304-3940(96)13197-9)
- Arosio, B., D'Addario, C., Gussago, C., Casati, M., Tedone, E., Ferri, E., ... & Mari, D. (2014). Peripheral blood mononuclear cells as a laboratory to study dementia in the elderly. *BioMed Research International*, 2014.
- Chow, V. W., Mattson, M. P., Wong, P. C., & Gleichmann, M. (2010). An Overview of APP Processing Enzymes and Products. *Neuromolecular Medicine*, 12(1), 1–12. <http://doi.org/10.1007/s12017-009-8104-z>
- Gomez-Nicola, D., & Perry, V. H. (2015). Microglial dynamics and role in the healthy and diseased brain: A paradigm of functional plasticity. *The Neuroscientist*, 21(2), 169–184. <http://doi.org/10.1177/1073858414530512>
- Holmes, C., Boche, D., Wilkinson, D., Yadegarfar, G., Hopkins, V., Bayer, A., ... & Zotova, E. (2008). Long-term effects of A_β 42 immunisation in Alzheimer's disease: follow-up of a randomised, placebo-controlled phase I trial. *The Lancet*, 372(9634), 216–223.
- Jóźwik, A., Landowski, J., Bidzan, L., Fülop, T., Bryl, E., & Witkowski, J. M. (2012). Beta-amyloid peptides enhance the proliferative response of activated cd4+cd28+ lymphocytes from alzheimer disease patients and from healthy elderly. *PLoS ONE*, 7(3), e33276. <http://doi.org/10.1371/journal.pone.0033276>
- "Latest Alzheimer's Facts and Figures." *2016 Alzheimer's Disease Facts and Figures*. Alzheimer's Association, 29 Mar. 2016. Web. 1 Nov. 2016.
- Latest Medication for Memory Loss. (n.d.). Retrieved February 26, 2017, from http://www.alz.org/alzheimers_disease_standard_prescriptions.asp

IMMUNE CELL RESPONSES TO AMYLOID-BETA PROTEINS

- Ma, H., DaSilva, N. A., Liu, W., Nahar, P. P., Wei, Z., Liu, Y., ... & Shaikh, Z. A. (2016). Effects of a standardized phenolic-enriched maple syrup extract on β -amyloid aggregation, neuroinflammation in microglial and neuronal cells, and β -amyloid induced neurotoxicity in *caenorhabditis elegans*. *Neurochemical Research*, 41(11), 2836-2847.
- Morris, G. P., Clark, I. A., & Vissel, B. (2014). Inconsistencies and controversies surrounding the amyloid hypothesis of Alzheimer's disease. *Acta Neuropathologica Communications*, 2(1), 135.
- Mayo Clinic Staff (2015) "Alzheimer's Disease." *Symptoms and Causes - Alzheimer's Disease*. Mayo Foundation for Medical Education and Research. <http://www.mayoclinic.org/diseases-conditions/alzheimers-disease/symptoms-causes/dxc-20167103>
- O'Brien, R. J., & Wong, P. C. (2011). Amyloid precursor protein processing and Alzheimer's disease. *Annual Review of Neuroscience*, 34, 185–204. <http://doi.org/10.1146/annurev-neuro-061010-113613>
- Pimplikar, S. W. (2009). Reassessing the amyloid cascade hypothesis of Alzheimer's disease. *The International Journal of Biochemistry & Cell Biology*, 41(6), 1261-1268.
- Simard, A. R., Soulet, D., Gowing, G., Julien, J. P., & Rivest, S. (2006). Bone marrow-derived microglia play a critical role in restricting senile plaque formation in Alzheimer's disease. *Neuron*, 49(4), 489-502 <http://dx.doi.org/10.1016/j.neuron.2006.01.022>
- Solito, E., & Sastre, M. (2012). Microglia function in Alzheimer's disease. *Frontiers in Pharmacology*, 3, 14. <http://doi.org/10.3389/fphar.2012.00014>
- Stansley, B., Post, J., & Hensley, K. (2012). A comparative review of cell culture systems for the study of microglial biology in Alzheimer's disease. *Journal of Neuroinflammation*, 9(1), 115.
- Wake, H., & Fields, R. D. (2011). Physiological function of microglia. *Neuron Glia Biology*, 7(1), 1–3. <http://doi.org/10.1017/S1740925X12000166>
- Zhang, Y., Thompson, R., Zhang, H., & Xu, H. (2011). APP processing in Alzheimer's disease. *Molecular Brain*, 4, 3. <http://doi.org/10.1186/1756-6606-4-3>

Endnotes

- 1 A transmembrane protein refers to a protein that is partially protruding out of a cell and partially covered inside the cell. The ectodomain defines the section exposed outside of the cell and the C-terminus refers to the part remaining inside the cell (O'Brien & Wong, 2011).
- 2 A protease is an enzyme involved in the breakdown of proteins.
- 3 Peptides are the simplest structures that combine to form proteins.
- 4 Isoforms refer to variations of related proteins.
- 5 Phagocytosis is the process by which cells in the body engulf bacteria.
- 6 A biomarker is any measurable indicator that shows medical health (Strimbu & Tavel, 2010).
- 7 Lyophilization is the freeze-drying of biological substances.

My Teacher, My Peers, or Myself? A Collective Case Study in Regards to Classroom Comfort and Academic Success Concerning the Taxonomy of Motivations within Self-Determination Theory

Hollyn Saliga

This case study intends to research the correlation between the learning climate - including teachers, peers, and students - and student academic achievement in regards to the Taxonomy of Human Motivations created within the Self-Determination Theory (SDT) created by Richard M. Ryan and Edward L. Deci. This study is a triangulation of data collected through tested SDT questionnaires (for teacher and student), additional questioning, and interviewing. The purpose of this study is to help readers understand the effects of different aspects of the learning climate on a student's motivation and to determine which aspects are the most dominant in influence- success and hindrance wise. An understanding of this can allow teachers, students, and peers to alter their interactions with the environment to enable positivity and achievement.

Keywords: education, self-determination theory, teachers, motivation, learning climate

Establishing the motivation to achieve academically is a common problem among high school students. Graduation requirements, core curriculum, and constant competition for further education acceptance and scholarships shift classroom emphasis away from facilitating personal interests. Many students find self-motivation difficult because of personal and external pressures hindering their academic performance and diligence. This deviation from intrinsically regulated desires negatively impacts student competency, retention, and overall performance. Thus, development of a solution is critical. Despite research validating potential correlations between student anxieties, and negative influences stemming from restricting external pressures, limited prevention efforts have been implemented. Although current literature attempts to evaluate educator effects on student autonomy, personal perception and desires, and social interaction, the application and effect on student motivation has yet to be determined. This research intends to compile data to clarify the impact educators, and students have on academic success.

The aim of my research is to use three in-depth student evaluations to make this determination in order to aid educators, parents, and students in the betterment of the learning climate.

Literature Review

Self-Determination Theory (SDT)

The late 20th century introduced a shift in motivation research towards a cognitive theory which pertains to goal orientation as opposed to psychological and physiological need (Deci & Ryan, 1980 & 2000). As a byproduct of common replacement of goals over needs, SDT was developed, effectively combining motivation theory with a cognitive theory of goals, personal elements, and psychological need - which allowed for insight into the reasoning behind certain goals and the level of fulfillment provided. The means by which goal oriented individuals feel competent, able to relate socially, and supported, yet autonomous,

are integral to progressive self-development (Deci & Ryan, 2000). Within this proper facilitation of integration motivation, SDT necessitates recognition or personal and environmental variables associated with behavior and motivation. While predisposed internal opinions and emotions within an individual may exist, external factors can replace and develop an individual's feelings. Due to substantial interaction between personal and external factors, both must be analyzed when assessing human experience in respect to its effect on tasks and goals. Additionally, a complete analysis of human experience allows environmental and personal consciousness factors to be analyzed together, not only to benefit personal development, but also to discover what factors potentially hinder self-motivation, social functioning, and overall well-being (Deci & Ryan, 1980). Together, these factors facilitate three motivational subsystems: intrinsic, extrinsic, or amotivation (Deci & Ryan, 2000).

Human Taxonomy of Motivations

According to Deci and Ryan (2000b), energy and activation come from motivation, whereas the inverse is to lack those along with inspiration of any degree. Current literature suggests that motivation should no longer be viewed as a unitary phenomenon that strictly boxes an individual into extrinsic, intrinsic, or amotivation. Similar to SDT, the Hierarchical Model of Intrinsic and Extrinsic Motivation also agrees that motivations cannot be a dichotomy (intrinsic/extrinsic), but more so a continuum (Vallerand, 2000). The commonality between research shows that not only do motivations vary in level, but also in orientation—i.e. type (Deci & Ryan, 2000b). However, in order to understand the variations, one must know the broad categories:

Intrinsic—“the doing of an activity for its inherent satisfactions rather than for some separable consequence” (Ryan & Deci, 2000c, p.56)

Extrinsic—“a construct that pertains whenever an activity is done in order to attain some separable outcome” (Ryan & Deci, 2000c, p.60)

It is clear that these motivational subsets contrast each other. While intrinsic is pure in its contingencies,

extrinsic motivation is slightly more complex due to the variability of extrinsic motivation within individuals. The creation of the sub-theory of Organismic Integration Theory (OIT) tackles these variations (Deci & Ryan, 1980). The further right one goes on the extrinsic motivation regulation, the more internal the perceived locus of causality becomes. This internalization reflects the incorporation of mind consciousness with the subject that is being motivated. The further left, in contrast, is gradually more external, which reflects a disconnect between the conscious mind and the value of the subject being motivated. Amotivation represents no relation between behavior and outcome.

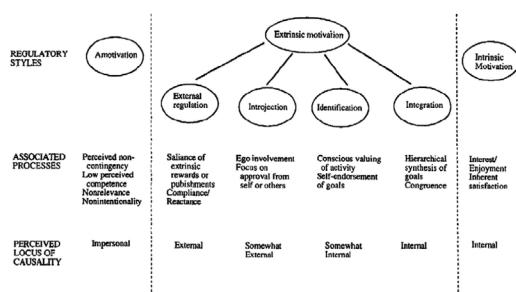


Figure 1. A taxonomy of human motivation (Deci & Ryan, 2000b)

How Need Fulfillment is Observed and Analyzed

Various applications to determine fulfillment and actualization levels of the three psychological innate needs: autonomy, competence, and relatedness exist within SDT through thoroughly developed and tested questionnaires.

Autonomy & Perceived Competence of Authority

Individual autonomy is one's level of independence whether perceived or actualized. One's predisposed personal experiences may render them more or less autonomous, however, according to SDT, environmental influences can strongly impact, or support, existing autonomy through controlling methods. The

student-teacher relationship specifically exemplifies this phenomenon. In the typical learning climate, students are engaged, motivated, interested, and proactive or blankly stare into space and simply go through the motions. The belief of “children’s motivation, engagement, and successful school functioning as an interpersonally coordinated process between teacher and students”, facilitate autonomy-supportive environments according to Eccles, Roeser, and Sameroff’s journal (as cited in Reeve, 2006, p.225) and other literature. It is a general belief that promoting a student-centered learning climate will benefit whatever the course may be: teachers will be more motivated and student-oriented, the motivation of students will then benefit, and performance will subsequently rise/adjust accordingly (Black & Deci, 2000). In the past, evaluations were lacking and did not show the complexity of the relationship between student and authority. However, the few studies attempting the evaluation are met with realizations that autonomy-support versus controlling methods are possibly not just what the teacher thinks they are providing, but more so what the students’ perceptions of the teachers’ methods are in aid to their autonomy.

Perceived autonomy support questionnaires have been developed to determine the students’ perception of their teachers, and some interesting correlations have been found such as the correlation with students recording higher personal autonomy making harsher evaluations of their teachers’ support. Literature reveals that “student consent and acceptance of teachers’ decisions and directives” determine teacher effectiveness (Barata, Casneiros, & Graca, 2013, p.1066). While in the aforementioned study, Barata et al uses the RMA (Relational Model of Authority), the vast analysis of the effectiveness of the Perceived Autonomy Support SDT justifies its use. A review of the more recent theories and ideologies surrounding autonomy-supportive versus controlling learning climates further substantiates the emphasis on student perception of autonomy being the most valuable; a question of traditional societal ways of entrusting authority in education, naturally expecting students to obey unquestioningly, has even been proposed (Hemmings & Pace, 2007). My research to investigate further what happens in classrooms, as its effects are relevant to students in regards to these scarcely observed formations of teacher-student relationships in autonomy support.

Perceived Self-Competence & Relatedness

Self-esteem/competence is a crucial factor which identifies potential physiological hindrances in terms of academic performance, and is a catalyst towards significant individual growth. Another sub-theory of SDT is Cognitive Evaluation Theory (CET) which essentially delves deeper into the motivation continuum determining that increased feelings of individual competency when performing tasks produces increased levels of intrinsic motivation to continue execution. Subsequently, feeling less competent increases externally regulated motivation steering individuals to avoid particular tasks. Emphasis on self-esteem growth and competence aims to promote student-centered learning environments/instruction. Cooper, Dubois, and Valentine’s journal (noted in Heath & Stringer, 2008) discuss how positive outcomes, like good academic performance, typically stems from a positive self-perception of competence. Alongside benefits to academic performance, individual ability to tackle challenging tasks is also strengthened (Ferla, Schuyten & Valcke, 2010). However, while self-confidence is beneficial, in excess, it can inflate an individual’s perception of their own academic capabilities which can ultimately hinder student success.

Relatedness and perceived self-competence go hand-in-hand. Relatedness is necessary when developing close-knit relationships with others (Deci & Ryan, 1985). It is essentially discovering a sense of belonging while competence necessitates effectiveness when dealing with one’s environment, such as teachers and peers within the classroom climate. Whether a result of weak correlations or negligence, literary research pertaining to relatedness has been lacking. This research intends to bridge the gap by evaluating social context within classroom settings.

Overall, data pertaining to SDT application in education is limited. Contemporary research focuses on fulfillment of a singular innate psychological need rather than all three. Although studies exist discussing teacher (autonomy-support versus control) and one’s self (perceived competence and autonomy/motivation continuum) social context within the environment is rarely introduced. Furthermore, a gap in knowledge is evident regarding which element – teacher, peers, or oneself – is dominant in aiding, or hindering, self-determination because current literature fails to eval-

MY TEACHER, MY PEERS, OR MYSELF?

ate all factors comparatively. This study aims to build on current knowledge of SDT within a high-school education system comparatively to identify what has the greatest effects on students. Hopefully, an in-depth student analysis of learning climates and its variables will offer new knowledge regarding dominant factors which could cause implementations ensuring more internal intrinsic and extrinsic motivation which would increase student comfort and academic success.

Method

Three freshmen high-school students that cumulatively identify (based on operational definitions) as low, average, and high academically, make up the sampling. Classifications will not be included necessarily in comparison, but this was important to have

a random selection with all types of students. Both genders were included, although in the end only females participated. Individual tables and charts that compared data succeeded in triangulating the data in an effective comparative manner. Each student received questionnaires tested and created by SDT researchers and additional questions created, by myself, to fill in any gaps between questionnaires that were specific to my study - such as the personal element of free response opportunities- in order to collect data. Data was taken from both student and specified teacher to ensure accurate analysis or discrepancies of learning climate perception. Data collection of students concluded with a ten-to-twenty minute loosely-structured interview to validate data conclusion, assumptions, and to determine the dominant negative/positive factors which ultimately affected comfort, or lack thereof, in the chosen learning climates.

Figure 2. Student Self-Selection Survey

<p>Student Selection Survey</p> <p>Teacher: _____</p> <p>Grade: _____</p>	<p>Name: _____</p>
<p>1. Are you a High School 9th grader that will have the same classes year round?</p> <p>a. Yes/ No</p> <p>2. Would you be willing to share basic grade information before and after the study (anonymously)?</p> <p>a. Yes/ No</p> <p>3. Would you be willing to complete a total of 4 questionnaires in the next several months that take about 15 minutes in completion time?</p> <p>a. Yes/ No</p> <p>4. Would you be willing to participate in a student-based educational study where you would be observed approximately 2 times in two different classes at your discretion?</p> <p>a. Yes/ No</p> <p>5. Would you be willing to be interviewed after and have your responses shared anonymously for academic purposes?</p> <p>a. Yes/ No</p> <p>If all yes, please provide contact information that will only be shared with the student researcher and will remain confidential (preferably email and cell-phone number): _____</p> <hr/>	

MY TEACHER, MY PEERS, OR MYSELF?

Five different teachers- 2 teaching honors, 2 teaching standard, and 1 additional teacher for the freshman AP class, were distributed self-selection surveys. From there, approximately 7-15 students who were interested and in agreement to the terms, were contacted, and the three most cooperative and diligent were chosen as those qualities were highly sought after for the sake of time and ease of information acquisition.

To maintain ethical boundaries, I used informed consent with the Student Self-Selection Survey. A requirement for student participation was that they circled yes for each of the five questions in the survey. The option to opt out at any time desired was present for each student. At data completion, explanations of data and its implications, along with information on their motivation levels, were given to the students and they could ask any questions freely. To ensure an ethical use of human participants, I completed an IRB form and had my project approved. I also referred to the APA Ethical Guidelines.

For the actual study, each of the three students self-identified their most and least comfortable class. These identifications were extremely broad and allowed participants to select any of their classes. Course content and personal reasoning were not required in the initial identification stage. Students were told simply to select the class that they felt the most, and least, comfortable in based on any personal predisposed definitions of comfort they held. The reasoning/factors that affect comfort in the learning climate is what the study evaluates, therefore, allowing potential participants free reign was imperative as to not limit their selection of classes. For each of their two classes, they completed SDT questionnaires- Learning Climate Questionnaire (LCQ) and Self-Regulation Questionnaire (SRQ) - with add-on questions to address the social context, the teacher's perception of that, and more (see Appendix C, 1-2). The Motivator's Orientation Questionnaire (MOQ) went out to each of the teachers of the identified classes. To conclude, the data was calculated, analyzed, and followed up with an interview with each student (see Appendix C, 3).

With the Perceived Competency for Learning Scale (PCLS)- connected to the LCQ, a score of seven ranks as very competent while a score of one rank as the inverse. This scale is a brief but effective measure of students' perception of their own abilities. LCQ pairs with the PCLS to evaluate student perception of the

environment along with their perception of autonomy support.

The SRQ forms upon a 1-4 scale, one being low and four being high. Its use measures student motivation for learning. According to SDT, extrinsic is pursuing behavior for pay or reward, or because of coercion. Introjection is pursuing behavior due to an internalized guilt while identified is pursuing behavior because the outcomes are valued as important to the person's personal goals. Finally, intrinsic is pursuing behavior for the pleasure of knowing, the pleasure of accomplishment, or the pleasure of stimulation.

The creation of the Relative Autonomy Index takes the previous findings of motivation regulation, and then determines an overall score that relays an overriding regulation. To find it you follow this formula: $2 \times \text{Intrinsic} + \text{Identified} - \text{Introjected} - 2 \times \text{External}$.

Higher scores in the case of the LCQ indicate greater perceived autonomy support, while lower scores indicate the perception of a controlling instructor. This compares with the MOQ, which or self-perception of, or teachers' actual teaching style.

Findings, Discussions, and Limitations

Student A

Findings. The student was more intrinsically motivated in the comfortable class than the uncomfortable class but, it is imperative to note that the numbers are highest in both introjection and identification. In the student's comfortably rated class, they were extrinsically motivated. Similarly, in the student's designated uncomfortable class, the RAI was -1.5, which is classified as between introjected and external (see Appendix A, 3-4). The comfortable class's teacher scored a 5.88-their highest rank- in the highly autonomy-supportive section. This correlates to student A's score of their perceived autonomy support for their comfortable class at a 6.4. The uncomfortable class's teacher scored a 6- their highest rank- in highly autonomy-supportive as well. A correlation is not evident between the student's perceived autonomy support of the uncomfortable class' teacher as the score was a 3.5 (see Appendix A, 5).

MY TEACHER, MY PEERS, OR MYSELF?

Limitations. Teachers could have falsely reported what actions they would have taken by instead opting for choices that appear to be the most moral.

Discussion. The extremities of external and intrinsic motivations are hypothesized to be the cause. As discussed by several prominent researchers within the realm of SDT, it is less likely that a student is intrinsically motivated in education. Regardless of interest in a subject, an enrolled student is still required to attend school and complete work to an extent.

Interview & Connection to Data. The student said: "It's not that the classes are hard, it's just that the actual environment makes me not want to do anything...but I will still do the work, I'm just not like, let's do it!" Student A says that within the factors of a class environment, the most influential to them is the teacher. The teacher, specifically, with the comfortable class, is positively influential, while the negative factor is the peer influence. "I love that teacher but the people in that class make me not want to learn because they're just bad...they're the bad kids in the school and always doing inappropriate things." Therefore, in the situation of the comfortable class, the teacher autonomy support, along with the student's self-motivation, are beneficial. The negative factor is peer influence (see Appendix B, 1). The student also says that they feel being in standard classes compromises their learning. The student said:

"all my teachers want me to take honors next year but like I don't do well under pressure so like I know what works with me, I've done honors classes in 6th grade, and I just had a rough time...I know I'm more than capable I just like the pace of standard but I don't like the kids."

Roles switch in the uncomfortable class. The student becomes more reliant on the social environment and their peers, rather than the teacher who the student says is "barely in the class to help us, they normally have other students walking around to help." The uncomfortable class offers credentials that completely extrinsically motivate them. Regardless, it is difficult for them to motivate themselves to be academically successful. The uncomfortable teacher's interview rivals the student's autonomy perception data (see Appendix D, 2). They believe the student is comfortable. The data and the interview enable the assumption that when the autonomy-supportive environment is not present and perceived by both the peer

and the teacher, the student leans toward the social environment for support instead. The comfortable class' teacher's interview and data corresponded with the student perception of high-autonomy support (see Appendix D, 1). They have a strong student relationship that is noted to go beyond classroom discussion about curriculum and content.

Student B

Findings. The student's uncomfortable class' high score was 3.4, falling into the category of external regulation. The student showed primarily identified regulation in the comfortable class with the same score of 3.4 as the highest. Student B is slightly more identified in regulation when comparing their comfortable class to their uncomfortable class, with only a 0.3 difference noted. The external regulation rate of 3.4 in the uncomfortable class only varies by 0.1 in the comfortable class. The extrinsic motivator scores are 5.8 in the comfortable class compared to 5.9 in the uncomfortable class (see Appendix A, 6-7). The student's perceived autonomy of the comfortable teacher was a near perfect score of 6.93, compared to the uncomfortable teacher with a 4.93; while the latter is not a necessarily low score, it comparatively shows a more controlling perception of the teacher (see Appendix A, 8).

Limitations. The student's high scores lead one to believe that the comfortable class is primarily intrinsically motivated and the uncomfortable class is extrinsically motivated, it is somewhat misleading. I was unable to acquire data on the comfortable class' teacher because they are a virtual teacher and not on-campus educators. To make up for this, I inquired about the teacher in the student interview.

Discussion. Data shows the student believed the comfortable class's information was beneficial to their personal goals and self-advancement, while the uncomfortable class had little to offer. Both classes experience high extrinsic motivations. The extrinsic numbers outweigh the intrinsic regulations by 0.4. Student B shows external RAI scores in both classes, however, like student A, there is a more external score in the uncomfortable class in comparison to the comfortable one. Like student A, student B has identical scores in introjected with regulation, with very similar findings in external and identified as well. The data appears

MY TEACHER, MY PEERS, OR MYSELF?

indicative of a student who is primarily extrinsically motivated for academics. It is possible that they are not interested in either subject. The high score of the uncomfortable teacher was in the controlling category. High autonomy support was also high in score, but again as seen in student A's perceived support versus the motivator's orientation scores, it seems that regardless of autonomy support score, if a controlling score rivals it, the student has a lesser perception of their autonomy support overall.

Interview & Connection to Data. Student B feels unsure about school. They say they "don't hate it, but they don't love it," because they can hang out with friends, but they also have to get up very early and sit through one-hundred and three-minute classes - which was noted to be unbearable. The student immediately delves into how they like Wednesdays better because the shorter periods prohibit information overload and allow for a better understanding. The student's interview supports their externally regulated data because they do not believe the classes they are taking are preparing them for their future at all (see Appendix B,2).

It is important to note that the student is interested in further education. The student specifically enjoys science, history, and English. The student is not interested in the content of their uncomfortable class. The content is a big push for motivation, even though it is not entirely intrinsic because they do not see the pure benefit. Socially, the student says they do not have problems. They are well liked and have a lot of friends, but they know when the time comes to be quiet and focus on the task at hand (see Appendix B,3). Student B says their virtual class is their comfortable one. According to growing data on virtual classes, this can be contradictory to many individual beliefs and comfort in these courses is not universal by any means. While, for some, online instruction leads to higher test scores and greater overall academic performance, others experience incredible difficulty assimilating to virtual instruction and cannot efficiently manage their workload resulting in drastically increased dropout rates, especially in high school (Morgan, 2015). However, the student elaborates on the extra effort their virtual teacher makes even though they have countless students. They said that texts are sent every day to ensure their success in the class. The teacher has horses too, which is a love of the student, so they bond over the

phone. The student agrees that a bond with a teacher forms a solid autonomy-supportive relationship and enables more comfort in asking questions and furthering academic discussion as well. The aforementioned observations offer an intriguing topic which would serve as an interesting future research endeavor geared towards involving self-determination theory into virtual classes. This could be done in an effort to discern the circumstances under which students meet, if not surpass, contemporary academic standards extrapolated from traditional classroom settings.

In totality, the student believes that teacher has the biggest impact on success.

Again, the virtual teacher that is identified as the most comfortable class teacher was not accessible for information, although some were obtained in the student interview. In regards to the uncomfortable teacher, the data disconnect between the ranking of student autonomy support from the student versus the teacher is reinforced by the interview through the teacher's assumption that the student is comfortable in their class (see Appendix D,3). The teacher, however, does admit that they struggle with motivating students that are unmotivated.

Student C

Findings. Student C varied the most. Their high score was identified in both the uncomfortable and comfortable class. Both classes show a higher level of intrinsic motivation (see Appendix A, 9-10). Student C has the lowest overall scores of external regulation, showing that while the student may be extrinsically motivated to an extent, the primary weight of the extrinsic score is accredited to introjection. The gap between the classes RAI's is wide. Student C rated that teacher at a 5.46, decently autonomy-supportive for an uncomfortable class. Their comfortable class' teacher at a high score of 6.25 in the highly autonomy-supportive category, with the second highest score in the other autonomy support category of moderately autonomy-supportive, scoring in at a 5.63. The comfortable teacher still has elements of high control in their teaching style, but in this case, the gap between the score of autonomy-supportive and controlling is wide enough that the perception by the student of their true style is not altered.

MY TEACHER, MY PEERS, OR MYSELF?

Limitations. Both classes were very similar and the students indicated their comfortable and uncomfortable class practically switched roles half-way into the study due to class and teacher discussions. Therefore, it was difficult to get a strong comparison from each side.

Discussion. Data shows that the student still has a greater sense of ought or should in comparison to pure outside coercion forces, in both comfortable and uncomfortable classes. The difference between the uncomfortable and comfortable class- which is made clear by the RAI score- is that even though they are both seemingly highly intrinsically motivated overall, the comfortable class leans more towards pure intrinsic and the uncomfortable is wedged between introjected and identified. That is still a primarily intrinsic score, which is an outlier in itself being the uncomfortable class, but it indicates one of slightly more external value.

Again, in contrast to the other two prior students, student C really likes going to school and always has. They note that their friends consider them a nerd, but they are okay with that because they have a joy of gaining new knowledge. The student strongly believes that their academic curriculum is preparing them for their future; this future is noted to entail college optimally, however, the struggle to find scholarships is noted as the student is experiencing financial hardships. Student C has a strong love for animals and wants to pursue that love as a marine biologist rescuing animals. Student C is primarily motivated by the love for content and the teacher influence (see Appendix B, 4). This is key. When the social impact is strong, it is more because of disruptiveness or lack of focus, not bullying or negative environments.

The students' self-impact seems to have a negative effect at times. They note strong test anxiety. The student says:

"I have all the knowledge and then boom paper is in front of me and my mind goes blank it's like what the heck I had this in my mind a second ago and now it's all blank...I'm a really bad test taker, tests are not my thing."

This was specifically emphasized in the student's one AP class, primarily due to the intense rigor and pressure of the academic environment. The student uses their teachers as an aid to getting past external pressures. The student said that even the classroom

noted as uncomfortable is no longer an uncomfortable class because they talked to the teacher by writing a note, explaining their hardships and struggles (see Appendix B,5). This student is primarily intrinsically motivated due to their own love of the content (self-motivation) and extremely highly autonomy-supportive teachers.

The uncomfortable class' teacher is autonomy-supportive, but also with controlling/strict elements that could be intimidating to a freshman, backed by their interview responses (see Appendix D, 5). The comfortable class' teacher believes the student is comfortable in the class and hopes that they are motivated by a little bit of them, their own motivations, and their peers. This also appears to be autonomy-supportive, backing the data of the questionnaires (see Appendix D,4).

Conclusion

My hypothesis was that autonomy-supportive teachers and peers that heighten perceived competency, paired with an intrinsic/internal regulation of self-motivation toward a particular subject or class, would lead to higher comfort and subsequent success in the classroom. I hypothesized the internal regulation of self-motivation would be the dominant factor that had the power to override the others in positive or negative effect. I believed the teacher and social aspect would come next in order. This was partially supported and partially not.

The outcomes matched the hypothesis that greater perceived competency shows a direct correlation with comfort in classes. All of the students rated at least a .5 higher perceived competency score for learning in the comfortable class in comparison to the chosen uncomfortable class (see Appendix A, 1). Even if the RAI was extrinsically motivated for both classes, still the comfortable class was more internal- aka introjected or identified. The three participants all separately noted in their interviews and questionnaires that if they are more comfortable in a class and enjoy it more overall, they are more academically successful in the class, or at least prone to be.

It was consistently noted that the teachers of the comfortable classes prioritize students liking them. A mutual liking appears to be needed/ heavily encour-

MY TEACHER, MY PEERS, OR MYSELF?

aged for a relationship and autonomy-supportive teaching is equal to forming relationships. The inconsistencies of some data with discrepancies between student perception of an environment and the teacher versus the teacher's perception reveal some teachers are not aware of the student's feelings towards a class and may not necessarily be purposefully aloof, just unaware. This contributes to less feeling of autonomy-support, thus counteracting the teacher's efforts regardless of their actual motivator's orientation. As shown by the data, while the teacher could be primarily autonomy-supportive, certain things such as disregard for feelings or elements of controlling styles can override that in student perception. This, in turn, can harm the student's comfort, motivation, and success.

Intense competition was not promoted socially; it was promoted within the student. None of the students had major problems with their social environments as a detriment, except for one that cited it as a distraction at times in the standard environment. Several leaned towards the social climate as a back-up if they did not have a strong teacher relationship.

The teacher and the student's parents were said to have a large impact on the pressure of succeeding, regardless of actual and perceived relationships. All students agreed that the teacher has the strongest impact on student success and interest, so this disproves my hypothesis that self-motivation would be the most impactful. However, there cannot be one factor that is the most important to student success. In one student's case, the teacher was supportive, but the social environment distracted them from reaching their full academic potential, regardless of their intrinsic motivation towards the content. It is also evident that no matter how autonomy-supportive a teacher is, a student will not be as academically successful if they do not have some level of internal regulation towards the content, so self-motivation is still very relevant. While teacher impact appears to have the greatest potential in the case study to affect a student's success and motivation, this could also be because two of the three participants had limited content motivation and more external regulation to begin with. This study needs to be carried out again with a larger sample size to determine if the same prioritization of teacher autonomy-support would manifest over self-motivation when there are more students that enjoy learning and school. One cannot look at just the teacher factor

without evaluating the context of the learning climate holistically- including peers and motivational content interest.

A possible limitation of this research study was the decision to continue with the three most diligent and cooperative participants. While variability among work ethic and academic skill was evident amongst participants, all exhibited a level of diligence and cooperation not met by other candidates. Due to the personal nature of a portion of the inquiries found on the questionnaires and interviews, it seemed most effective to incorporate participants that were readily partaking without continuous force. While this approach was most efficient when dealing with a small sample size selected from a freshman class at a singular high-school, it may not be ideal should one replicate the study with a larger sample size and time frame where a much more diverse participant pool could be selected which could potentially offer a more detailed data. A larger sample size would be especially beneficial as the small sample size of three participants served as a limitation throughout this research study. Purposefully studying students that provide more difficulty in the data acquisition process could provide information from an entirely different perspective, thus progressing this initial analysis through further future research.

Additionally, limitations of the study holistically included time constraints, the honesty of student responses, an abundance of moving factors, age/need of parental consent, and a lack of teacher motivation. Upon board approval, this study was required to be completed within a few short months. This limited amount of time ultimately led to a smaller participant sample, a less in-depth analysis, and an inability to observe students in the classroom- which was initially intended for the research process. Furthermore, the questionnaires could not all be distributed face to face. This gives birth to the possibility that participants answered questions inaccurately in an effort to depict themselves as what they may view as ideal. The concern of honesty is especially relevant with the teacher questionnaires as certain scenarios posed to them and their descriptions of the varying ways to handle the situations presented could possibly be distorted through writing. Teachers could describe particular ways by which they claim they would handle a classroom situation when in reality their ac-

tions should this situation arise could potentially be completely different. Another limitation of this study is simply the fact that there was an obscene amount of factors that had to be taken into account. Due to the abundance of factors being analyzed, paired with the time constraints previously mentioned, less in-depth connections and comparisons could be made. Also, all three of the students participating were minors. This gave rise to concerns with parental consent at times, and limited potential research options and approaches. Finally, the lack of student and teacher incentives led to less motivated participation resulting in tasks being completed in a less detailed manner, and difficulty receiving assigned tasks in a timely fashion.

Possible opportunities for future research include evaluating all boys and comparing those results to these. In addition, expanding the number of participants or having a longitudinal study could offer an interesting analysis. Evaluating at what level controlling factors of a teacher's style is perceived as dominant over existing autonomy-support factors would also be important for education research.

References

- Black, A. E., & Deci, E. L. (2000). The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective. *Science Education*, 84(6), 740-756. doi:10.1002/1098-237x(200011)84:6<740::aid-sce4>3.0.co;2-3
- Deci, E., & Ryan, R. (1980). Self-determination theory: When mind mediates behavior. *The Journal of Mind and Behavior*, 1(1), 33-43. Retrieved from <http://www.jstor.org/stable/43852807>
- Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior* (1st ed., Vol. XVI, Perspectives in Social Psychology). NY: Springer Science Business Media. doi:10.1007/978-1-4899-2271-7
- Deci, E. L., & Ryan, R. M. (2000a). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227-268. doi:10.1207/s15327965pli1104_01
- Deci, E. L., & Ryan, R. M. (2000b). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1), 68-78. doi:10.1037//0003-066x.55.1.68
- Deci, E., Koestner, R., & Ryan, R. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research*, 71(1), 1-27. Retrieved from <http://www.jstor.org/stable/3516064>
- Ferla, J., Valcke, M., & Schuyten, G. (2010). Judgments of self-perceived academic competence and their differential impact on students' achievement motivation, learning approach, and academic performance. *European Journal of Psychology of Education*, 25(4), 519-536. Retrieved from <http://www.jstor.org/stable/23421486>
- Goldstein, L. (1999). The relational zone: The role of caring relationships in the co-construction of mind. *American Educational Research Journal*, 36(3), 647-673. Retrieved from <http://www.jstor.org/stable/1163553>
- Graça, J., Calheiros, M., & Barata, M. (2013). Authority in the classroom: Adolescent autonomy, autonomy support, and teachers' legitimacy. *European Journal of Psychology of Education*, 28(3), 1065-1076. Retrieved from <http://www.jstor.org/stable/23581536>
- Morgan, H. (2015). Online instruction and virtual schools for middle and high school students: Twenty-first century fads or progressive teaching methods for todays pupils? *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 88(2), 72-76. doi:10.1080/0098655.2015.1007909
- Pace, J., & Hemmings, A. (2007). Understanding authority in classrooms: A review of theory, ideology, and research. *Review of Educational Research*, 77(1), 4-27. Retrieved from <http://www.jstor.org/stable/4624886>
- Reeve, J. (2006). Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit. *The Elementary School Journal*, 106(3), 225-236. doi:10.1086/501484
- Ryan, R. M., & Deci, E. L. (2000c). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, 25(1), 54-67. doi:10.1006/ceps.1999.1020
- Stringer, R., & Heath, N. (2008). Academic self-perception and its relationship to academic performance. *Canadian Journal of Education / Revue Canadienne De L'éducation*, 31(2), 327-345. Retrieved from <http://www.jstor.org/stable/20466704>
- Vallerand, R. (2000). Deci and Ryan's self-determination theory: A view from the hierarchical model of intrinsic and extrinsic motivation. *Psychological Inquiry*, 11(4), 312-318. Retrieved from <http://www.jstor.org/stable/1449629>

Appendix A

Table A1

PCLS- Perceived Competency for Learning Scale

	Comfortable Class	Uncomfortable Class
A	6	5.5
B	6.75	3.5
C	7	6

Table A2

LCQ- Learning Climate Questionnaire

	Comfortable Class	Uncomfortable Class
A	6.4	3.5
B	6.93	4.93
C	6.32	5.46

Table A3

SRQ- Self-Regulation Questionnaire for Learning

STUDENT- A	Comfortable Class	Uncomfortable Class
External Regulation	2.7	2.9
Introjected Regulation	3.3	3.3
Identified Regulation	3.6	3.6
Intrinsic Motivation	2.1	2

Table A4

RAI- Relative Autonomy Index

Comfortable Class	Uncomfortable Class
-0.9	-1.5

MY TEACHER, MY PEERS, OR MYSELF?

Table A5

MCQ- The Motivators' Orientation Questionnaire

STUDENT- A	Comfortable	Uncomfortable
Highly Controlling	2.25	4
Moderately Controlling/ Slightly Autonomy Supportive	4.38	4.63
Moderately Autonomy Supportive	2.38	4
Highly Autonomy Supportive	5.88	6

Table A6

SRQ- Self-Regulation Questionnaire for Learning

STUDENT- B	Comfortable Class	Uncomfortable Class
External Regulation	3.3	3.4
Introjected Regulation	2.5	2.5
Identified Regulation	3.4	3.1
Intrinsic Motivation	2.0	1.6

Table A7

RAI- Relative Autonomy Index

Comfortable Class	Uncomfortable Class
-1.7	-3

Table A8

MCQ- The Motivators' Orientations Questionnaire

STUDENT- B	Comfortable	Uncomfortable
Highly Controlling	n/a	4.13
Moderately Controlling/ Slightly Autonomy Supportive	n/a	4.5
Moderately Autonomy Supportive	n/a	3.5
Highly Autonomy Supportive	n/a	4.25

MY TEACHER, MY PEERS, OR MYSELF?

Table A9

SRQ- Self-Regulation Questionnaire for Learning

STUDENT- C	Comfortable Class	Uncomfortable Class
External Regulation	2.1	2.4
Introjected Regulation	3.2	3.4
Identified Regulation	3.4	3.6
Intrinsic Motivation	3.3	2.4

Table A10

RAI- Relative Autonomy Index

Comfortable Class	Uncomfortable Class
2.6	0.2

Table A11

MCQ- The Motivators' Orientations Questionnaire

STUDENT- C	Comfortable	Uncomfortable
Highly Controlling	3.75	n/a
Moderately Controlling/ Slightly Autonomy Supportive	4.5	n/a
Moderately Autonomy Supportive	5.63	n/a
Highly Autonomy Supportive	6.25	n/a

Appendix B

Student Excerpt B1

In totality, the student says as far as what is most motivation for them: "I say a little bit of everything because the material...I was so excited when I found out we were reading Romeo and Juliet, like the class with the bad kids, I was so excited...and like the teacher is very nice and I love when you can feel comfortable with them and it's good when you have a class with good students rather than the ones that are bad...like a quiet class with good kids where you still have fun is the ideal, so I really do think a mix of all but its mostly a teacher because they can make boring material fun."

Student Excerpt B2

"I just don't feel like you're being taught necessary things that you need for when you get older; like I don't know how to do taxes, but I'll have to do them. I don't know how to manage your house, but I'll have to. I'm not going to need to know how to do Pythagorean's Theorem in a grocery store. I understand if you want to be a mathematician or something like that but not everybody wants to be a mathematician."

Student Excerpt B3

"When I say my peers don't really do anything for motivation it's just because they're more focused on themselves, also in my biology class we have a couple of kids that just mess around and snicker and whatnot a lot so that's the one class where I'm like okay (disruptive) yeah, but in my other classes we are just focused on what we are doing. I mean disruptive sometimes yeah but making fun no, nothing really negative which is nice."

Student Excerpt B4

"My father, like I even told you in the questionnaire, my father is working right now and with all the stress being put on him with work cause he has crazy

hours, he always comes back stressed and puts issues on my mom and I...like he's always been pretty strict with grades but he wouldn't like scream at me but now that I'm taking like AP and honors where it actually counts for college, now comes the yelling now comes the... cause it matter...I mean I guess the yelling does really scare me but what really scares me is when I'm at school or I'm alone and then I see a test grade that's not so good or I look on skyward, which is rare...it gives me anxiety going on skyward because whenever I see something bad, I'm like crap he's going to kill me."

Student Excerpt B5

"Yeah, I actually just uh wrote them a letter. (oh really?) Yeah! A couple days ago, during class um telling them a few personal issues and stuff and that I wasn't ready for this and that I'm so not used to this, I know I could be a lot better but you know I'm really sorry for not being able to do this and if I get behind... um I just am not used to this and I'm very shocked that you didn't kick me out of the class. But, I put it on their desk and they actually texted me on remind, because I have them on there, and they actually texted me about it, a personal text on remind saying: hey, I read your note, I understand what you're going through, but we can talk tomorrow during class about all the academic stuff and that's what we did! They pulled me out of class the other day and we just had a one-on-one conversation. (How'd that go? That's amazing) It went great. They are just definitely an inspiration for me to do very well in school and they gave me a lot of confidence um to do better, and not just in that class but in all of my classes and they are very, very nice. They helped a lot. (That's amazing!) Yeah, (that teacher) is there for his students. They can be strict at times when um there's only five assignments and you already have a D or and F but when it comes down to a student's emotional state, they are there."

Appendix C

Questionnaire C1

Perceived Autonomy Support:

The Climate Questionnaires

The Learning Climate Questionnaire (LCQ)

This questionnaire contains items that are related to your experience with your instructor in this class. Instructors have different styles in dealing with students, and we would like to know more about how you have felt about your encounters with your instructor. Your responses are confidential. Please be honest and candid. If you wish to elaborate, do this on the sides or the provided space.

Please use the following scale:

1. I feel that my instructor provides me choices and options.
 2. I feel understood by my instructor.
 3. I am able to be open with my instructor during class.
 4. My instructor conveyed confidence in my ability to do well in the course.
 5. I feel that my instructor accepts me.
 6. My instructor made sure I really understood the goals of the course and what I need to do.
 7. My instructor encouraged me to ask questions.
 8. I feel a lot of trust in my instructor.
 9. My instructor answers my questions fully and carefully.
 10. My instructor listens to how I would like to do things.
 11. My instructor handles people's emotions very well.
 12. I feel that my instructor cares about me as a person.
 13. I don't feel very good about the way my instructor talks to me.
 14. My instructor tries to understand how I see things before suggesting a new way to do things.
 15. I feel able to share my feelings with my instructor.

Feel free to elaborate on any of these on the sides or here:

Climate Perception

1. Do you feel judged or stereotyped in any way in class by your peers? If so, how? Please elaborate.
 2. Do you feel like you can easily participate in class discussions and answer questions without fear or student judgment? Please elaborate.
 3. Do you feel overwhelmed by the course material in any way? Please elaborate.
 4. Do you feel the class should be taught differently at all? Please elaborate.
 5. Are your student-student interactions in class positive or negative? How so? Please elaborate.
 6. Do you feel as if your teacher is approachable? Please elaborate.
 7. Overall, do you feel as if you are in a positive learning environment with a supportive teacher and peers? Please elaborate.

Questionnaire C2

Academic Self-Regulation Questionnaire (SRQ-A) The Scale (standard version)

WHY I DO THINGS IN: _____

Name: _____

Age: _____

Grade: _____ (Boy or Girl) (Teacher: _____)

A. Why do I do my homework?

1. Because I want the teacher to think I'm a good student.
2. Because I'll get in trouble if I don't.
3. Because it's fun.
4. Because I will feel bad about myself if I don't do it.
5. Because I want to understand the subject.
6. Because that's what I'm supposed to do.
7. Because I enjoy doing my homework.
8. Because it's important to me to do my homework.

B. Why do I work on my classwork?

9. So that the teacher won't yell at me.
10. Because I want the teacher to think I'm a good student.
11. Because I want to learn new things.
12. Because I'll be ashamed of myself if it didn't get done.
13. Because it's fun.
14. Because that's the rule.
15. Because I enjoy doing my classwork.
16. Because it's important to me to work on my classwork.

C. Why do I try to answer hard questions in class?

17. Because I want the other students to think I'm smart.
18. Because I feel ashamed of myself when I don't try.
19. Because I enjoy answering hard questions.
20. Because that's what I'm supposed to do.
21. To find out if I'm right or wrong.
22. Because it's fun to answer hard questions.
23. Because it's important to me to try to answer hard questions in class.
24. Because I want the teacher to say nice things

about me.

- D. Why do I try to do well in school?
25. Because that's what I'm supposed to do.
26. So my teachers will think I'm a good student.
27. Because I enjoy doing my school work well.
28. Because I will get in trouble if I don't do well.
29. Because I'll feel really bad about myself if I don't do well.
30. Because it's important to me to try to do well in school.
31. Because I will feel really proud of myself if I do well.
32. Because I might get a reward if I do well.

Part 2: Self Perception

Perceived Competence for Learning

Please respond to each of the following items in terms of how true it is for you with respect to your learning in this course. Use the scale:

1	2	3	4	5	6	7
Not at all true	Somewhat true					Very true

1. I feel confident in my ability to learn this material.
2. I am capable of learning the material in this course.
3. I am able to achieve my goals in this course.
4. I feel able to meet the challenge of performing well in this course.

Answer in sentences.

1. Do you enjoy this subject? Why or why not?
2. Do you see a use for this subject in your future and in what ways?
3. Are you self-motivated for this class, or do you have to be pushed?
4. Are you afraid to fail in this class/subject? Why or why not?

Questionnaire C3

The Motivators' Orientations Questionnaires

Part 1: The Problems in Schools Questionnaire (PIS)

On the following pages you will find a series of vignettes. Each one describes an incident and then lists four ways of responding to the situation. Please read each vignette and then consider each responses in turn. Think about each response option in terms of how appropriate you consider it to be as a means of dealing with the problem described in the vignette. You may consider the option to be perfect, in other words, extremely appropriate, in which case you would respond with the number 7. You might consider the response highly inappropriate, in which case you would respond with the number 1. If you find the option reasonable you would select some number between 1 and 7. So think about each option and rate it on the scale shown below. Please rate each of the four options for each vignette. There are eight vignettes with four options for each.

There are no right or wrong ratings on these items. People's styles differ, and we are simply interested in what you consider appropriate given your own style.

Some of the stories ask what you would do as a teacher. Others ask you to respond as if you were giving advice to another teacher or to a parent. Some ask you to respond as if you were the parent. If you are not a parent, simply imagine what it would be like for you in that situation.

Please respond to each of the 32 items using the following scale.

1	2	3	4	5	6	7
Very Inappropriate	Moderately Appropriate		Very Appropriate			

A. Jim is an average student who has been working at grade level. During the past two weeks he has ap-

peared listless and has not been participating during reading group. The work he does is accurate but he has not been completing assignments. A phone conversation with his mother revealed no useful information. The most appropriate thing for Jim's teacher to do is:

1. She should impress upon him the importance of finishing his assignments since he needs to learn this material for his own good.
2. Let him know that he doesn't have to finish all of his work now and see if she can help him work out the cause of the listlessness.
3. Make him stay after school until that day's assignments are done.
4. Let him see how he compares with the other children in terms of his assignments and encourage him to catch up with the others.
- B. At a parent conference last night, Mr. and Mrs. Greene were told that their daughter Sarah has made more progress than expected since the time of the last conference. All agree that they hope she continues to improve so that she does not have to repeat the grade (which the Greene's have been kind of expecting since the last report card). As a result of the conference, the Greenes decide to:
 5. Increase her allowance and promise her a ten-speed if she continues to improve.
 6. Tell her that she's now doing as well as many of the other children in her class.
 7. Tell her about the report, letting her know that they're aware of her increased independence in school and at home.
 8. Continue to emphasize that she has to work hard to get better grades.
- C. Donny loses his temper a lot and has a way of agitating other children. He doesn't respond well to what you tell him to do and you're concerned that he won't learn the social skills he needs. The best thing for you to do with him is:

MY TEACHER, MY PEERS, OR MYSELF?

9. Emphasize how important it is for him to control himself in order to succeed in school and in other situations.
10. Put him in a special class which has the structure and reward contingencies which he needs.
11. Help him see how other children behave in these various situations and praise him for doing the same.
12. Realize that Donny is probably not getting the attention he needs and start being more responsive to him.
- D. Your son is one of the better players on his junior soccer team which has been winning most of its games. However, you are concerned because he just told you he failed his unit spelling test and will have to retake it the day after tomorrow. You decide that the best thing to do is:
 13. Ask him to talk about how he plans to handle the situation.
 14. Tell him he probably ought to decide to forego tomorrow's game so he can catch up in spelling.
 15. See if others are in the same predicament and suggest he do as much preparation as the others.
 16. Make him miss tomorrow's game to study; soccer has been interfering too much with his school work.
 - E. The Rangers spelling group has been having trouble all year. How could Miss Wilson best help the Rangers?
 17. Have regular spelling bees so that Rangers will be motivated to do as well as the other groups.
 18. Make them drill more and give them special privileges for improvements.
 19. Have each child keep a spelling chart and emphasize how important it is to have a good chart.
 20. Help the group devise ways of learning the words together (skits, games, and so on).
 - F. In your class is a girl named Margy who has been the butt of jokes for years. She is quiet and usually alone. In spite of the efforts of previous teachers, Margy has not been accepted by the other children. Your wisdom would guide you to:
 21. Prod her into interactions and provide her with much praise for any social initiative.
 22. Talk to her and emphasize that she should make friends so she'll be happier.
 23. Invite her to talk about her relations with the other kids, and encourage her to take small steps when she's ready.
 24. Encourage her to observe how other children relate and to join in with them.
 - G. For the past few weeks things have been disappearing from the teacher's desk and lunch money has been taken from some of the children's desks. Today, Marvin was seen by the teacher taking a silver dollar paperweight from her desk. The teacher phoned Marvin's mother and spoke to her about this incident. Although the teacher suspects that Marvin has been responsible for the other thefts, she mentioned only the one and assured the mother that she'll keep a close eye on Marvin. The best thing for the mother to do is:
 25. Talk to him about the consequences of stealing and what it would mean in relation to the other kids.
 26. Talk to him about it, expressing her confidence in him and attempting to understand why he did it.
 27. Give him a good scolding; stealing is something which cannot be tolerated and he has to learn that.
 28. Emphasize that it was wrong and have him apologize to the teacher and promise not to do it again.

MY TEACHER, MY PEERS, OR MYSELF?

H. Your child has been getting average grades, and you'd like to see her improve. A useful approach might be to:

29. Encourage her to talk about her report card and what it means for her.

30. Go over the report card with her; point out where she stands in the class.

31. Stress that she should do better; she'll never get into college with grades like these.

32. Offer her a dollar for every A and 50 cents for every B on future report cards.

Part 2: Self and Student Perception

Please answer these questions to the best of your ability regarding the student's social interaction in your class, their interaction with you, and their academic success/ potential. These answers will be anonymous and the student will not be shown. Please be as candid as possible.

Self:

1. Why did you decide to become a teacher?
2. What is your teaching philosophy?
3. What are your perceived strengths and weaknesses as an educator?
4. How would a student describe you?
5. How do you keep students engaged?
6. Do you want your students to like you? Why or why not?
7. How do you promote student success in learning for retention, not just for the test?

Student:

1. How does the student interact with his/her peers in the classroom?
2. Is the student disruptive? If so, how?
3. Does the student participate in classroom discussions and activities?

4. Do you believe the student is comfortable or uncomfortable in your class? Why or why not and how can you tell?
5. What do your interactions with the student consist of and what are they like?
6. Is the student academically successful in your class?
7. Do you believe the student's individual success is determined more by their social interactions, their self-motivations, or their interactions with you?

Appendix D

The Motivators' Orientations Questionnaires- Part 2: Self and Student Perception
(teacher responses in order of appearance)

Comfortable Class Teacher Response D1

Self

1. "I became a teacher because my mom was one and I always admired what she did. Specifically, reading because it is necessary to be an effective reader in all fields and most people take it for granted."
2. "My teaching philosophy is that all students can be reached and be successful."
3. "Strengths: patience, sense of humor, skill/knowledge, strong presence. Weaknesses: organization, follow-up."
4. Characteristics: "Bubbly, positive, always smiling, easy to talk to."
5. Keeping students engaged: "I always tell them why what we are doing is relevant to their lives. I try to give them choice."
6. "I want my students to both like and respect me. If they don't "like" the teacher, they are less willing to apply themselves."
7. Promoting student success in learning for retention: "Students are aware if the relevance if the context/ skill, so they understand how it applies to their lives and betters them."

MY TEACHER, MY PEERS, OR MYSELF?

Student

1. Student interaction with peers: "She has a small group of friends and always wants to participate and answer questions."
2. Student behavior: "Definitely not disruptive. Works hard and participates."
3. Participation: "Often. She is very insightful and contributes fresh ideas."
4. Comfort vs. uncomfort: "I believe she is very comfortable because of how often she participates and how she interacts with peers."
5. Interactions: "She tells me about her 'crushes' and seeks advice. She asks a lot of thought -provoking questions about the novel."
6. Academic success: "Extremely. She applies herself and works hard."
7. Determination motivation of the three: "I believe number one would be self-motivation."

Uncomfortable Class Teacher Response D2

Self

1. "I enjoy being a mentor and inspiring others."
2. "Students are people first."
3. "Strengths: I believe I relate well with others and have empathy."
4. Characteristics: "Hopefully outgoing, fun, and caring."
5. Keeping students engaged: "Lots of movement!"
6. Student liking: "Of course, it just makes things easier and happier!"
7. Promoting student success in learning for retention: "Cooperative activities like Kagan- fun academic games!"

Student

1. Student interaction with peers: "They plan lessons together, work together teaching Little Hawks."
2. Disruptive?: "Not this particular student."
3. Participation: "Yes!"
4. Comfort vs. uncomfort: "I think so because she speaks to me often and is involved with discussions."
5. Interactions: "Our interactions mostly involve this class; however, we sometimes talk about extra curricular activities."
6. Academic success: "Yes!"
7. Determination motivation of the three: "With her peers mostly."

Uncomfortable Class Teacher Response D3

Self

1. "I love math and enjoy working with kids."
2. "Set high expectations. Create a positive learning environment. The only way to learn math is to do math."
3. "Strengths: positivity, availability to help, ability to explain. Weaknesses: motivating students (I am self-motivated, so I struggle to motivate the unmotivated.)"
4. Characteristics: "A good teacher, but she gives too much work!"
5. Keeping students engaged: "Frequently ask questions, review games."
6. Student liking: "It would be nice, but it isn't needed."
7. Promoting student success in learning for retention: "Constantly add spiraling questions, try to use catch phrases or have students answer questions instead of me."

Student

1. Student interaction with peers: "Positively."
2. Disruptive?: "Sometimes, she likes to talk/express her opinions and sometimes does so while I am talking."
3. Participation: "Yes."
4. Comfort vs. uncomfort: "She works with others during class work, not afraid to ask me questions or offer her opinion/ tell me about her weekend."
5. Interactions: "Some social, some content based, some pluses, some minuses (whining by student)."
6. Academic success: "No."
7. Determination motivation of the three: "Self-motivations"

Uncomfortable Class Teacher Response D4

Self

1. "Education is the key to a successful life. It is the noble profession."
2. "All students are capable of learning but only if they're willing to work
3. "Strengths: work ethic."
4. Characteristics: "Bald and beautiful! But fair and knowledgeable."
5. Keeping students engaged: "Technology. Not be-

MY TEACHER, MY PEERS, OR MYSELF?

ing aloof?”

6. Student liking: “Sure, but I’m not in it to win a popularity contest.”
7. Promoting student success in learning for retention: “Examples of others’ success stories. Teaching to the test is stupid!”

Student

1. Student interaction with peers: “She is outgoing and kind.”
2. Disruptive?: “Never.”
3. Participation: “Sometimes.”
4. Comfort vs. uncomfort: “She’s intimidated by the level of AP. She told me so.”
5. Interactions: “Informal conversations before and after class.”
6. Academic success: “Could do better.”
7. Determination motivation of the three: “All of the above.”

Comfortable Class Teacher Response D5

Self

1. “Firm, but fair.”
2. Student liking: “Don’t have to.”
3. Promoting student success in learning for retention: “Little prizes for students/ smiley faces and stickers/ relate things to them.”

Student

1. Student interaction with peers: “Very well.”
2. Disruptive?: “No, participates (stuff needs to be in on time though).”
3. Comfort vs. uncomfort: “Yes.”
4. Academic success: “Yes.”
5. Determination motivation of the three: “I would hope that it’s a little bit of everything. Peers tend to be the most influential (positive if they’re role models).”

Determining Stress Management Activities for Various Myers-Briggs Personality Types

Jensen Ghidella

Stress, a component of everyday life, can be detrimental to health. Previous research has shown an increase in studies on stress in recent years, but little on linking stress and personality type. Because of this, new and innovative research in stress management is of utmost importance. This study combined the personality type theory of Myers-Briggs with de-stressing activities to determine which personality types found which de-stressing activities the most effective. The study focused on teenagers to bring more light to their stress management. There were different correlations, but they were insignificant. A conclusive statement cannot be made about the original research question, but a plethora of useful information was still discovered. While the results were varied, the conclusion of this study was that it was possible to determine which activities would most benefit people with certain personality types.

Keywords: stress, Myers-Briggs, personality, stress management, Jung

Introduction

It is important to study methods of stress management because over time, stress has dire health consequences (Kumar, Rinwa, Kaur, & Machawal, 2013). Because stress and its sources are different for every person, the unique approach of using personality was taken to account for individuality within the participants. The process of stress has been extensively researched, as well as the managing of stress, but using personality type to determine the best de-stressing activities for individuals has not had a large amount of scientific research. Thus, this study contributes to the research by collecting data on the trends found between one's Jung-based personality type and which de-stressing activities one found effective.

Literature Review

Stress is, perhaps unfortunately, a phenomenon to which anyone can relate, as people experience stressful situations everyday. Generally, stress is defined as responses to demands imposed on the body. Even though this topic has seen a surge in research in the past few decades, there is still uncertainty surrounding its fundamental mechanisms because it involves a wide array of cellular activities (Kumar, Rinwa, Kaur, & Machawal, 2013). Upon sensing a stressor – defined as anything causing the stress reaction – the brain sends signals to the body which catalyzes a chain of events to ready the person to take action in a stressful situation (Fritz, 2014). However, experiencing stress for a prolonged period of time wreaks havoc on the body (Toussaint, Shields, Dorn, & Slavich, 2016).

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

Long-term stress is associated with a variety of physical, physiological, and psychological ailments, such as: anxiety, depression, infertility, memory impairment, obesity, and dementia. It is a key factor in neuropsychiatric disorders such as PTSD. Stress can be even more detrimental than other well-known risk factors, such as drug-use, alcohol use, and physical inactivity, which can lead to, “substantial morbidity and mortality” (Toussaint, Shields, Dorn, & Slavich, 2016, p. 1). Based on these sources, and given the fact that the stress response is crucial to human life, it is clear that research on stress management is important.

Humans experience a variety of stressors every day. Stress is a part of everyday life, which is no different for today’s average teenager. While a teenager typically does not face the same stressors as an adult, they still have their fair share: academics, sports, peer/family conflict, college or career decisions, various social pressures, relationships, etc. (Fritz, 2014).

Previous research displayed millions of results when searching for “stress” and “stress management,” indicating a proliferation of studies on stress. In order to narrow down this vast field, a unique, less extensively researched niche was selected: stress in relation to personality.

There is a personality system created to categorize people by how they handle stress, called the Type A or B personalities. Type A personality is typically described as more high-strung, more competitive, with a great sense of urgency. Type B is much more relaxed, indulgent, more accepting of failure, and has lower aspirations (McLeod, 2014). This model was not used in this research study because this personality type has strong indications Type A handles stress with more difficulty than Type B, and there are only two options for any individual.

Instead, the personality type used in the present study was the Myers-Briggs personality type, measured by the Myers-Briggs Type Indicator (MBTI). The MBTI is derived from the archetypes of famous psychiatrist Carl Jung, one of the founders of modern depth psychology (Hollis, 2013). The MBTI is a self-assessed, forced-choice, multi-item questionnaire which results as one of 16 personality types indicated by four letters (*The Myers-Briggs Foundation*). MBTI personality was used for this research study because it is based on four psychological categories, each category having two preferences. According to Myers-

Briggs Type theory, everyone uses all eight preferences, but more easily and naturally uses only four, one from each category (Hirsh & Kummerow, 1989). The first letter is I or E, for the “Introversion- Extraversion” category. Introversion is obtaining energy during solitude, from one’s internal mindscape. Extraversion is obtaining energy from social interactions and one’s external world (Hirsh & Kummerow, 1989). The second letter is S or N, for “Sensing-iNtuition (Intuition).” Sensing focuses on practical facts, details, and events the five senses interpret, while Intuition focuses on the big picture, underlying patterns, and following “gut feeling.” The third letter is either T or F, for “Thinking-Feeling.” Thinking is known for logical reasoning in decision-making, while Feeling is known for deciding upon personal values. The fourth letter is J or P, for “Judging-Perceiving.” Judging preference indicates one making confident, concrete decisions, while Perceiving leaves life plans more open-ended, and more apt to change (Hirsh & Kummerow, 1989).

Most studies that utilized MBTI personality were concerned with how it affected peoples’ careers. One such study at the University of East London investigated the relationship between executive coaching styles and the Myers-Briggs types of the coaches. The paper mentions that while each person has their preference of the four binary categories, everybody has the ability to use and strengthen their non-preference; it just requires more energy and practice. For example, a person with the preference for Introversion will have a natural tendency to be less social and more reflective, but if they are social and outgoing enough, they can learn to utilize their Extraversion non-preference. However, if this person is subject to stress, they will operate under their preference of Introversion. This is how, “The four preferences do not operate independently,” but rather fluidly and interchangeably (Holloway, Passmore, & Rawle-Cope, 2010, p. 3). The fact that this fluidity in personality is present with the Myers-Briggs personality type is precisely the reason this personality type was chosen for this study. It accounts for the adaptability within an individual.

Another study measured desirable qualities within job performance using Myers-Briggs types. This study drew conclusions such as ENFP types typically had the highest job performance score (Shybut, 1993). These conclusions further support that Myers-Briggs personalities can be manifested within everyday life

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

and affect one's job. A similar study by the American Counseling Association supported these conclusions by developing its own situations for the participants by administering twelve different, real-life "career obstacles" and measuring participants' responses to those obstacles over the course of one month. Each participant took the MBTI to determine which preferences affected the obstacles that were challenging for the participants. For instance, it was found that Sensing-Thinking types were reluctant to change, which was consistent with the type as they were "wanting to analyze facts impersonally to reach decisions" (Healy & Woodward, 1998). This led to the current hypothesis that those with Sensing over Intuition or Thinking over Feeling would yield less positive results in de-stressing because stress can be emotionally charged, which these types are less able to navigate. The American Counseling Association study, while using career obstacles instead of stress levels, still supports Myers-Briggs relevance to an individual's day-to-day life, especially regarding problem-solving or reacting to situations. Both aforementioned studies also support the fact that Myers-Briggs type is valid in researching personality influences on daily life.

Because personality type could affect one's behavior, it follows it could also affect one's interactions with stress. Previous research indicates countless studies have focused on stress, and several related stress levels and their effects on psychological tendencies or personality traits. In one study done at Robert Morris University, Myers-Briggs personality type was examined in relation to worry. One of the results was that those who use Introversion more than Extraversion tended to worry more, as they were more inclined to reflect and concentrate within their inner world (Ragozzino, 2011). This led to the hypothesis for the current study that people with the Introversion preference would have higher stress levels, but also yield more positive results when focusing on activities meant to lower stress levels. While the Robert Morris study did not relate the particular notion of stress to one's personality, it did demonstrate an interest in relating personality to negative effects on one's life, and also used the Jung Type Indicator, a personality test based on the MBTI, to categorize one's personality. These studies show that Jung-based personality types can be used to discover how different people perceive stress.

In other studies, individuals were assessed on their stress levels and also tested for their personality type, such as a study done on kindergarten teachers in Hong Kong. This study administered the MBTI and a General Health Questionnaire to the teachers to determine their personality types and their mental health in their workplace. It found ESFP types were the most likely to be satisfied with their jobs and have the most positive scores on the health survey (Yau-ho & Li-fang, 2014). This suggests personality type can have a positive impact on one's health, as it affects satisfaction in a certain environment which in turn impacts mental health. Because different personalities thrive in different situations and because personality type affects mental health, it was concluded that personality types could be used to indicate how different personalities handle stress.

None of the reviewed studies, however, assessed one's personality, their stress, and how to best manage the measured stress based on the assessed personality type. Personality was found to be used as simply another data point and was never ultimately used as a tool used to decrease stress. This lack of research was identified as the gap to be covered, and therefore produced the research question of this investigation: which de-stressing activities were the most effective for which Jung-based personality types?

Method

The current study utilized survey analysis and case study to discover which of these de-stressing activities were beneficial to which personality types through quantitative and qualitative measures.

Participants

The 10 participants were juniors at a public high school. All participants were 16-17 years old, and 8 were female while 2 were male. Participants were not offered any incentive to complete the study and all voluntarily consented to join. Each participant was given a number, from 1 through 10, that was known only to the researcher and that participant. This number ensured the participants' anonymity throughout the study.

Materials

Stress Test. The Stress Test is a self-assessment the researcher created with questions pertaining to a participant's stress level in various areas of their life: academic life, home life, sports, extracurricular activities, and social life. Participants were asked to rate their stress level in each area on a scale of 1-5, with 1 being little to no stress and 5 being a large amount. The total stress score ranged from 5-25. The assessment also asked what classes the participants were taking, denoting AP, online, and dual-enrollment, which sports if any, and which extracurriculars. The researcher created an assessment tool rather than finding a pre-existing one because it was more feasible, and it also gave the researcher control over which areas of the study were investigated.

Jung Type Indicator. The Jung Type Indicator (JTI) is an online, 64-item self-assessment in which the results compute one's JTI personality type. Items are phrased as statements, such as "You think everything in the world is relative," with 5 possible answers: "YES," "yes," "uncertain," "no," and "NO." The JTI result is a compilation of four letters, with each letter having two options. The letters are identical to those used in the MBTI, with E or I, S or N, T or F, and J or P. The test is a free alternative to the widely-used MBTI, which was the reason the MBTI itself was not used.

De-Stressing Activities. The De-Stressing Activities documents are comprised of three activities designed to lower a participant's stress levels and were given to participants to start their five-week de-stressing period. The activities were meant to be performed for a duration of 5-10 minutes, and participants were asked to do 2-3 per week for 5 weeks. The first activity was "Deep Abdominal Breathing Exercises," (DABE) which instructed the participant to breathe deeply and slowly while in a standing position. The exercise was meant to counteract the rapid, shallow breathing that can accompany stressful situations (Antai-Otong, 2001). This activity was chosen because focusing on breathing is a practice of mindfulness, a process proven to be helpful in allowing adolescents to relax (Monshat et al., 2013). The second activity was "Visualization or Imagery," (VI) which instructed the participant to use a deep breathing exercise to prepare and then visualize, in detail, a relaxing scene. The exercise was meant to provide an entire-body escape from stressful

feelings (Antai-Otong, 2001). This activity was chosen because, like the deep breathing activity, it promoted mindfulness in the participants, but gave the option to let the mind be active in imagination, which can be easier to do than focus on breathing alone. Lastly, the third activity was "Mandala Coloring," (MC) which instructed the participant to spend time coloring any of four mandala designs. This exercise was meant to be a mindless activity that focused thought and energy on creating a pleasing picture rather than whatever was stressing the participant. This activity was chosen because therapeutic mandalas were first advocated by Jung himself for their, "calming and healing effect on [their] creator" (Henderson, Rosen, & Mascaro, 2007, p. 149).

De-Stressing Journals. The De-Stressing Journal is a document packet comprised of 15 copies of a single form that participants were asked to fill out after each time they performed an activity. The form identifies the activity, asks if the participant felt it helped in de-stressing, whether the task was easy or difficult to perform, whether the participant actually liked the task or not, if the participant had performed the activity before for de-stressing purposes, and whether or not the participant thought they could use it in the future. The journals are qualitative data in which the researcher can find and evaluate trends or patterns among the participants, based on their answers to these questions and also to their JTI personality type.

Wrap-Up Questions. The Wrap-Up Questions are documents surveying participants on their overall experience in the study. They rated each activity on effectiveness and if it was a positive experience on a scale of 1-5, with 1 being poor and 5 being great, and also explained their rating. Other questions included whether there were any challenges that arose that would compromise their de-stressing during the investigation. These questions were designed to see which activities overall participants felt were the most effective in de-stressing, and also if there were any events that came up that impeded the study's effect.

Procedure

This study received IRB approval prior to beginning the investigation. The notion that stress would be measured through a survey was derived from the Hong Kong study, where they tested a variety of ailments, such as stress in the workplace, in correlation to Myers-Briggs personality. In this study, researchers used the General Health Questionnaire to provide the stress data because it is streamlined and informative, which is why they were used in this study. However, since this researcher did not have access to a professional stress survey, one was created. Because participants' reactions to certain, guided activities were needed, Research Journals were developed

as a way for participants to record their responses in real time, for added accuracy with their end results.

Participants took the Stress Test and JTI before the five-week de-stressing period. They were then given the De-Stressing Activities, and the Research Journals to complete on their own time. At the end of their five weeks, the journals were returned to the researcher, and the Stress Test was administered once more to test their overall stress levels again, and the Wrap Up Questions were given last.

Table 1: JTI Results Acronyms Explained

INFJ	Introversion iNtuition Feeling Judging
ENFP	Extraversion iNtuition Feeling Perceiving
ENFJ	Extraversion iNtuition Feeling Judging
INFP	Introversion iNtuition Feeling Perceiving
INTP	Introversion iNtuition Thinking Perceiving
INTJ	Introversion iNtuition Thinking Judging

Table 2: JTI Results of All Participants

Participant #	JTI Result	E / I and %	S / N and %	T / F and %	J / P and %
1	ENFP	E (34)	N (22)	F (34)	P (22)
2	ENFP	E (66)	N (16)	F (16)	P (12)
3	ENFJ	E (78)	N (22)	F (12)	J (25)
4	INFP	I (28)	N (19)	F (9)	P (12)
5	INTP	I (67)	N (9)	T (6)	P (12)
6	INTJ	I (69)	N (53)	T (81)	J (50)
7	ENFJ	E (25)	N (16)	F (3)	J (28)
8	INFJ	I (38)	N (19)	F (34)	J (28)
9	INFJ	I (62)	N (50)	F (12)	J (31)
10	INFJ	I (41)	N (19)	F (44)	J (34)

Higher percentages indicate a stronger favor for the shown preference.

Results

The purpose of this research study was to investigate if one could use an individual's JTI personality type to determine which de-stressing activities would be most effective. After data collection, participant results were analyzed quantitatively and qualitatively by comparing stress scores, De-Stressing Journal entries, and Wrap-Up answers to their JTI result.

Quantitative Results

The results from the JTI showed that among the ten participants, six of the sixteen possible types were represented. There were three INFJs, two ENFPs, two ENFJs, one INTP, one INFP, and one INTJ. Table 1 expands each acronym for clarification purposes.

Table 2 displays each participant with their JTI result and their percentage within each preference. For example, an N (22) refers to a 22% of Intuition, meaning that participant had a 22% preference for Intuition over Sensing.

Table 3 displays each participant and their stress score. The highest possible score was a 25 while the lowest possible score was a 5. There is seemingly no correlation between personality type and overall stress. For example, Participant 8, who has INFJ type, had a relatively low-stress score while the other two INFJ types had higher stress scores. There was a correlation between the pre-activities scores and the post-activities scores, however it was not significant (see Table 4). Furthermore, all four participants stated in their post-Activities Stress Tests that there was a direct, outside cause of their decrease of stress in certain areas.

Where:

r = The Pearson Product Moment Correlation
r² = Shared Variance
t = Student's t
df = N-2 = 8

Although a correlation of 0.866 appears strong, the t-test for significance between pre-test and post-test stress scores fell below the P<.05 critical value (2.306), meaning it was not statistically significant.

Table 3: Stress Scores of All Participants

Participant #	JTI Result	Pre-Activities Stress Score	Post-Activities Stress Score
1	ENFP	15	15*
2	ENFP	11	10
3	ENFJ	15	13
4	INFP	12	11
5	INTP	10	12
6	INTJ	12	15
7	ENFJ	10	12
8	INFJ	8	9
9	INFJ	17	17
10	INFJ	19	17

*Participant 1 reported an increased amount of stress in a certain area of their life, but since their score was already at ceiling (5), it could not change.

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

Table 4: The Relationship Between Pre-Test and Post-Test Stress Scores

Participant #	Pre-Test Stress Score	Post-Test Stress Score	Difference
1	15	15	0
2	11	10	-1
3	15	13	-2
4	12	11	-1
5	10	12	2
6	12	15	3
7	10	12	2
8	8	9	1
9	17	17	0
10	19	17	-2
			r=0.866059
			r ² =0.750059
			t=0.726314

The effectiveness of the De-Stressing Activities was varied. In Figure 1, all ten participants and their ratings of the activities are shown. The lowest effectiveness rating was a 1 and the highest effectiveness rating was a 5. None of the participants gave the DABE a score lower than a 3, and none of the participants rated the VI a 5.

Of the five participants who rated DABE a 5, three had an Introversion preference, and the other two had very high Extraversion preferences at 66% and 78%. Every participant had Intuition: four had a slight preference, while one had a moderate preference. Four had a moderate Feeling preference, while the fifth only had a marginal Thinking preference. There were three Perceiving and two Judging preferences, all of which were slight to moderate.

Of the three participants who rated the Mandala Coloring a 5, two moderately preferred Extraversion while one moderately preferred Introversion. All slightly preferred Intuition. Two moderately preferred Feeling while one marginally did. One slightly

preferred Perceiving, and two moderately preferred Judging at 28%.

The ENFPs found activities that they rated a 5, but they were different. Participant 1 rated MC a 5 while Participant 2 rated DABE a 5. Participant 1 rated the others highly while Participant 2 rated VI immediately at 3 and Mandala Coloring at 1.

The two ENFJs rated all activities 3 or above, and again, their 5's they administered were for different activities: Participant 3 rated DABE at 5, and Participant 7 rated MC at 5.

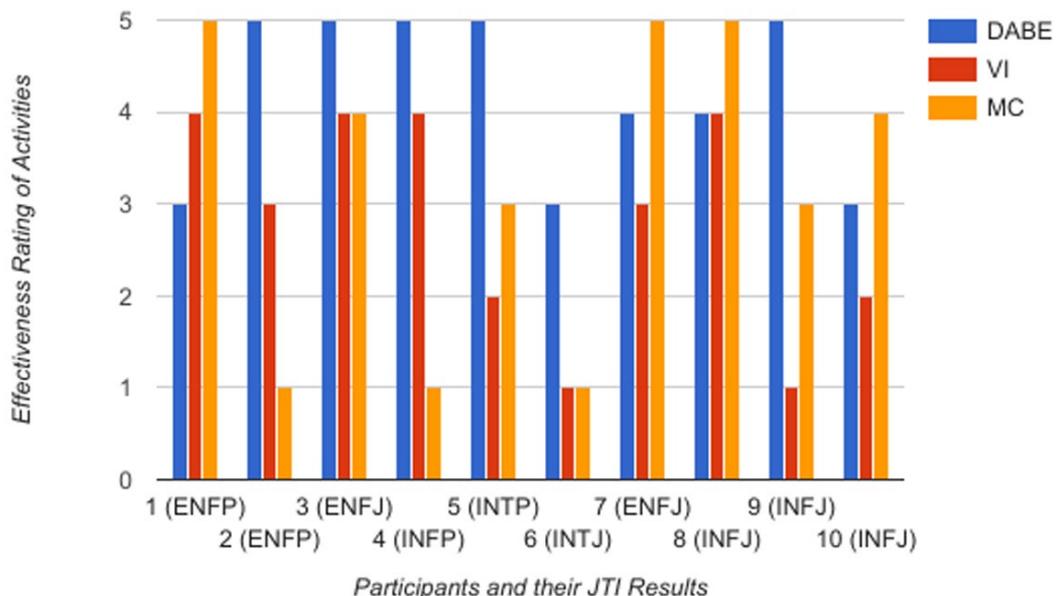
Two of the three INFJs, Participants 8 and 10, rated the MC the highest while Participant 9 rated DABE the highest.

Participant 6, the INTJ, had the least effective ratings for the activities, rating them all either 3 or below. Participants 4 and 5, the INFP and INTP respectively, rated DABE a 5. However, Participant 4 rated the VI higher than MC, whereas Participant 5 did the opposite.

Since participants were not instructed to perform the activities the same number of times, each par-

Figure 1

JTI Results vs. Effectiveness of De-Stressing Activities

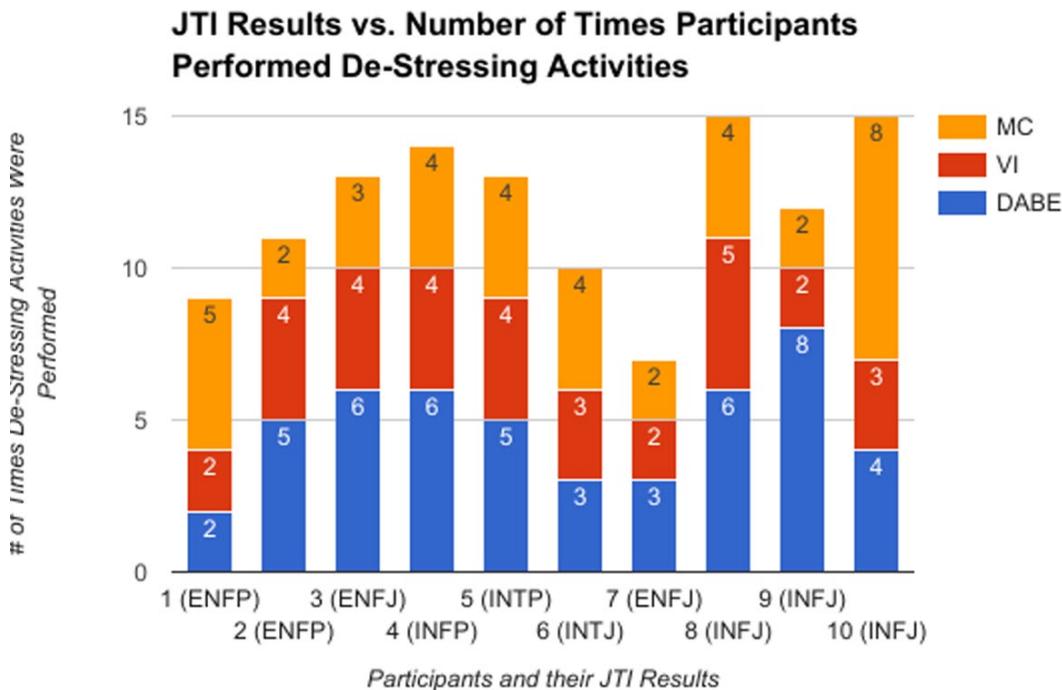


ticipant had a different ratio of how many times they performed each one within the total amount. Each participant was also not required to perform the full 15 times, so the total number of activities completed varied as well. Figure 2 displays every participant.

Correlations were developed in order to determine if there was a relationship between a participant's JTI score and the number of times they chose a specific activity. The results are found in Tables 5-8. The JTI scores were converted to a continuum for statistical analysis. The original scores are bi-directional rang-

ing from 0-100, meaning the scale ranges 200 points. The continuum moves the 0 so that the 200-point scale goes in one direction. To do the calculations for the Extraversion/Introversion category, 100 is added to an Extraversion score. To calculate an Introversion score, the score is subtracted from 100. For example, an Extraversion score of 34 would be converted to 134. An Introversion score of 28 would be converted to 62. This calculation strategy is applied to all four categories.

Figure 2



Tables 5-8 represent the participants' number, their JTI preference, their JTI score, their JTI continuum score, their pre-test and post-test stress scores, their growth, the number of times they performed each activity, and the total number of activities they performed. Pearson Product Moment Correlations were calculated for the continuum score, the number of times each activity was performed, and the total. Although a few of the correlations appear strong, the results show no statistical significance. This is most likely due to the small sample size.

Qualitative Results

Participants were also asked whether they would do each of the activities in the future for de-stressing purposes. When the participants were asked if they had performed any of these activities prior to the study for de-stressing purposes, the only activity any of them had performed was DABE. Participants 2, 3, 6, 7, and 8 had all done the same or a similar breathing activity prior to this study. When the participants were asked if these activities had an overall positive or negative impact on them, seven answered positive, two answered neutral, and one answered neutral-positive.

For qualitative results on the effectiveness of the activities, refer to Tables 9-14.

Table 5: Relationship Between Extraversion / Introversion and Preferred Choice of De-Stressing Activities

Participant #	Preference	Score	Con- tinuum	Pre-Test	Post-Test	Growth	DABE	VI	MC	Total
1	E	34	134	15	15	0	2	2	5	9
2	E	66	166	11	10	-1	5	4	2	11
3	E	78	178	15	13	-2	6	4	3	13
4	I	28	72	12	11	-1	6	4	4	14
5	I	67	33	10	12	2	5	4	4	13
6	I	69	31	12	15	3	3	3	4	10
7	E	25	125	10	12	2	3	2	2	7
8	I	38	62	8	9	1	6	5	4	15
9	I	62	38	17	17	0	8	2	2	12
10	I	41	59	19	17	-2	4	3	8	15
	r=	0.000456644	-0.296975815	-0.47688811	-0.183278434	0.012370436	-0.31356597	-0.3355875433		
	r2	2.08524E-07	0.088194635	0.227422269	0.033590984	0.000153028	0.098323618	0.112812306		
	t=	0.001884754	0.726314211	9.36327E-07	0.000746406	0.021956202	0.464157896	2.26008E-06		

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

Table 6: Relationship Between Sensing / Intuition and
Preferred Choice of De-Stressing Activities

Participant #	Preference	Score	Con-tinuum	Pre-Test	Post-Test	Growth	DABE	VI	MC	Total
1	N	22	78	15	15	0	2	2	5	9
2	N	16	84	11	10	-1	5	4	2	11
3	N	22	78	15	13	-2	6	4	3	13
4	N	19	81	12	11	-1	6	4	4	14
5	N	9	91	10	12	2	5	4	4	13
6	N	53	47	12	15	3	3	3	4	10
7	N	16	84	10	12	2	3	2	2	7
8	N	19	81	8	9	1	6	5	4	15
9	N	50	50	17	17	0	8	2	2	12
10	N	19	81	19	17	-2	4	3	8	15
	r=	-0.330889455	-0.576807902	-0.267217054	-0.149824787	0.409670018	0.162310186	0.172725745		
	r2=	0.109487831	0.332707356	0.071404954	0.022447467	0.167829523	0.026344596	0.029834183		
	t=	6.62561E-07	0.726314211	9.36327E-07	0.000746406	0.021956202	0.464157896	2.26008E-06		

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

Table 7: Relationship Between Thinking / Feeling and Preferred Choice of De-Stressing Activities

Participant #	Preference	Score	Con-tinuum	Pre-Test	Post-Test	Growth	DABE	V1	MC	Total
1	F	34	134	15	15	0	2	2	5	9
2	F	16	184	11	10	-1	5	4	2	11
3	F	12	188	15	13	-2	6	4	3	13
4	F	9	191	12	11	-1	6	4	4	14
5	T	6	94	10	12	2	5	4	4	13
6	T	81	19	12	15	3	3	3	4	10
7	F	3	103	10	12	2	3	2	2	7
8	F	34	134	8	9	1	6	5	4	15
9	F	12	112	17	17	0	8	2	2	12
10	F	44	144	19	17	-2	4	3	8	15
		r=	0.150185178	-0.351713922	-0.862035929	0.372286949	0.369115794	-0.017938733	0.390991026	
		r2=	0.022555588	0.123702683	0.743105943	0.138597572	0.136246469	0.000321798	0.152873982	
		t=	5.58268E-05	0.726314211	9.36327E-07	0.000746406	0.4641576202	0.464157896	2.26008E-06	

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

Table 8: Relationship Between Judging / Perceiving and Preferred Choice of De-Stressing Activities

Participant #	Preference	Score	Con-tinuum	Pre-Test	Post-Test	Growth	DABE	VI	MC	Total
1	P	22	122	15	15	0	2	2	5	9
2	P	12	112	11	10	-1	5	4	2	11
3	J	25	75	15	13	-2	6	4	3	13
4	P	12	112	12	11	-1	6	4	4	14
5	P	12	112	10	12	2	5	4	4	13
6	J	50	50	12	15	3	3	3	4	10
7	J	28	72	10	12	2	3	2	2	7
8	J	28	72	8	9	1	6	5	4	15
9	J	31	69	17	17	0	8	2	2	12
10	J	34	66	19	17	-2	4	3	8	15
		r=	-0.18311436	-0.36453782	-0.220534502	-0.0905776	0.137741434	-0.054442919	-0.044288227	
		r2=	0.035530869	0.132887822	0.048635467	0.008204302	0.018972703	0.002964031	0.001961447	
		t=	1.01095E-05	0.726314211	9.36327E-07	0.000746406	0.021956202	0.464157896	2.26008E-06	

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

Table 9: Will You Use the Deep Breathing in the Future and Why?

Participant / JTI Result	Yes or No?	Felt calmed, relaxed, or soothed	Easy and / or quick	Focused (on something else) or cleared head	Felt it was useful / versatile or good for them	Ineffective
1 - ENFP	1x yes, 1x no					x
2 - ENFP	Yes	x	x	x	x	
3 - ENFJ	Yes	x	x	x	x	
4 - INFP	Yes	x	x			
5 - INTP	Yes	x		x		
6 - INTJ	2x no, 1x maybe					x
7 - ENFJ	Yes	x	x		x	
8 - INFJ	Yes	x	x		x	
9 - INFJ	Yes	x	x			
10 - INFJ	3x yes, 1x maybe				x	

Table 10: Will You Use Visualisation in the Future and Why?

Participant / JTI Result	Yes or No?	Felt it was fun / easy / effective	Liked with an aid	Depend on situation / if they got better at it	Could be used in many situations	Good during time performing it	Hard to concentrate/ ineffective
1 - ENFP	1x yes, 1x maybe		x				x
2 - ENFP	1x yes, 3x no			x			
3 - ENFJ	Yes				x		
4 - INFP	Yes	x					
5 - INTP	No					x	
6 - INTJ	No						x
7 - ENFJ	No						x
8 - INFJ	4x yes, 1x no		x	x			
9 - INFJ	No						
10 - INFJ	Maybe			x			

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

Table 11: Will You Use the Mandala Coloring in the Future and Why?

Participant / JTI Result	Yes or No?	Felt it was calming/relaxing	Fun/good for them	Felt it was a chore/overall ineffective
1 - ENFP	Yes	x	x	
2 - ENFP	No			x
3 - ENFJ	Yes		x	
4 - INFP	No			x
5 - INTP	No			x
6 - INTJ	No			x
7 - ENFJ	1x yes, 1x no		x	
8 - INFJ	Yes	x	x	
9 - INFJ	1x yes, 1x no		x	
10 - INFJ	Yes	x	x	

Table 12: Did the Deep Breathing Help You Destress and Why?

Participant / JTI Result	Yes or No?	Felt calmed / relaxed	Cleared their head	Could focus on something else / refocus	Ineffective	Had lots going on
1 - ENFP	1x yes, 1x no				x	
2 - ENFP	Yes		x			
3 - ENFJ	Yes	x	x	x		
4 - INFP	Yes	x		x		
5 - INTP	Yes	x	x	x		
6 - INTJ	2x yes, 1x no	x				x
7 - ENFJ	2x yes, 1x no	x		x		
8 - INFJ	Yes	x				
9 - INFJ	Yes	x				
10 - INFJ	Unclear	x				x

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

Table 13: Did the Visualization Help You Destress and Why?

Participant / JTI Result	Yes or No?	Felt calmed / relaxed	Took mind off of worries	Had difficulty focusing / performing task	Ineffective
1 - ENFP	Yes			x	
2 - ENFP	1x yes, 3x no			x	x
3 - ENFJ	3x yes, 1x no	x	x		x
4 - INFP	Yes	x	x		
5 - INTP	No				x
6 - INTJ	No			x	x
7 - ENFJ	No			x	x
8 - INFJ	Yes		x	x	
9 - INFJ	No				x
10 - INFJ	No			x	x

Table 14: Did the Mandala Coloring Help You Destress and Why?

Participant / JTI Result	Yes or No?	Felt calmed / relaxed	Helped focus on something (else)	Found it fun	Found it effortful, tedious, or annoying	Ineffective
1 - ENFP	Yes	x	x	x		
2 - ENFP	No				x	x
3 - ENFJ	2x yes, 1x no		x			
4 - INFP	No				x	x
5 - INTP	2x yes, 2x no					x
6 - INTJ	No				x	x
7 - ENFJ	No			x		
8 - INFJ	Yes	x	x			
9 - INFJ	Yes	x	x			
10 - INFJ	6x yes, 2x no	x				x

Discussion

This is the first study, compared to those discovered within the literature review, to attempt to measure personality and effectiveness of de-stressing activities, as well as examine if personality could be utilized to determine which de-stressing activities would most effectively be used for teenagers. Because of the extensive amount of data collected and the lack of conclusiveness of this data, the original question of determining which de-stressing activities were best for which personality types was not answered. Instead, this study offers an exploration into the relationship between personality types, ratings of de-stressing activities, and ratings of overall stress levels.

The Stress Test scores suggest that the activities did not decrease stress over a period of five weeks, because participants either had an increase, a decrease due to outside factors or stayed the same. The hypothesis that those with the Introversion preference would have higher levels of stress was not supported, as there was no difference between stress levels of those who preferred Introversion or Extraversion. However, because the Stress Test has never been validated as a reliable measure of stress, it is possible that the activities could actually have affected the participants in a meaningful way, and the data-collecting methods simply did not reflect that. Further research is needed for a strong conclusion.

In contrast, even though the activities may not have decreased overall stress, the results show they did help the participants in the moment. While the statistical analysis did not prove any significance in the results, the qualitative analysis did. The activities were clearly helpful in aiding participants in general in their de-stressing, because of the high ratings of effectiveness for MC and especially DABE. The effectiveness of the MC is consistent with previous research, such as the Texas A&M University study that describes the mandala as, “a meditative tool...thought to promote psychological healing and integration when used by an individual” (Henderson, Rosen, & Mascaro, 2007, p. 149).

The Sensing over Intuition hypothesis could not be tested as no participants preferred Sensing. The Thinking over Feeling hypothesis was supported as the two participants who had the Thinking preference expressed overall less effective stress management than the rest of the sample.

ENFP

The fact that both Participant 1 and Participant 2 rated 5's for different activities alludes to their widespread interests and enthusiasms (Hirsh & Kummerow, 1989). Their 5 ratings to their respective activities indicate their enthusiasm for perceiving the activities as effective, and their effective activities being different shows that one ENFP can enjoy an activity more than another ENFP. Their mutual moderate rating of VI could also allude to the fact that ENFPs are creative and imaginative, and enjoy dreaming (Hirsh & Kummerow, 1989), to which VI is most alike out of the three. Participant 2 displays enthusiasm in their answer for the question, “Will you use the Visualization Activity in the future and why?” because even though they answered three times out of four “No,” their use of it in the future depended on the situation or if they could improve. Participant 1 supports ENFPs love of drawing (Hirsh & Kummerow, 1989) by rating MC a 5. The 5 results also are consistent with MBTI Practitioner Susan Storm’s stance on the stress management of ENFPs; DABE and MC, because they require mindfulness, can be thought of as forms of meditation, which Storm has stated as a helpful de-stressing activity for ENFPs (Storm, 2015).

ENFJ

The number of times ENFJ personality types performed activities overall was inconsistent with their supposed trait of “loyalty” (Hirsh & Kummerow, 1989). While Participant 3 performed an adequate number of activities for this study, Participant 7 performed roughly half as many, resulting in an inadequate number of times performing the designated activities. Participant 3 displayed loyalty to participating in the study while Participant 7 did not, even performing the lowest amount of activities out of the sample. However, both participants displayed the supposed traits of ENFJs by expressing enthusiasm, expressiveness, and energy. Participant 3 was one of the most responsive in answering the qualitative data questions, providing the most detail and also displaying high regard for each of the activities, finding future uses for and positive things to say about each one. Participant 7 displayed enthusiasm when asked if the MC helped them de-

STRESS MANAGEMENT ACTIVITIES FOR MYERS-BRIGGS PERSONALITY TYPES

stress because they described it as being a fun activity, even though they answered no to its effectiveness. Enthusiasm was also supported in that both ENFJs rated each activity 3 or higher, displaying their perceptions of the study as positive even though Participant 7 did not express as many benefits as Participant 3.

INFP

Participant 4 rated DABE and VI a 5 and 4 respectively, indicating a high regard for the more introspective activities. This is consistent with their Introversion preference, as drawing energy from themselves, rather than others, by practicing mindfulness in solitude could lower stress levels, thus increasing their effectiveness. Their supposed trait of “adaptable” was inconsistent, as their responses to questions concerning MC were generally negative and continually describing it as worse than the other two activities. A display of adaptability would suggest an over-time shift in perspective about an activity that did not work out for them at first. Storm’s (2015) interpretation of effective ways for an INFP to de-stress included, “Give them space and time alone to sort their feelings.” This is consistent with the INFP’s highly rated activities, as both of them gave full attention to whatever topics were on their mind, without the hindrance of the “annoying lines” of the mandalas the INFP complained about staying within.

INTP

Interestingly, Participant 5 was the only participant to perform one activity several times before moving on to another, instead of performing them interspersed with each other. This is consistent with their described “systems-building approach to their work,” (Hirsh & Kummerow, 1989) because the INTP performed in the study within a system they themselves created as they were not asked to perform the activities in this way. The tendency for INTPs to perceive inconsistencies negatively (Hirsh & Kummerow, 1989) is another validated claim according to this study. The INTP’s effectiveness ratings for DABE, VI, and MC were a 5, 2, and 3, respectively. These results show negativity towards inconsistencies because of

the process of actually performing each of these activities; to perform DABE at any given time, the actions an individual does are the exact same, whereas VI can be performed a multitude of different ways. MC then falls somewhere in the middle, as the same tools are needed each time it is done but the way in which the tools are used can vary.

INTJ

There are several reasons why Participant 6 of this study had the poorest experience within the sample. According to *Life Types*, INTJs are logical, independent, and “systems-minded.” Systems-minded means INTJs believe everything can be explained by a certain model or system. This is closely related to the fact that most INTJs feel as though the world ought to be certain way (Hirsh & Kummerow, 1989). An INTJs need for logical systems could prove a major hindrance in attempting to de-stress, as stress itself is variable and at times, a subconscious event. Attempting to lower stress when its source and impact are inconsistent could be difficult for an INTJ to do, as certain “systems” or perhaps “models of de-stressing” may produce inconsistent outcomes. If these inconsistencies did not fit the INTJs model, the results could have been frustrating, and the reason the activities were overall ineffective. Also, INTJs are value-oriented, and tend to have strong opinions on what is right for them and worth their time (Hirsh & Kummerow, 1989). It is possible Participant 6 simply did not place any importance on lowering their stress levels and thereby did not perform these activities with either the adequate amount of time, patience, interest, or motivation that it would have taken to perceive these activities as effective.

INFJ

The two participants out of the entire study, Participant 8 and Participant 10, who performed the activities the full 15 times were both INFJs. According to *Life Types*, INFJs tend to be extremely dedicated to their endeavors, describing how one should “not...underestimate the amount of perseverance, energy, and time INFJs give to their priorities,” so this claim is supported by this finding. This book also describes how

this commitment allows INFJs the ability to foresee and complete long-term goals. This claim is supported by this study because in the questions concerning if the participants would use these activities in the future, all three INFJ participants said “Yes” at least once for every activity, except for Participant 9 and VI. The INFJs also, more often than not, had positive things to say about the activities they performed, which shows support for their supposed traits of “conceptual,” “idealistic,” and “holistic.” This would then explain why most of the effectiveness ratings were high, because that means INFJs would perceive de-stressing activities as a positive experience as a whole, especially if the participants idealized relieving their own stress.

Limitations

Because there were only ten participants in this sample, the distribution of personality types was not a sufficient representation of the overall population of the world, as some personality types were absent. Also, the fact that there were uneven distributions within the six represented types is another limitation.

The Stress Test itself is a limitation, as the researcher created it and it has never been used before. The Stress Test presents adequate face validity, however there is no proof it is a valid measure of an individual's overall stress or change in stress. It was used nonetheless as there were no other adequate stress surveys available at the researcher's disposal. Because of this, when analyzing the participants' results, it is imperative one does not compare one participant's score to another's, as the survey was created with the subjectivity of stress in mind. One person's perception of their own stress will be different than another's, even if they have the same objective stressors in their lives.

Implications

Jungian theory-based practices are few and far between in the world of scientific research, which has led to its regard being essentially spiritual, artistic, and overall un-scientific (Henderson, Rosen, & Mascaro, 2007). Although the MBTI is controversial due to its theoretical construct based on Jungian ideas, it is often used in personnel testing to determine personal-

ity characteristics of employees, as well as used relationally. In this study, the MBTI model-based JTI was used to add to the scientific research, because the lack of research contributes to Jungian-theory controversy. While this study is but one, conducted on limited time and resources, it is important in the fact it adds to the available research conducted on Jungian theory in the psychological field. Adding more knowledge to the research studies on Jungian theory further increases the scientific community's understanding of Jungian type and how to best utilize it, as well as increases its ability to determine if Jungian theories are scientifically verifiable at all.

This leads to the second implication: understanding of stress management for all types of people. Because this study aimed to discover which techniques worked for which individuals based on their JTI personality type, it supplied information potentially useful to people with those same personality types. Even people whose personality types were not represented can benefit by referring to results of people who share one to three of the same preferences as them, and gain insight from there on which activities were helpful and which were not. For example, an ENFP could obviously refer to the ENFPs results to decide which activities are most likely to be effective for them, but they could also refer to the ENFJ results. Furthermore, an ESFP could examine ENFP results.

Also, this study sheds additional light on research regarding stress relief for teenagers, given that the sample consisted of strictly teenage high school juniors. While stress in teenagers is not an uncommon topic for the scientific community, the psychological and subjective perspective of this study could further the community's conclusions about stress management in teens. Teenagers can often be more volatile and impulsive, and in order to alleviate teen stress, creative measures should be taken.

Finally, because this study contributes to the conversation of stress management, it also contributes to helping people live a healthier life. As mentioned in the literature review, stress can have serious health consequences, and because this study focuses on stress management, it also focuses on reducing the risk of these consequences. That offers great importance, as improving life quality for the masses is a worthwhile goal.

Further research is needed on this topic. As pre-

viously stated, this study did not cleanly answer the research question. However, it certainly discovered a wealth of information on how personality types manage their stress and how they view how they manage their stress. In the technical sense, because preference for the Sensing type had no representation, investigating these activities' effects on individuals with Sensing type is needed for accurate conclusions. As aforementioned, Jungian theory is not widely investigated in scientific research, and more studies would benefit the scientific community for more insight on its objective validity, integrity, and utility.

Conclusion

While this study has its limitations, it still has value. Even though the original question of research, to discover which personality types found which stress-relieving activities effective, was perhaps only attempted, the study was successful in obtaining new information that can be useful to researchers in the future.

Further research in this area would include a replicated version of this study, but with more participants to increase its reliability. With more participants, a new study could also separate them into different groups with all personality types represented and have each group perform a different activity. This would perhaps investigate the hypothesis more clearly, since the different groups would be performing different activities. Another phenomenon that could be studied is what actually causes teenagers to be stressed, such as strenuous academic course load, and how to either eliminate that from happening or investigate why some teenagers overwhelm themselves in the first place. Yet another suggestion is possibly having one or more of the de-stressing activities involve exercise. All three in this study were static and done by staying still. Finally, future research could investigate essentially the same research question as this study, but with a control group. The control group would consist of participants who were unaware of their personality type, while the experimental group was aware of theirs. The experimental group would be identical to this study, while the control also did everything the same, except without taking the JTI. This would eliminate the possibility that some participants reported

their results as they did based on what they believed about their own personality and how it "should" make them behave.

Although the results of the study were inconclusive, they still shed light on the relationship between personality type and stress in teenagers. Research on the connection between stress and personality will greatly benefit those who wish to decrease the stress in their lives.

References

- Antai-Otong, D. (2001). Creative stress-management techniques for self-renewal. *Dermatology nursing*, 13(1), 31.
- Fritz, G. K. (2014). *Managing stress in teens and adolescents: A guide for parents*. Retrieved from: <http://onlinelibrary.wiley.com.offcampus.lib.washington.edu/doi/10.1002/cbl.20210/epdf>
- Healy, C. C., & Woodward, G. A. (1998). The Myers-Briggs type indicator and career obstacles. *Measurement and Evaluation in Counseling and Development*, 31(2), 74.
- Henderson, P., Rosen, D., & Mascaro, N. (2007). Empirical study on the healing nature of mandalas. *Psychology of Aesthetics, Creativity, and the Arts*, 3, 148-154. doi:10.1037/1931-3896.1.3.148.
- Hirsh, S. K., & Kummerow, J. (1989). *Life types*. New York, NY: Warner Books, Inc.
- Hollis, J. (2013, December 12). *A brief note on Carl Jung*. Retrieved from <http://www.cgjungpage.org>
- Passmore, J., Holloway, M., & Rawle-Cope, M. (2010). Using MBTI type to explore differences and the implications for practice for therapists and coaches: Are executive coaches really like counsellors?. *Counselling Psychology Quarterly*, 23(1), 1-16.
- Kumar, A., Rinwa, P., Kaur, G., & Machawal, L. (2013). Stress: Neurobiology, consequences and management. *Journal of Pharmacy and Bioallied Sciences*, 5(2), 91.
- McLeod, S. A. (2014). Type A Personality. Retrieved from www.simplypsychology.org/personality-a.html
- Monshat, K., Khong, B., Hassed, C., Vella-Brodrick, D., Norrish, J., Burns, J., & Herrman, H. (2013). "A conscious control over life and my emotions?" mindfulness practice and healthy young people. A qualitative study. *Journal of Adolescent Health*, 52(5), 572-577.
- The Myers Briggs Foundation (2017). Retrieved from <http://www.myers-briggs.org/my-mbti-personality-type/mbti-basics/>
- Ragozino, R. L., & Kelly, W. E. (2011). Typing the worrier: relationship between worry and Jung's personality types. *Education*, 131(4), 791.
- Shybut, S. J. (1993). Job performance and type as measured by the Myers-Briggs Preference Inventory: Implications for clubhouse staffing. *Psychosocial Rehabilitation Journal*, 16(3), 113.
- Storm, S. (2015, August 2). How Each-Myers Briggs Type Reacts to Stress (And How to Help!) [Web log]. Retrieved from <http://psychologyjunkie.com/2015/08/02/how-each-mbti-type-reacts-to-stress-and-how-to-help>
- Toussaint, L., Shields, G. S., Dorn, G., & Slavich, G. M. (2016). Effects of lifetime stress exposure on mental and physical health in young adulthood: How stress degrades and forgiveness protects health. *Journal of Health Psychology*, 21(6), 1004-1014.
- Wong, Y. H. P., & Zhang, L. F. (2014). Perceived school culture, personality types, and wellbeing among kindergarten teachers in Hong Kong. *Australasian Journal of Early Childhood*, 39(2), 100.

Operative Utilization of Agricultural Wastes for Amending Pyrolysed Carbonaceous Feedstock, or Biochar, in a Simulated Unindustrialized Agricultural Setting

Palmer Short

Biochar—pyrolysed organic material—has the capacity to sequester recalcitrant carbon, making it a viable method of carbon capture and storage internationally. Biochar can also be used as a soil amendment, as it has many benefits to plants when in the soil; however, biochar must be treated properly for its agricultural benefits to be realized. This investigation tests the efficacy of four composted agricultural wastes with biochar to grow corn and soybeans, as compared with controls of no biochar or amendment during a fourteen-day pot trial. The biochar and fertilizers were produced and composted locally, using replicable, unsophisticated methods. It was predicted that biochar, a known nutrient sink, would delay initial growth in all soils; however, plants in soil only amended with biochar had higher germination rates and grew taller than those without biochar. This gives evidence that biochar alone may give a benefit to plants.

Keywords: agriculture, biochar, corn, soybean, climate, botany

Introduction

Biochar is the name commonly given to a form of close-to-pure carbon for agricultural use.^{1-3, 5-6, 10} It is produced by the destructive distillation, or pyrolysis, of organic material in high-temperature, low-oxygen environments.^{1-2, 5, 7} It has received widespread interest for its potential in long-term carbon sequestration and sustainable soil improvement.²⁻⁴ Among its benefits when applied to soil are moisture retention, greater prevalence of soil biota, and efficient retention of fertilizer that both minimizes leaching and facilitates nutrient uptake into plants.^{1-3, 5, 7} Because biochar acts as a nutrient sink and not as a direct fertilizer, the full agricultural benefits of biochar are not realized until the material has been amended with a fertilizer.¹⁰ This is usually urea or another chemically-derived nitrogenous fertilizer. Raw biochar can be

produced cheaply, and is scalable from small family farms to industrial operations²; however, the chemical fertilizers used to amend biochar, as well as other refined agricultural techniques, are often not present in developing nations and small farms. In order for biochar used in agriculture to make a significant impact on the global climate, it would need to be implemented more broadly than chemical treatment and production methods currently allow. This study seeks to investigate whether prevalent agricultural wastes such as manure and greenwaste can provide nutrients with which to charge biochar in many of the areas in which chemical fertilizers are unavailable or impractical and to document the interactions between biochar and composted agricultural wastes as measured by crop germination and growth. This study is relevant and highly necessary, as most of the research currently done with biochar tends to

use chemical fertilizer as urea, while little data exists on the use of biochar with alternative nutrient sources that are more sustainable and produce fewer environmental problems than chemical fertilizers. The ultimate objective of this study is to establish recommended practices for rural and unindustrialized farmers such that they can more assuredly and effectively apply biochar with resources more likely to be available to them, thereby increasing the global sequestration potential of biochar.

Background

The word “biochar” broadly describes the black carbon produced from heating a feedstock in the absence of diatomic oxygen.^{1-2, 5} Feedstocks, the substances that become biochar after processing, can consist of any carbon-rich substance; however, due to economic considerations, biochar is most often produced from some form of biomass, especially agricultural residues.² These include rice husks, sugarcane bagasse, corn stalks, and peanut shells. Biochar is chemically indistinct from charcoal, as it is produced by similar methods using similar feedstocks.⁵ The principal difference between the two is usage; charcoal is black carbon often used as a heat source, while biochar is black carbon used as a soil amendment or sequestration vector.

The thermochemical process by which biochar is made is called pyrolysis, during which the water and volatile organic compounds in feedstock are driven off as incompletely combusted vapour, leaving black carbon behind.⁵ The released vapour can either complete its combustion in an oxygen-rich environment, such as an afterburner, or can be condensed and cooled into a composite liquid known as pyroligneous acid, which can be further refined into chemical products, including acetone and methanol.¹⁷⁻¹⁸ Other names for pyrolysis include “gasification” and “destructive distillation”, while pyroligneous acid refined for fuel or heating are often called “syngas” or “wood gas”.¹⁷⁻¹⁸ It ought to be noted that an oxygen-free environment is critical to the production of these products.⁵ When biomass is heated in open, oxygenated air, it is allowed to completely combust the feedstock. This yields mostly ash, which does not have the soil benefits offered by biochar.

Literature Review

In the scientific community that conducts research into biochar, there are two primary categories of study: climate science research and agricultural science research. Biochar research from a climate science perspective attempts to justify biochar as a stable tool for carbon capture and storage. Biochar research from an agricultural science perspective is largely concerned with the agronomic benefits of biochar application, and the ability to increase land productivity, fertilizer efficiency, or other factors with direct relevance to the health and productivity of crops. The following review, intended as a primer for the current scientific understanding of biochar, seeks to first establish the benefits of biochar for carbon sequestration, then to discuss biochar from the perspective of agricultural science, the field to which this study aims to directly contribute. This was done to justify the broad implementation of biochar not just as an agricultural aid, but as a method of carbon capture and storage. It must be noted at the outset that this review is limited and narrowed to the use of biochar from plant-based feedstocks with little standalone fertility, and does not detail the emerging field of research into directly pyrolysing animal wastes to create nutritive biochars.

The independent scientific disciplines of agricultural and climate science investigate biochar for different purposes and with different goals in mind, but a paper entitled “sustainable biochar to mitigate climate change” published in *Nature* by D. Woolf et al. has become a landmark study that is relevant to both primary categories of biochar study.¹ This was a collaboration among researchers at Swansea University, Pacific Northwest National Laboratory, the University of New South Wales, and Cornell University in departments relevant to materials science, agricultural science, and climate engineering. The study bolsters hundreds of citations, and represents a strong convergence and intersection of different fields of science to examine the subject of biochar through the lenses of many independent scientific disciplines. Utilizing and synthesizing the body of work that had been done on biochar, the team¹ sought to calculate the “maximum sustainable technical potential of biochar to mitigate climate change.” To perform this synthesis, the researchers¹ used not only climate science research, but considered the agronomic application of biochar to promote and

ensure food security. They concluded that a maximum of twelve percent of annual human emissions could be offset by biochar without any negative consequences to the environment or to global food security.¹ This indicates that although biochar cannot be the only method used to fully solve Earth's climate problems, it will certainly be an invaluable tool in the goal of offsetting human impact on the global climate. This gives further justification into researching biochar application methods, as it demonstrates that biochar could be safely implemented on much greater scales than it currently is. This was the first comprehensive biochar-related study to be accepted into such a prestigious scientific journal, and represents the point in time in which biochar reached a broader audience within the related scientific communities, causing it to become more widely researched.

The validity and importance of biochar as a carbon sequestration tool has been recognized by the Intergovernmental Panel on Climate Change, or IPCC.² This international aggregate of researchers and scientists forms a world authority on the science concerning climate change, and is actively used to shape public policy related to carbon emissions. In the eleventh chapter of their 2014 publication on the most current strategies for the mitigation of climate change, a segment was dedicated to detailing the promising research into biochar, wherein the benefits of the substance not only for carbon sequestration, but for agriculture and heat production were laid out.² The IPCC classifies biochar as one of their recommended land-based mitigation strategies,² and even identify biochar-manure interactions as an underexplored area of study.² This is a highly credible organization of scientists, researchers, and policy-makers, and their identification of biochar-manure interactions – the focus area of the study described in this paper – as being insufficiently researched is a reliable indication that a shortage of knowledge exists on the subject.

The claim that biochar is chemically stable, or recalcitrant, in soil is central to its usefulness as a means of carbon sequestration. A collaborative study³ among researchers at the University of Göttingen in Germany, Nanjing Agricultural University in China, and Kazan Federal University in Russia conducted a meta-analysis of dozens of biochar-related studies in an attempt to discover trends regarding the degradation of biochar to accurately characterize its stability.

They found that a 97% majority of biochar's mass is biologically inaccessible, which means it is not subject to degradation by normal biological processes in the soil.³ Biochar, therefore, has a high degree of recalcitrance, which is a necessary component for the longevity of biochar in soils. In addition, the researchers³ found that biochar degradation decreased logarithmically, even in the short-duration studies they examined. This shows that after a short period, most likely to do with the oxidation of biochar after its production, biochar becomes extremely stable in soils. They were also able to confirm that biochar enhances soil fertility by promoting the propagation of beneficial bacteria and fungi.³ This research suggests that biochar is, in fact, stable in soils, albeit after a brief integration period.³ This is key to the usefulness of biochar for carbon capture and storage.

Although the popularity of biochar has been increasing rapidly over the course of the past few decades, it is by no means a new invention. There is evidence to suggest that biochar was used by Amazonians several thousand years ago.⁴ Bruno Glaser and Jago Jonathan Birk from the Soil Physics Group at the University of Bayreuth in Germany conducted a review⁴ to summarize the current understanding of a certain type of highly fertile soil, *terra preta*, found scattered throughout central Amazonia. They concluded that the high concentration of aromatic carbon found in *terra preta* was the result of biochar.⁴ Glaser and Birk concluded that biochar applied to farmland "has the potential to combine sustainable agriculture with long-term CO₂ sequestration".⁴ This further justifies the interdisciplinary approach to biochar as both a climate mitigation strategy and as an agricultural technology, and provides evidence that biochar truly is recalcitrant in soils over longer periods than can be experimentally simulated. It also suggests a correlation between increased black carbon content and soil fertility. While other studies^{1,3} have examined the stability and concentration of biochar in newly produced biochar amended soils, this review⁴ was advantaged in that it was able to examine the recalcitrance of biochar amended soils thousands of years after its creation. This provides evidence suggesting that biochar can be relied upon as a highly-recalcitrant and effective method of carbon capture and storage around the world. Given the unsophisticated methods and limited resources the ancient Amazonians would have pro-

AGRICULTURAL WASTES AND BIOCHAR

duced these soils with, it simulates the sorts of soils produced for the experiment in this paper's study.

Having explained the benefits of biochar for the global climate,¹⁻² the question of implementing its use must be addressed. Biochar has a number of benefits to soil, including the aforementioned increases in soil biota and aromatic carbon,³ which makes it a valuable substance for farmers. One key benefit offered by biochar is its ability to efficiently distribute existing nutrients to plants through cation exchange.⁵ This claim was reviewed by researchers with expertise in biochar and soil science writing for the scientific journal *Biology and Fertility of Soils*.⁵ Through a meta-analysis of several independent studies of biochar performance in agricultural fields, the researchers sought to find, through synthesis, a consensus on the impact of biochar on nutrient retention and distribution, and explain the chemical and physical properties of biochar that cause these benefits. They found that biochar application in conjunction with other fertilizers consistently improved nutrient uptake into plants. They also noted that the application of biochar had a noticeable regulatory effect on soil pH. In addition to this, they concluded that the aromatic structures and carboxyl groups found on biochar, mostly produced as a result of post-production oxidation, were largely responsible for the nutrient holding and exchanging properties of biochar. This property is the mechanism by which biochar conditions the soil to which it is added,⁵ and is therefore of vital importance to any investigation of biochar interactions with different nutrient-rich soil amendments. This research also confirms that biochar application is correlated with increased microbial activity in soils, which is beneficial to plant growth.⁵ This is corroborated by the aforementioned collaborative study between German, Chinese, and Russian researchers, which stated in their conclusion that biochar "stimulates microbial activities" in soil.³ The pH regulation performed by biochar was also noted by a separate team of researchers.⁶ In their study, biochar from several plant-based feedstocks was combined with several different soil types to test for a variety of chemical and physical properties including water holding capacity, soil carbon content, and nitrogen mineralization.⁶ Although the impact of biochar on these soils varied quite substantially, the researchers state in their conclusion that "biochars, regardless of origin, significantly raised the pH of all soil types".⁶

This is known to compensate for the pH-lowering effect of increased nitrogen in soil, and is yet another benefit conferred by biochar to agricultural soils.^{5,6}

The key benefit of biochar for agriculture is as a soil conditioner. The current scientific consensus is that biochar made from plant-based feedstocks provides little direct nutrient benefit to the soil.⁷ Research published in the journal *Soil Science* details an incubation study wherein soils containing biochar were chemically analyzed against control soils⁷. This was done by directly analyzing the leachate after the 67-day study. It was found by this study that biochar application increased soil organic carbon,⁷ which is an unsurprising result given that biochar is almost entirely composed of aromatic carbon.¹⁻³ They found, as did other studies, a number of oxygenated functional groups on the surface of the biochar after incubation that would likely contribute to soil fertility.^{3,7} The important finding of this study, however, was that biochar did not substantially increase the nitrogen content of the soil to which it was added.⁷ This is indicative of the function of biochar as a nutrient distributor, rather than as a source of nutrient itself. The concentration of certain micronutrients in the leachate from biochar soils indicated that biochar absorbs these substances, and decreases their availability in soil during the integration and oxidation period. This may explain any stagnation of, or indeed drop in, productivity of plants in biochar-only soils as opposed to soils amended with a fertilizing substance. The means by which biochar is incorporated into soil is also likely to impact the leaching of nutrients.⁸ In a study designed to simulate rain-induced leaching, a 20% loss of total phosphorus was recorded when the fertilizer-amended biochar had been applied on top of, rather than mixed into, the soil.⁸ Although biochar can reduce leaching of fertilizer,⁷ it must be incorporated into the soil properly in order to function in this capacity. This emphasizes the importance of not only producing biochar with the correct chemical properties and fertilizer additions, but of the physical properties as well.

Other research, from researchers writing for the *Journal of Environmental Quality*,⁹ provides evidence that certain feedstocks yield biochar with non-negligible levels of nitrogen and other macronutrients. Most of these nutritive feedstocks are manures, and are therefore outside the scope of this review. Pyrolysed peanut hulls, however, are an outlier; their nitrogen

content of 30kg per tonne is similar to the nitrogen content of some pyrolysed manures.⁹ Despite this, the trend is for biochar from plant-based feedstocks not to be used in a nutritive capacity.⁷

The most important type of research for the study conducted for this paper is research that incorporates a plant growth element to test the efficacy of biochar. The results of a similar study to the one conducted here was published in the *Australian Journal of Soil Research*, and was produced by a team of researchers – predominately Australian – with expansive portfolios on biochar research, especially Lukas Van Zwieten.¹⁰ This research tested the effect of biochar alone, as well as biochar amended with a nitrogenous chemical fertilizer, on the yields of radishes. The pot trial was conducted with different concentrations of biochar measured in tons per hectare as an application rate, and different concentrations of nitrogenous fertilizer. The team found that a number of soil fertility factors– including cation exchange capacity, loam, and organic carbon– were positively correlated with the presence of higher concentrations of biochar in the soil.¹⁰ There was a 266% increase of plant mass in the highest-concentration biochar pots, as opposed to the 95% increase observed in pots with fertilizer alone.¹⁰ More importantly, they found that, “application of biochar to the soil did not increase radish yield even at the highest rate”, meaning that biochar provided little benefit on its own.¹⁰ This source informs the research conducted in this paper’s study by providing a precedent for the way in which biochar-amended plots will influence the growth of a food crop; however, their use of chemical fertilizers and pot trials, as well as the crops used is where the studies differ. Similar research, produced by multiple USDA researchers, also emphasizes the positive interaction between a fertilizer source and biochar.¹¹ Although the study focuses mostly on soil gas exchange, it recommends in its conclusion that biochar be used in conjunction with a fertilizer rather than on its own because “it eliminated potential yield reductions from biochar”¹¹. This relates to my study’s area of inquiry; the fertilizer source used was bovine manure, and separate trials were conducted for biochar-only, manure-only, and manure-and-biochar soils. Their results strengthen the notion that the best agricultural usage of biochar is when applied in conjunction with a fertilizer.

Materials and Methods

To measure the interactions between biochar and different composted fertilizers, two crops with different nutrient requirements,¹² namely Early Sunglow corn and Envy soybeans, were grown during a fourteen-day indoor pot trial. These crops were selected for their widespread international use.¹³ The one-hundred total plants, fifty plants each of Envy soybean and Early Sunglow corn, were divided into ten rows, each containing a distinct blend of biochar and agricultural wastes. There were two control blends. The first, containing sandy soil and nothing else, controlled for the absence of both biochar and compost. The second control, containing sandy soil and biochar, controlled for the absence of compost. The eight remaining blends were the four compost sources, each having a blend with and without biochar. Given the small sample size of five plants of each species per blend, the inclusion of statistical analysis was not recommended. This limitation was caused by the limited resources available for this study. The height of each plant was measured daily in millimetres, as well as plant death or non-emergence. During the growing period, the soil temperature was maintained at 30°C, the plants were exposed to twelve continuous hours of light provided by a 60W grow light, and were watered by mist twice a day. This was done to better simulate ideal growing conditions, and to control for extraneous confounding factors. These trials are similar to those conducted in the aforementioned radish trial published in the *Australian Journal of Soil Research*.¹⁰ The Australian study served as a useful model for the conduction of pot trials such as the one used in this study. Time constraints prevented any yield analysis in this study, so plant height was used as a growth metric instead.

The soils were produced by layering nitrogenous (green, or manure) and carbonaceous (brown) materials in approximate ratios pursuant to the Berkeley composting method,¹⁴ being left covered in black plastic for a shorter-than-normal two week period due to seasonal time constraints. In the compost plots for biochar soils, the brown layers were composed of biochar. In the compost plots for non-biochar soils, the brown layers were composed of shredded dry oak leaves. The three types of animal manures used in this study– bovine, equine, and poultry– were sourced from a local farm in Seminole County, Florida. The

greenwaste used in this study was manually harvested and shredded Indian goosegrass, chosen for its regional abundance. These materials were chosen not only for their availability, but for their varying nutrient content¹⁵. Poultry manure has the highest nutrient concentration, followed by equine and bovine manures respectively¹⁵. Greenwaste is known to be less nutrient dense than all of these because lower nutrient contents are associated with soils incorporating greenwaste rather than animal manures as a fertilizer¹⁶. The soil used was a nutrient-poor sandy soil with no prior history of cropping, and was mixed with the manure and greenwaste before the two-week composting period. After composting, the layers were manually broken up and each blend was mixed well. This was done not only to ensure a uniform distribution of soil constituents in each pot, but to minimize the potential leaching that may result from top-dressed application of biochar.⁸

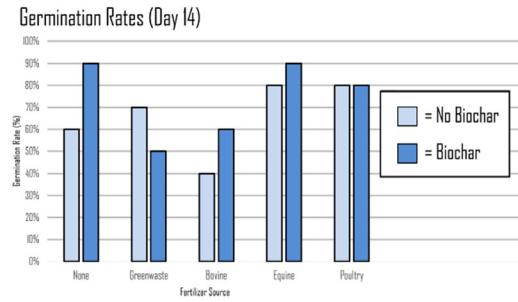
The biochar used in this study was produced in a custom-built pyrolytic reactor. The design was based on similar reactors, called Top-Lift Up-Draft (or TLUD) kilns. These are operated by starting a fire on the top of the bottom subunit, establishing a coal bed, and putting an afterburner subunit on top to finish combusting the volatile organic compounds rather than collecting them or releasing them as smog. This style of reactor employs a thermochemical process called slow pyrolysis, which was chosen for its relatively high feedstock conversion efficiency compared to other thermochemical methods.⁹ The reactor was designed such that welding was not necessary, as the limited funds were insufficient for advanced manufacturing to be used. The pyrolytic reactor was constructed from two 55-gallon steel drums without an interior epoxy coating. One barrel formed the top, afterburner region. The other barrel formed the bottom, reactor region. Vents were bored around the bottom rim of the bottom barrel. This was done by striking the barrel with a pickaxe to produce holes with diameters of approximately 1cm each, at approximately 3cm intervals. The top of the bottom barrel was cut along its diameter four times to create eight triangular tabs, which were manually bent upwards to serve as a stable coupling between the top and bottom barrels. The bottom of the top barrel was entirely cut out and sanded, allowing the two barrels to couple correctly. The top of the top barrel was cut identically to the top

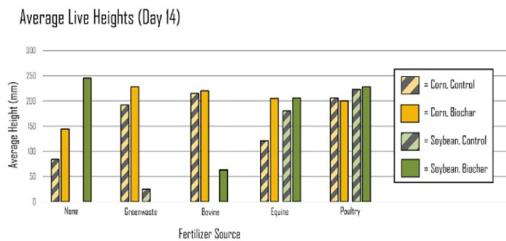
of the bottom barrel. The triangular tabs were kept only partially bent upwards, as this seemed to allow the exiting gases to mix better when trial operations were conducted.

Manually split and chopped oak branches were the feedstock used to produce all the biochar in this study. Oak was chosen for its local abundance. After loading the bottom barrel with feedstock, the top was set aflame and left to burn openly until the first signs of glowing coals could be observed, at which point the second barrel would be set on top of the first. This served as a combustion chamber for the exiting vapours. As the heat radiated downwards towards the bottom vents, the feedstock in the bottom barrel was gradually pyrolysed over the course of approximately two hours. After the reactor had finished pyrolysing its contents, it was extinguished by sealing the vents with wet sand and dousing the coals in water. This was the most expeditious method of extinguishing the coals in this design, though other designs could simply be sealed and left to cool overnight.

Results

The control soils without fertilizer, as well as those with bovine and equine manure, showed an increase in germination rates for all plants in the presence of biochar when contrasted with the no-biochar controls. The greenwaste and poultry soils were outliers. The germination rate of plants in greenwaste-amended biochar soils was 20% lower than the germination rate of plants in the greenwaste no-biochar control. There was no observed difference in germination rates of plants in poultry-amended soils.





In most cases, the presence of biochar in the soil was correlated with an increased average height. For corn, a positive biochar-height correlation was true of greenwaste, bovine manure, equine manure, and no-fertilizer control soils. For soybeans, this was true of equine manure, poultry manure, and no-fertilizer control soils. A small decrease in average corn height was observed for plants in poultry manure soils. No soybeans germinated in the greenwaste-amended biochar soils; however, while no soybeans germinated in the absence of biochar in no-fertilizer control and bovine manure soils, germinations were recorded for plants in the corresponding biochar-amended soils. The highest average live height was for soybean plants grown in the biochar-amended no-fertilizer control soils.

Discussion

This study yielded some noteworthy results regarding the impact of different fertilizer sources with biochar on the average height and germination rate of the resulting plants. The addition of biochar to otherwise untreated soils appears to have increased both the germination rate and height of resulting plants. If it can be established through further study that wood-feedstock biochars can reliably increase germination rates, it would be possible to create a new class of biochar-based germination aids. This result was not anticipated, since plant-feedstock biochar produced via slow pyrolysis is not generally thought to provide a nutritive benefit.⁸⁻¹¹ Although certain feedstocks yield nutritive biochar, wooden feedstocks such as the oak used in this study are not thought to be nutritive.⁹ This means that either the non-nutritive properties of biochar account for this increase in germination and height, or the current characterisation of wood-

feedstock biochars as being minimally nutritive is incorrect or incomplete. Some non-nutritive properties that may be hypothesised to increase germination rates are increased water retention and increased aeration through porosity.^{1-3,5,7} Further research is needed to discover the reasons for the increase in germination rates observed in this study.

Biochar also appears to aid germination in soils amended with bovine and equine manures, and hinders germination in soils amended with greenwaste. The increase observed in soils containing bovine and equine manure were anticipated; positive interactions between biochar and fertilizers are already found in the literature.¹⁰⁻¹¹ The decreases seen in greenwaste-amended biochar soils, however, were unexpected. The possibility of contamination cannot be eliminated, meaning that experimental error may be sufficient to explain this difference. There is, however, another possibility; given the relatively low nutrient density of greenwaste when compared with the other soil blends, it is likely that biochar, as a nutrient sink, had absorbed nutrients from the soil and left little for the plants' initial growth.¹⁶ The relative abundance of nutrients in other soil blends, such as those containing bovine and equine manure, would likely have compensated for this effect. To ensure that biochar is not applied to the detriment of agricultural productivity, the full reasons for the observed decrease in germination rates observed in the greenwaste-amended biochar blend must be investigated and identified.

Biochar has no confirmed effect on germination in soils amended with poultry manure. Poultry manure had the highest nitrogen content of all the soils tested in this study, which means that it is possible that the biochar's absorption of nutrients, and the distribution of those nutrients to the plants, was overshadowed by the sheer abundance of nutrients available for the plants regardless of biochar application.¹⁵ The addition of biochar to soils is correlated with a greater average height of corn and soybean plants in this study, with the significant exception of greenwaste-amended soils, where biochar appeared to have an inhibiting effect on the growth of soybeans.

It may be argued that the purity of materials in this study, the relative imprecision of the technologies used, and the non-exact soil volume measurements would present confounding factors that would decrease the reliability of the results; however, the

aim of this study was to work with only the degree of precision that would be practiced by a farmer using rough guidelines and unsophisticated techniques. The results displayed here, therefore, are more likely to be representative of the sort of growth achievable by using biochar and composted agricultural wastes in unindustrialized settings, which is reflective of this study's ultimate objective. Using nutritive biochar was also outside the scope of this study. One possible direction for future research would be an investigation of soil fertility of slow-pyrolysed manure contrasted with fresh manures. Such a study might provide a better model for which nutrients are lost or concentrated as a result of pyrolysis, and could help to better explain the results of this study. In order to broadly implement biochar without unintended reductions in soil fertility, the causes for the disparate greenwaste result in this study must be identified, and a more comprehensive model of biochar interactions must be created.

Conclusion

Almost without exception, biochar is demonstrated by this study to have a positive or neutral effect on the height of corn and soybean plants during the first fourteen days of growth. Interactions between greenwaste and biochar were detrimental to plant growth, meaning that biochar does not have a consistent benefit across all fertilizer sources. The results of this study appear to indicate that the addition of biochar to otherwise untreated soils is correlated with an increase in the germination rate and height of resulting plants. An explanation for this result is not forthcoming, and in fact contradicts some of the existing literature on the use of biochar.⁸⁻¹¹ Perhaps further investigation into and replication of the procedures used here will yield valuable data on the production of positive-benefit standalone plant-feedstock biochar, and transform our presently held understanding about its use.

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References

1. Woolf D, Amonette JE, Street-Perrott FA, Lehmann J, Joseph S. Sustainable Biochar to Mitigate Global Climate Change. *Nature Communications*. 2010;1(5):1–9.
2. Smith P, Bustamante M. Chapter 11: Agriculture, Forestry and Other Land Use (AFOLU). *IPCC: Mitigation of Climate Change*. 2014;AR5.
3. Wang J, Xiong Z, Kuzyakov Y. Biochar Stability in Soil: Meta-Analysis of Decomposition and Priming Effects. *GCB Bioenergy*. 2015;8(3):512–523.
4. Glaser B, Birk JJ. State of the Scientific Knowledge on Properties and Genesis of Anthropogenic Dark Earths in Central Amazonia (terra preta de Índio). *Geochimica et Cosmochimica Acta*. 2012;82:39–51.
5. Glaser B, Lehmann J, Zech W. Ameliorating Physical and Chemical Properties of Highly Weathered Soils in the Tropics with Charcoal – a Review. *Biology and Fertility of Soils*. 2002;35(4):219–230.
6. Streubel, J. D., Collins, H. P., Garcia-Perez, M., Tarara, J., Granatstein, D., & Kruger, C. E. (2011). Influence of Contrasting Biochar Types on Five Soils at Increasing Rates of Application. *Soil Science Society of America Journal*, 75(4), 1402–1413
7. Novak JM, Busscher WJ, Laird DL, Ahmedna M, Watts DW, Niandou MAS. Impact of Biochar Amendment on Fertility of a Southeastern Coastal Plain Soil. *Soil Science*. 2009;174(2):105–112.
8. Schnell, R. W., Vietor, D. M., Provin, T. L., Munster, C. L., & Capareda, S. (2012). Capacity of biochar application to maintain energy crop productivity: soil chemistry, sorghum growth, and runoff water quality effects. *Journal of Environmental Quality*, 41(4), 1044–1051.
9. Spokas, K. A., Cantrell, K. B., Novak, J. M., Archer, D. W., Ippolito, J. A., Collins, H. P., ... & Lentz, R. D. (2012). Biochar: a synthesis of its agronomic impact beyond carbon sequestration. *Journal of Environmental Quality*, 41(4), 973–989.
10. Chan KY, Zwieten LV, Meszaros I, Downie A, Joseph S. Agronomic Values of Greenwaste Biochar as a Soil Amendment. *Australian Journal of Soil Research*. 2007;45(8):629.
11. Lentz, R. D., Ippolito, J. A., & Spokas, K. A. (2014). Biochar and manure effects on net nitrogen mineralization and greenhouse gas emissions from calcareous soil under corn. *Soil Science Society of America Journal*, 78(5), 1641–1655.
12. Mylavapu R, Wright D, Kidder G. Standardized Fertilization Recommendations for Agronomic Crops. UF/IFAS. 2015 Apr.
13. Agricultural Marketing Service, Economic Research Service, Farm Service Agency, Foreign Agricultural Service. World Agricultural Supply and Demand Estimates 566. WASDE. 2017;566:1–40.
14. Misra RV, Roy RN, Hiraoka H. *On-Farm Composting Methods*. Food and Agriculture Organisation of The United Nations: Land and Water Discussion. 2003 Dec.
15. Ozores-Hampton M. Developing a Vegetable Fertility Program Using Organic Amendments and Inorganic Fertilizers. *HortTechnology*. 2012;22(6):743–750.
16. Pearson AJ, Spiers TM, Cant G. Crop Uptake of Nitrogen, Phosphorus and Potassium from Soil Amended with Chicken Manure and Green Waste Compost. *Proceedings Agronomy Society of N.Z.* 1998;28:31–34.
17. Balat M, Balat M, Kirtay E, Balat H. Main Routes for the Thermo-Conversion of Biomass into Fuels and Chemicals. *Part 1: Pyrolysis systems. Energy Conversion and Management*. 2009;50(12):3147–3157.
18. Balat M, Balat M, Kirtay E, Balat H. Main Routes for the Thermo-Conversion of Biomass into Fuels and Chemicals. *Part 2: Gasification systems. Energy Conversion and Management*. 2009;50(12):3158–3168.

Glossary

- Biochar:** black carbon produced for agricultural use.^{1–11, 17–18}
- Carbon sequestration:** the act of removing carbon-containing compounds from the atmosphere by adding them to the carbon sink.^{1–3, 8–11}
- Combustion:** an exothermic reaction wherein a substance is combined with oxygen.^{17–18}
- Feedstock:** a carbonaceous substance that can be pyrolysed to produce biochar.^{1–11, 17–18}
- Greenwaste:** an organic fertilizer derived from decomposed herbaceous plant materials.^{10, 15}
- Leach:** to drain a soluble substance from its substrate.^{5, 8}
- Pyroligneous acid:** a collection of condensed vapours produced through pyrolysis or similar thermochemical processes.^{17–18}
- Pyrolysis:** the thermochemical process by which a substance is broken down by heat in the absence of oxygen.^{1–11, 17–18}
- Recalcitrance:** the measure of chemical stability and resistance to degradation.^{1, 3–4}
- Urea:** a common nitrogenous compound that is often used as a fertilizer.^{10, 16}

An Evaluation of Mental Health Stigma Perpetuated by Horror Video Gaming

Elizabeth G. Dickens

Video games often feature mental patients in their storylines. This review is intended to test the hypothesis that these depictions potentially contribute to stigma surrounding mental health communities, and may negatively reflect on those with mental health difficulties. The criteria for evaluating the chosen games were created by combining elements from four separate academic papers. The games were analyzed via screenshots from online videos detailing a playthrough of chosen games, and text from the games themselves. The research within this paper suggests stigma can exist outside of conventional media platforms and highlights the availability of stigma-related horror video games inside the gaming market. This study also emphasizes how the depictions of those with mental health difficulties inside of video games have the capacity to harm mental health communities.

Keywords: stigma, mental health, video games, horror video gaming, review

The priming effect, a widely-discussed mass media effects theory, explains the influence media has over its viewers. Priming, defined as the impact of exposure to media on following judgments and behaviors (Roskos-Edwoldsen, Rokos-Edsoldsen, & Carpentier, 2009, p. 74), acts as an underlying force with the potential to guide people's thoughts and actions. In its initial application, the priming theory was used in reference to political science to explain the phenomena of mass media exposure having a significant effect on individual perspectives (Giodel, Shields, & Peffley, 1997, p. 289). Over time, however, this theory was applied more broadly. According to an updated discussion of media priming by professors David and Beverly Roskos-Edwoldsen, alongside Francesca Carpentier (2009), an associate professor in mass communication theory, the study of media priming in recent years has legitimized and undergone a massive shift from television to video games, in order to assess the reach and impact priming has on viewers (p.74). The potential expansiveness of media priming, in the context of video games, is dependent upon the developing community surrounding gaming.

Video Games as a Culture

According to the Entertainment Software Association (n.d.), the video game sector of the U.S. economy grows at an incredibly quick rate, especially when compared to its competitors (p. 1). Consequently, video games have developed into a form of culture, much like literature or film. In a study by Simon Egenfeldt-Nielsen, CEO of Serious Games Interactive, Jonas Smith, and Susana Tosca (2016), they state video games present an interesting perspective on digital media (p. 158). Horror video games uniquely found their place in gaming early on, and have essentially been a part of the horror community since the founding of modern-day video game consoles, according to video game designer Richard Rouse III (2009, p. 15). Rouse III (2009) attributes the success of video games in the horror genre to their ability to shed light on the inherently twisted nature of humanity, independently of other media (p. 15-16). However, the expanding exploration of this twisted nature has led to what social scientists refer to as stigma. According to Kaushik, Kostaki, & Kyriakopoulos (2016), stigma is

described on its most surface level, in terms of mental health, as qualities associated with mental conditions that are directed towards those deemed lesser in the social sphere (p. 470). However, to fully quantify the effects of stigma, it must be further broken into two subcategories: public stigma, resulting from the general population endorsing stereotypes, and self-stigma, a result of people with mental health difficulties internalizing these stereotypes (Chan & Mak, 2015, p.1). In accordance with the idea that media perpetuates such stereotypes, Egenfeldt-Nielsen et al. (2016) found cultural forms are fluid in their functioning, and highly integrated and shaped by society (p. 158).

Terminology for this Study

A study by Magnus Mfoafo-M'Carthy, Charles Gyan, and Cynthia Sottie (2016) discusses the negative depictions of people with mental health difficulties inside of newspapers in Ghana as one example of stigma. The study uses newspaper publications through the allotted ten-year search parameters to provide evidence for the perpetuation of stigma through language, and conclude the use of language such as “crazy,” “lunatic,” and “mentally ill” perpetuate stigma and delay progress (2016). Therefore, to reduce the likelihood of unintentional stigmatization throughout this paper, the term “people with mental health difficulties” will be used to refer to those with diagnosed or undiagnosed psychological conditions, regardless of whether they are seeking treatment or not, that can affect the capacity of an individual to function (“Mental Health Difficulties,” 2004).

Stigma Reinforced Through Media Exposure

Stigma has been directly attributed by various authors as an effect of media, or, more accurately, in the opinion of Anne Robbins, a reflection of medical professionals perpetuated through media (2015). In her dissertation, Robbins (2015) states the media is not independently responsible for the stigma surrounding mental health communities, for media merely reflects the views held in the medical profession (p. 17). This interpretation is an extension to the analysis

presented in a book published by professors Jim Flynn, Paul Slovic, Howard Kunreuther, and Baruch Fischhoff (2001) in which the authors examine the role of stigma in several complex social circumstances to provide evidence for how stigma is caused. Additionally, the authors (2001) provide explanations for the way stigma functions within society, and paint stigma as a compelling force interacting with various aspects of civilization to disrupt the lives of people (p. 331). Further research on what aspects of television shows and movies are responsible for perpetuating stigma was completed by Julia Maier, professors Scott Kaplan and Dr. David Vogel, and psychology researcher Douglas Gentile (2014). The study utilized a three-prong model analyzing TV shows and movies to explain the role stigma plays in treatment-seeking individuals (2014). The authors (2014) concluded that TV shows and movies are a powerful tool in shaping societal perceptions, and the portrayal of members of the mental health community in media contribute directly and indirectly to self-stigma (p. 254). The work of the authors mentioned above establishes that media affects the perceptions of people with mental health difficulties, be it through direct influence or indirect from the opinions of medical professionals represented in media. Thus, a further investigation into the sources that prompt stigma is necessary.

The occurrence of negative portrayals of people with mental health difficulties can be seen in even the earliest of classic films, *One Flew Over the Cuckoo's Nest*. George Domino, previously a professor of psychology, studied the attitudes of students before seeing the film, after seeing it, and after seeing a documentary about the actual experience of patients inside of the hospital the movie was filmed in (1983). To evaluate the effects of the film, Domino distributed a 108-item attitude questionnaire to 146 college students before and after viewing the film. Domino (1983) reported that students who watched the film exhibited less positive attitudes in four of the five attitudinal areas, which were primarily used to assess the shifting opinion of students towards mental health professionals, patients, and facilities (p. 180). His findings concluded, overall, “cinematography can be used as a medium which has an equally powerful effect on attitudes [towards mental illness]” (p. 182) as experiences with mental health in hospital communities (Domino, 1983).

Moreover, in a study conducted by mental health consultant Dr. Madhusudan Singh Solanki and psychiatry specialist Girish Banwari, several Hindi films were evaluated to identify the particularly stigmatizing portrayals of people with mental health difficulties within them (2016). In their research, Solanki and Banwari (2016) established that the dream-like visual experiences in films, combined with audio, have prolonged impacts on viewers (p. 21). To accompany these lasting images, the researchers (2016) discovered a number of harmful stereotypes endorsed throughout the duration of these films, including the ideas of horrific asylums, drug-addict anti-depressant pill poppers, and electroconvulsive therapy for the intent of punishment. In the conclusion of their study, Solanki and Banwari (2016) state the trend of confirming the stereotypes society holds against the mental health community through media only further stigma attached to mental illness (p. 22).

What Solanki and Banwari found is also consistent with the findings of John Goodwin (2013b) in his 55-movie study of twenty-first century horror films. Goodwin (2013b) advocates that modern horror films influence public opinion by misinforming the public and discriminating against mental health communities (p. 230). Goodwin (2013b), emphasizing the popularity of the horror genre, also advocates for the reasonability in concluding such films have impacted the viewpoint the public holds of people with mental health difficulties negatively, given the circumstances set forth by horror film producers. Accordingly, Goodwin (2013a) speaks to the confusion, delays in treatment, false beliefs and conflict treatment-seeking individuals experience because of stigma inside of horror films. This can also be seen in Brian Smith's (2015) analysis of media representations, which associates high levels of self-stigma with a decrease in treatment-seeking patterns in people with mental health difficulties (p. 1). Smith (2015) uses various studies analyzing the ways in which people receive their media to provide evidence for the abundance of media portraying negative images of people with mental health difficulties and to justify his subsequent labeling of media as a primary cause of stigma (p. 1). Smith (2015) goes on to explain the connection between self-stigma and treatment seeking, as self-stigma can then delay the recovery process

and prompt unnecessary stress for mental health professionals (p. 1). In specifically connecting the idea of negative representations of people with mental health difficulties to the concept of self-stigma, Smith (2015) is further qualifying the effects of inaccurate media portrayals through the internalization of cultural stereotypes and behavioral responses particularly associated with self-stigma (Chan & Mak, 2015). In addition, Patrick Corrigan and Amy Watson (2014), in association with the University of Chicago Center for Psychiatric Rehabilitation, published a study claiming stigma has the power to deter people with mental health difficulties from pursuing their goals and aspirations, due to their claim that fear leads to avoidance. These authors (2014) use a variety of previously published studies to provide evidence for the impact collective stigma has on every aspect of life for people with mental health difficulties. The establishment of this correlation uniquely characterizes the relationship between media and stigma as heavily co-dependent, and thus supports the analysis above, stating media has the capacity to influence the opinion of the public towards people with mental health difficulties negatively.

Video Games as a Medium for Stigma

Despite the above research, the relationship between stigma and media has still not been fully explored. Just as Roskos-Edwoldsen et al. claimed in 2009, the media priming theory has shifted to evaluate the ability for video games to influence the thoughts and behaviors of players. However, this research only investigates the relationship between video game violence and actualized violence in the real world. For example, in a study by Dr. James Sauer, Natalie Nova, and Dr. Aaron Drummond, it was found different reward structures selectively affect in-game aggression, whereas narrative contexts selectively affect postgame aggression (2015). In comparison, a study by Wolfgang Bösche focuses on the potentially negative and positive affects violent gaming has on the formation of aggressive thoughts and concepts in players (2010). Regardless of their conflicting conclusions, these authors represent the vast base of literature surrounding

violence in video games. This, in turn, highlights the significant lack of academically published literature concerning the stigmatization of people with mental health difficulties inside of horror video games, despite calls from the research community for further investigation. Robbins (2015), in focusing on the portrayal of people with mental health difficulties in films, concludes her paper stating her method should be reproduced with the intention of examining other mediums to eventually pinpoint and reduce self-stigma in individuals (p. 76). Similarly, Smith (2015) states studies in the past have connected high media usage with more negative attitudes towards people with mental health difficulties, but acknowledges previous research hasn't fully explored possible mediums for stigma (p. 10). Thus, the purpose of this paper is to fill the research gap between stigma studies and video games that depict people with mental health difficulties in a negative or stereotypical light.

To further build the case for studying video games, an overview of current research discussing developments in the technological community is necessary. The primary concern of all recent technological developments in the gaming world have revolved around immersion—the utilization of virtual environments (VE), spatial cognition, presence, sound, and point of view—which all act as tools to achieve the highest player immersion, or player experience, possible. In a study by Julia Fröhlich, a cognitive interaction researcher, and Ipke Wachsmuth (2013), a cognitive and artificial intelligence computer scientist, the occurrence of VE immersion was explained further in terms of presence—defined as the psychological state of being a part of a VE that allows an unbroken stream of interaction (p. 160). The purpose of evaluating presence inside of a VE is to make the experience as realistic as possible, which can have repercussions when discussing the stigmatizing representations of people with mental health difficulties inside of video games.

An introduction to a collection of VE studies states media technologies are essentially a simulator, modeling extensions of an individual's body or senses (Biocca, 2009, p. 2). These authors use various studies defining presence, its effects, and its relation to real-world action and perception, as well as evaluations of real and virtual representations of environments to

provide evidence for the relationships between spatial cognition, embodied cognition, virtual reality, and real life. This collection of works emphasizes the efforts to bolster the reality of video gaming to make a situation more probable in the eyes of a gamer. As game developer Rouse III (2009) stated in an essay, the immersiveness of gaming is one of its core advantages (p. 21)

To add, a study published by Alena Denisova and Paul Cairns (2015) focused on the immersion in first-person video games versus the immersion in third-person video games, specifically in role-playing games. Denisova and Cairns (2015) believe immersion is a state of absolute engagement in a game (p. 1). These authors used a study in which players chose a specific game and played in either third or first person and were later distributed a 31-item questionnaire on their experience to provide evidence for which point of view gave the best player experience. The authors provided evidence that first person POV in the video game gave players a stronger sense of disassociation, as well as cognitive engagement, from the real world. This provides clear evidence players do become heavily immersed in gaming and feel they are a part of the virtual world, which could be a widely negative outcome regarding their attitudes towards people with mental health difficulties.

Another study by associate professor of game design Barbaros Bostan, and freelance video game developer Sercan Altun (2016), showed players make in-game choices to work towards goals via a system of incentives, goals, motivations, actions, reinforcers, or punishers (p. 57). In short, players satisfy a form of hierarchical needs per their in-game character's needs. The authors (2016) concluded the player's motivations determine the player's action towards reaching an objective in the game (p. 70). This explains why, even if they have the knowledge it is morally wrong, players will engage in behavior which may be ethically questionable to reach an objective. This directly ties back to the treatment of people with mental health difficulties within the reward-structure of most horror games, giving a clear reason for further research on the topic.

Study Description

This study focused on analyzing horror video games to specifically pinpoint their depictions of people with mental health difficulties and their potential to contribute to the stigma surrounding the mental health community. This was done by applying the definitions and criteria of stigma presented above (Kaushik et al., 2016, p. 470; Chan & Mak, 2015; Rüscher et al., 2005, p. 530). The evaluation of media such as television and newsprint have been investigated previously and yielded connections to stigma, and the following research aims to echo these results. The purpose of this study is to investigate the possible link between horror video games and stigma, given that they are a medium for communication, and to further work towards an effort to decrease the stigma surrounding people with mental health difficulties.

How do the depictions surrounding people with mental health difficulties present in horror video games contribute to the stigmatization of people with mental health difficulties?

Methods

Materials

The video games used in this study were found using the large game search engines “Itch.io” and “Steam Machine,” as well as Google and the Xbox One Store. These websites and applications are widely accessible to users, and provide a variety of free and pay-to-play games available to download to any Windows and most Apple computers, as well as Xbox One or PlayStation 4 consoles. The certain key words used to search for video games were “psychological horror games” and “horror games,” as these terms are generally used within the video game community to classify games. Games released between 2010 and 2017 were utilized within the study, to keep the data current and relevant. These criteria produced an abundance of usable games, but a list of 4 AAA titles directly coincided with the theme of mental hospitals were compiled: *The Evil Within*, *Outlast*, *A Chair in a Room: Greenwater*, and *The Park*.

Design and Procedure

The research design of this project was that of a review, in order to identify the possible link between stigma and horror video gaming. Previous studies published by Robbins (2015) and Goodwin (2013b) called for the investigation of the stigmatizing effects of media through various media. In this study, the alternative medium chosen to investigate was video games, given the absence of literature surrounding the topic of video games and stigma and the relative availability of video games in the constantly growing and immersive culture surrounding gaming. Robbins (2015) explained that furthering such research can analyze potential media which perpetuate or reduce stigma surrounding mental health in the future (p. 76-77). Therefore, the recommendations of Robbins’ (2015) study were used to guide the research process.

The criteria for evaluating the chosen games were created by combining elements from four separate academic papers, each detailing their own stigma-causing stereotypes. Combining the efforts of these researchers allowed for a more complete picture of what stigma can look like in media manifestations. The developed criteria for stigma were that the game negatively stereotyped people with mental health difficulties by portraying horrific images of asylums, pinned people with mental health difficulties as addicted to prescription drugs, painted mental health facilities as using electroconvulsive therapy as punishment (Solanki & Banwari, 2016, p. 22), promoted fear and subsequent societal exclusion of those who experience mental health difficulties (Rüscher et al. 2005), and those who treat it (Smith, 2015, p. 1), and depicted those with mental health difficulties as seeing themselves as “enlightened member[s] of society” (Hyler, Gabbard, & Schnieder, 1991).

As games were examined, they were evaluated using the definitions of stigma provided by Kevin Chan, a psychiatric researcher, and Winnie Mak, a faculty member at the Chinese University of Hong Kong, dealing primarily with the endorsements of stereotypes to portray a certain community negatively (2015). According to their paper, public stigma is the “the prejudice and discrimination that result from the general population endorsing stereotypes about mental illness,” whereas self-stigma is the “harm to self-esteem that results from internalizing cultural stereo-

types about mental illness” (Chan & Mak, 2015).

The games were analyzed via screenshots from online videos detailing a playthrough of chosen games, and text taken from the games themselves. If possible, primary sources and direct engagement with the games were used to gather evidence; however, if the title was not available for firsthand play, it was evaluated through an online video accordingly, providing proper sourcing to the original content creator when necessary.

Findings

Images of Horrific Asylums

The Evil Within is set within Beacon Mental Hospital. Upon arriving at the scene as Detective Sebastian Castellanos, the player discovers scores of bodies of both patients and medical staff littering the floor (Markiplier, 2014a). Similarly, in Outlast, investigative reporter Miles Upshur is thrown into a psychiatric cell inside Mount Massive Asylum after being attacked by a patient in the opening sequence. (Markiplier, 2013a) These games lend themselves entirely to the stereotype of a “horrific asylum,” and perpetuate the idea mental hospitals are inherently violent places, and prone to catastrophe. Following this theme, A Chair in a Room: Greenwater finds its core setting in a mental hospital (GT Live, 2016b), and utilizes virtual reality technology to give the “experience of... being the protagonist of a horror film” (“A Chair in a Room: Greenwater, 2017). This first-hand experience, according to game developer Rouse III (2009), is the primary advantage of gaming—its level of immersion. Along those lines, although the game The Park is set outside of a mental hospital, single-mother Lorraine is sent spiraling through her memories of being carted through what is likely a mental hospital throughout the gameplay, while the walls around her are covered in negative messages such as “all that you love will be carried away” (Jacksepticeye, 2015a).

Fear of People with Mental Health Difficulties

Images which paint people with mental health difficulties in a negative light also contribute to the

stereotype they should be feared. One “creature” in The Evil Within is the AlterEgo, which is created by connecting a person with dissociative identity disorder to the STEM system (a system which uploads the subject’s consciousness into a generated reality [Markiplier, 2014c]). This idea is echoed as the player is directly pitted against an enemy described as a psychiatric patient (Markiplier, 2015). Along these same lines, throughout Outlast, the player is confronted with aggressive mental patients as the core enemies of the game. People with mental health difficulties are also seen surrounded by puddles of blood, guts, and gore, as well as attacking other patients (Markiplier, 2013a). The representation of people with mental health difficulties in the game directly reinforces the idea people with mental health difficulties are monsters to be kept from society and feared. Likewise, in A Chair in a Room: Greenwater the player is sent through a severely altered reality in which they’re sent through “fragments of [the players’] memories” (GT Live, 2016b). Following this same gameplay pattern, throughout The Park, a mysterious hatted figure which appeared throughout the theme park stands behind Lorraine and guides her hand as she kills her son with an ice pick in a relieved experience. (Jacksepticeye, 2015b) This characterizes Lorraine as violent and potentially contributes to the stereotype people who experience mental health difficulties are dangerous.

Fear of Those Who Treat Mental Health Difficulties

Throughout The Evil Within, Dr. Jimenez performs experiments on his psychiatric patient, Leslie. Moreover, the entirety of the STEM system is founded on the principle of patient experimentation (Markiplier, 2014e). Furthermore, in Outlast, Reporter Upsher observes the human experimentation going on in Mount Massive Asylum. The experimentation is so extensive the player encounters various mutilated bodies of mental patients throughout the game (Markiplier, 2013b). Depicting those who treat mental illness in such a negative light is a major deterrent for treatment seeking, according to mental health specialists Solanki and Banwari (2016, p. 22).

View of People with Mental Health Difficulties as Prescription Drug Addicts

A gameplay feature in *A Chair in a Room: Greenwater* is to take chlorpromazine, an antipsychotic prescription, to travel to the next step of the game. This occurs at various points throughout the gameplay (GT Live, 2016a). Incidentally, in *The Park*, Lorraine treks through her increasingly decaying home environment and finds her to-do list, instructing she repeatedly pick up her prescription for depression, all the while ignoring her father and husband (Jacksepticeye, 2015b). The idea portrayed in these games that those with mental health difficulties are more likely to become addicted to prescription medications fuels negative stereotypes surrounding mental health communities, and has the potential to incite self-stigma in those who experience mental health difficulties (Kaushik et al., 2016, p. 470; Chan & Mak, 2015; Rüsch et al., 2005, p. 530; Maier, Kaplan, Vogel, & Gentile, 2014, p. 254).

Electroconvulsive Therapy as Punishment

A key game mechanic in *The Evil Within* is the upgrade system, in which the player is seated in an electroshock chair by a nurse, and shocked with each new upgrade. The nurse has dialogue which states “you mustn’t fight it. This is for your own good” (Markiplier, 2014d). Both the mechanic itself and the cynicism of the nurse endorse the negative stereotype of electroshock punishment in mental health facilities, and furthers both the public and self-stigma caused by negative depictions of people with mental health difficulties and those who treat it in video games (Chan & Mak, 2015, p.1; Smith, 2015, p. 1).

View of Oneself as an Enlightened Member of Society

In the *Evil Within*, the primary antagonist of the game, Ruben Victoriano (Ruvik), states “they lose who they are and become clay, completely reshapeable in my image... I have surpassed you in every way you can imagine” (Markiplier, 2014b). This feeds into Hyler, Gabbard, and Schneider’s (1991) analysis of the negative stereotype of people with mental health difficulties viewing themselves as “enlightened

members of society.” This often reflects negatively on people with mental health difficulties, which makes this stereotype particularly harmful.

Conclusion and Future Study

Video games like *The Evil Within*, *A Chair in a Room: Greenwater*, *Outlast*, and *The Park* portray negative stereotypes of people who experience and treat mental health difficulties through images of horrific asylums, portraying people with mental health difficulties and their caretakers as frightening, painting those with mental health difficulties as addicted to prescription drugs, and the idea that electroconvulsive therapy is used as punishment. Given each of the games evaluated presented at least one of the six stereotypes attributed with causing stigma (see Figure 1), a possible link may exist between horror video gaming and public and self-stigma surrounding people with mental health difficulties and their caretakers (Chan & Mak, 2015, p.1). At any rate, there is no research directly attributing the stigma caused by horror video games to a decrease in treatment seeking, or an increase in public and self-stigma. However, according to Brian Smith’s (2015) analysis of media representations, stigma is caused primarily by an abundance of media representing people with mental health difficulties negatively. Research by Maier, Kaplan, Vogel, and Gentile in 2014 also found the media is an extremely useful tool in shaping society’s perception of people with mental health difficulties. Therefore, with the combined efforts of Smith and Maier and associates, it can be concluded, given video games are a form of media, they have the potential to cause public and self-stigma.

Limitations of this study include a limited available space for evaluating additional video games and a shortage of time to look in-depth at each game to make definite plot and gameplay connections to directly identify stigma-causing elements of these titles. Additionally, a lack of funding prevented firsthand gameplay by the researcher, which limits the extent to which the VE and overall immersion present in the games could be evaluated to build a stronger case for stigma-causing elements inside of video games.

The collective assessment of these games was subjective to the researcher’s attention to detail, and view

STIGMA PERPETUATED BY HORROR VIDEO GAMING

Mental Health Stereotypes in Video Games

Video Games	Stereotypes							
	Images of Horrific Asylums	Fear of People with Mental Health Difficulties	Fear of Those Who Treat Mental Health Difficulties	People with Mental Health Difficulties as Drug Addicts	Electro-convulsive Therapy as Punishment	People with Mental Health Difficulties as Enlightened	Total: Stereotypes per game	
The Evil Within	Yes	Yes	Yes	No	Yes	Yes	5/6	
A Chair in a Room: Greenwater	Yes	Yes	No	Yes	No	No	3/6	
Outlast	Yes	Yes	Yes	No	No	No	3/6	
The Park	Yes	Yes	No	Yes	No	No	3/6	
Total: Games per stereotype	4/4	4/4	2/4	2/4	1/4	1/4		

Figure 1. Mental health stereotypes in video games. This figure illustrates the four games examined in this study, and the stereotypes each exhibit.

of necessity of inclusion in the final analysis. Additionally, the discernment and analysis process of this study was entirely subjective, and dependent solely upon the judgement of the researcher. This means the analysis present in this study was subject to the inherent bias of the researcher, which may have potentially trivialized or diminished the reliability of the results and ultimately hindered the impact and investigation into the extent of which stigma is prevalent inside these titles. This study would benefit greatly from the input of various researchers when evaluating the extent to which these stereotypes are present inside the chosen video games, and would provide coherent insight into the legitimate effects stigma may have on players. Further research should include the opinions of multiple researchers to ensure a more complete and objective analysis of data.

The inconclusiveness among researchers concerning the long-term effects of stigma, in terms of media, also serves as a limitation to this study. This lack of fluidity in the field leaves unanswered questions regarding the significance of this study, and its relevance to mental health communities. An extended look into the effects of stigma present in horror video games on people with mental health difficulties

should be completed in the future to put the possible impacts of this study into perspective.

To fully understand the extent to which stigma is portrayed in video games, however, a more in-depth investigation into video games of all styles is necessary, as well as an evaluation of smaller, independently developed video game titles. Stigma could be continued to be evaluated throughout other forms of media to raise awareness and elevate understanding of stigma in everyday society. In order to assess the impact this stigma may have, further research into the actual impact stigma has on individuals due to video games which depict people with mental health difficulties and their caretakers negatively is necessary, and should be evaluated to understand the collective impact, if any, this research has on people with mental health difficulties.

The research presented in this paper implies stigma has the ability to exist outside of conventional media platforms such as television and newsprint, and highlights the availability of stigma-causing horror video games inside of the gaming market. This research also brings to light the depictions inside of horror video games, specifically, and how the depictions of people with mental health difficulties inside

of both the storyline and environments of these games have the capacity to harm people with mental health difficulties. In the context of the academic field surrounding mental health stigma, this paper serves to confirm video games are a medium through which mental health stigma can be translated, but requires further research to evaluate the existing effects of this stigma.

References

- A chair in a room: Greenwater (2017). Retrieved from <http://www.achairinaroom.com/>
- Biocca, F. (2009). Lighting a path while immersed in presence: A wayward introduction. In M. Lombard, F. Biocca, J. Freeman, W. IJsselsteijn, R. J. Schaevitz (Eds.), *Immersed in Media* (pp. 1-9). Switzerland: Springer. doi:10.4324/9780203892336
- Bösche, W. (2010). Violent video games prime both aggressive and positive cognitions. *Journal of Media Psychology*, 22(4), 139-146. doi:10.1027/1864-1105/a000019
- Bostan, B., & Altun, S. (2016). Goal-directed player behavior in computer games. In *Gamer Psychology and Behavior* (pp. 57-71). Springer International Publishing.
- Chan, K. K., & Mak, W. W. (2015). Attentional bias associated with habitual self-stigma in people with mental illness. *PLoS ONE*, 10(7). doi:10.1371/journal.pone.0125545
- Corrigan, P. W., & Watson, A. C. (2002). Understanding the impact of stigma on people with mental illness. *World Psychiatry*, 1(1), 16-20.
- Denisova, A., & Cairns, P. (2015). First person vs. third person perspective in digital games. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems - CHI '15*. doi:10.1145/2702123.2702256
- Domino, G. (1983). Impact of the film, "One Flew Over The Cuckoo's Nest," on attitudes towards mental illness. *Psychological Reports*, 53(1), 179-182. doi:10.2466/pr0.1983.53.1.179
- Egenfeldt-Nielsen, S., Smith, J. H., & Tosca, S. P. (2008). *Understanding video games: the essential introduction* (3rd ed.) (p. 158). New York: Routledge.
- Entertainment Software Association. (n.d.). *Games: Improving the economy*. Retrieved January 8, 2016, from http://www.theesa.com/wp-content/uploads/2014/11/Games_Economy-11-4-14.pdf
- Fischbach, M. [Markiplier]. (2014a, October 14). Are you crazy?! | The Evil Within part 1 [Video file]. Retrieved from <https://www.youtube.com/watch?v=nmsiQJjVY2w>
- Fischbach, M. [Markiplier]. (2014b, November 15). End of all things | The Evil Within – part 17 (final) [Video file]. Retrieved from <https://www.youtube.com/watch?v=8NCcjxAyAc>
- Fischbach, M. (2014c, November 3). Hundreds of tiny men!! | The Evil Within – part 11 [Video file]. Retrieved from <https://www.youtube.com/watch?v=xvJAOLPIZKc>
- Fischbach, M. [Markiplier]. (2014d, October 15). Inside my own mind | The Evil Within – part 2 [Video file]. Retrieved from <https://www.youtube.com/watch?v=UAkCNB7jP74>
- Fischbach, M. [Markiplier]. (2013a, September 4). Outlast | Part 3 | Monsters around every corner [Video file]. Retrieved from <https://www.youtube.com/watch?v=j8ri1v8vTTM>
- Fischbach, M. [Markiplier]. (2013b, September 8). Outlast | Part 12 (final) | The end? [Video file]. Retrieved from <https://www.youtube.com/watch?v=ppPLYu883DA>
- Fischbach, M. [Markiplier]. (2015, August 1). The last Evil Within ever? | The Evil Within: The Executioner DLC #3 (final) [Video file]. Retrieved from <https://www.youtube.com/watch?v=ojhNLaMDWBQ&t=1326s>
- Fischback, M. [Markiplier]. (2014e, November 6). What is that thing? | The Evil Within – part 13 [Video file]. Retrieved from <https://www.youtube.com/watch?v=LFe4yk9wHjU>
- Flynn, J., Slovic, P., & Kunreuther, H. (2001). *Risk, media, and stigma: Understanding public challenges to modern science and technology*, 331-352, London: Earthscan.
- Föhrlisch, J., & Wachsmuth, I. (2013). The visual, the auditory, and the haptic— A user study on combining modalities in virtual worlds. In R. Shumaker (Ed.), *Virtual, Augmented, and Mixed Reality: Designing and Developing Augmented and Virtual Environments* (pp. 159-168). Springer.
- Goidel, R. K., Shields, T. G., & Peffley, M. (1997). Priming Theory and Ras Models. *American Politics Quarterly*, 25(3), 287-318. doi:10.1177/1532673x9702500303
- Goodwin, J. (2013a). The horror of stigma: Psychosis and mental health care environments in twenty-first-century horror film (Part I). *Perspectives in Psychiatric Care*, 50(3), 201-209. doi:10.1111/ppc.12045
- Goodwin, J. (2013b). The horror of stigma: psychosis and mental health care environments in twenty-first-century horror film (Part II). *Care Perspectives in Psychiatric Care*, 50(4), 224-234. doi:10.1111/ppc.12044

STIGMA PERPETUATED BY HORROR VIDEO GAMING

- Hyler, S.E., Gabbard, G.O., Schneider, I. (1991). Homicidal maniacs and narcissistic parasites: stigmatization of mentally ill persons in the movies [Abstract]. *Hosp. Community Psychiatry, 42* (10), 1044–1048.
- Kaushik, A., Kostaki, E., & Kyriakopoulos, M. (2016). The stigma of mental illness in children and adolescents: A systematic review. *Psychiatry Research, 243*, 469-494. doi:10.1016/j.psychres.2016.04.042
- Maier, J. A., Gentile, D. A., Vogel, D. L., & Kaplan, S. A. (2014). Media influences on self-stigma of seeking psychological services: The importance of media portrayals and person perception. *Psychology of Popular Media Culture, 3*(4), 239-256. doi:10.1037/a0034504
- McLoughlin, S. [jacksepticeye]. (2015a, November 1). Creepiest child ever | The Park #1 [Video file]. Retrieved from <https://www.youtube.com/watch?v=dw4X-WVaGH4>
- McLoughlin, S. [jacksepticeye]. (2015b, November 4). The horrible truth revealed | The Park #2 [Video file]. Retrieved from <https://www.youtube.com/watch?v=RWvItT0zVAY&t=669s>
- Mental Health Difficulties. (2004, June 20). Retrieved December 11, 2016, from <https://uk.scips.eu/disabilities/mentalhealthdifficulties/>
- Mfoafo-M'Carthy, M., Sottie, C. A., & Gyan, C. (2016). Mental illness and stigma: A 10-year review of portrayal through print media in Ghana (2003–2012). *International Journal of Culture and Mental Health, 9*(2), 197-207. doi:10.1080/17542863.2016.1165271
- Patrick, M. [GT Live]. (2016a, June 23). Caution jump chairs ahead! – Chair in a Room: Greenwater (part 2 of 3) [Video file]. Retrieved from https://www.youtube.com/watch?v=gr3_ckRxBcW
- Patrick, M. [GT Live]. (2016b, August 13). Immersed in horror! - The end of Chair in a Room: Greenwater (Part 3 of 3) [Video file]. Retrieved from <https://www.youtube.com/watch?v=SAHxxwueI9A>
- Robbins, A. (2015). A role for media in reducing the stigma of mental illness. *Alliant International University*, 1-117.
- Rouse, R., III. (2009). Match made in Hell: The inevitable success of the horror genre in video games. In B. Perron (Ed.), *Horror video games: essays on the fusion of fear and play* (p. 15-25). Jefferson, North Carolina: McFarland and Company, Inc.
- Roskos-Ewoldsen, D., Roskos-Eswolden, B., Carpenter, F. (2009). Media Priming: An Updated Synthesis. In J. Bryant & M. B. Oliver (Ed.), *Media effects: Advances in theory and research* (3rd ed.) (pp. 74-92). New York, NY: Taylor & Francis Group.
- Rüsch, N., Angermeyer, M. C., & Corrigan, P. W. (2005). Mental illness stigma: Concepts, consequences, and initiatives to reduce stigma. *European Psychiatry, 20*(8), 529-539. doi:10.1016/j.eurpsy.2005.04.004
- Sauer, J. D., Drummond, A., & Nova, N. (2015). Violent video games: The effects of narrative context and reward structure on in-game and postgame aggression. *Journal of Experimental Psychology: Applied, 21*(3), 205-214. doi:10.1037/xap0000050
- Smith, B. (2015). Mental illness stigma in the media. *The Review: A Journal of Undergraduate Student Research, 16*(10), 1-14.
- Solanki, M. S., & Banwari, G. (2016). Comedy to sleazy horror: No end to cinema's stigmatizing and ridiculing attitude towards mental illness and psychiatry. *Asian Journal of Psychiatry, 21*, 21-22. doi:10.1016/j.ajp.2015.12.009

Is Oklahoma's State-Mandated Minimum Teacher Salary Sufficient? Evidence from 90 Oklahoma Districts

Lia Martin

The state of Oklahoma recently implemented a minimum salary schedule for all public school educators. There is a lack of research on the efficacy of this new salary schedule and its effect on student academic achievement. This research aims to analyze the effectiveness of this salary schedule by comparing the scores of students from districts that pay only the minimum salary and districts that pay above the minimum. Ninety school districts were selected for analysis, and teacher salary data were collected, along with student score data for state standardized math and reading tests, for each of these districts. There was significant evidence that students performed better on reading tests (but not necessarily math scores) when their teachers were paid more. The fact that students from districts paying above the minimum scored higher than students from districts paying only the minimum implies that student performance might improve if the minimum salary was raised.

Keywords: teacher pay, student achievement, education finance, Oklahoma education

Introduction

During his visit to Boston in 1990, Nelson Mandela famously said “education is the most powerful weapon which you can use to change the world.” Given this importance, understanding and perfecting education is a top priority of researchers. An important area of focus is the relationship between student achievement and teachers, specifically how student performance is affected by teacher salary. Current research holds that teacher pay and student success are positively correlated: as instructors are paid more, the performance of their students improves (Harris & Sass, 2011; Rockoff, 2004; Ronfeldt, Loeb, & Wyckoff, 2013). If this contention is true, then states with low teacher salaries should be concerned about their students’ academic performance.

One such state is Oklahoma, where educators receive some of the lowest salaries in the nation (Hendricks, 2015). In an effort to start remedying this issue, Oklahoma recently enacted a minimum teacher salary

schedule. Little is known about the effectiveness of this new policy; is the minimum high enough? This research aims to answer this question by comparing student performance on state standardized math and reading tests from the 2016 school year in thirty randomly selected school districts that pay above the minimum salary to student performance in sixty randomly selected districts that pay just the minimum salary. Additionally, the study endeavors to support the general consensus that teacher salary and student achievement are positively correlated by comparing average salary data from the 2014–2015 school year for all ninety selected districts to student performance on the same tests. This research suggests that a correlation between salary and performance does exist and that the state mandated minimum salary might not be sufficient. This study begins with an overview of the relevant literature, then proceeds to a description of the methods used and a detailed presentation of the results, and concludes with a discussion of these results, including a consideration of the study’s implications and limitations and recommendations for future research.

Literature Review

One of the most important fields of research in education policy is school finance; the equitable distribution of the funds provided to and used by school districts is of great interest to many researchers. Equity, or the fairness with which resources are distributed to schools and students, is one of the primary concerns of education finance literature because inequalities in school financing can lead to inequalities in student opportunity and achievement (Augenblick, Myers, & Anderson, 1997; Springer, Liu, and Guthrie, 2009; Turner, 2016). After the No Child Left Behind Act stated that all students must receive instruction from a “highly qualified teacher,” as part of its plan to reduce these inequalities in opportunity and achievement, researchers began to focus on teacher quality, and by extension teacher salary, as one way to measure funding equality (NCLB, 2002).

Teacher Pay and Teacher Quality

A great deal of the literature on teacher salaries is focused on the relationship between teacher pay and teacher quality. It has been thoroughly proven that higher teacher salaries are positively correlated with instructor experience, as well as overall teacher quality (Hanushek, Kain, & Rivkin, 1999; Hendricks, 2014; Rockoff, 2004). There are differing theories as to how this works. One theory is that paying teachers more improves their work ethic, leading them to perform better in the classroom (Hanushek, Kain, & Rivkin, 1999).

Another theory is that higher teacher pay attracts more capable recruits to the profession in the first place, meaning that the pool of applicants is of a higher caliber (Dolton & Marcenaro-Gutierrez, 2011). Essentially, higher pay makes teaching positions more desirable and thus more competitive. A higher quantity of talented individuals would be interested in becoming educators because of the promise of a rewarding salary, much like a large number of people are traditionally interested in becoming a doctor or a lawyer (Dolton & Marcenaro-Gutierrez, 2011, p. 8).

Other literature suggests that increasing teacher pay encourages instructors to stay in their positions, solving the problem of teacher turnover, which can be detrimental to students and schools alike (Hendricks,

2014; Ronfeldt, Loeb, & Wyckoff, 2013). Much of the literature agrees that teacher turnover is dangerous because districts often fill positions with less qualified educators, thus lowering the overall effectiveness of the teaching force (Hendricks, 2015). Further, teacher turnover could decrease the effectiveness of the teaching staff as a whole, because a new addition to the team would not be trained in the school's policies and practices, meaning that the staff would be less cohesive than before (Ronfeldt, Loeb, & Wyckoff, 2013). Although many important factors are involved in whether a schoolteacher stays at a job or seeks other employment, such as working conditions or student quality, a study of panel data in Texas asserts that salary is a deciding factor in a teacher's decision to stay or leave (Hanushek, Kain, & Rivkin, 2004; Hendricks, 2014; Loeb & Page, 2000). This is supported by a 2015 report by Matthew Hendricks, which found that in Texas (where teacher salaries are sixteen percent higher than in Oklahoma), instructors leave their jobs at a much lower rate than they do in Oklahoma (Hendricks, 2015). To combat this flight of teacher talent, many researchers suggest pay incentives (Hendricks, 2014; Hendricks, 2015; Ronfeldt, Loeb, & Wyckoff, 2013). A study of rich panel data from Texas revealed that a flat pay increase encouraged educators to stay at a higher rate than they had previously (Hendricks, 2014). Because increasing teachers' salaries encourages them to stay in the district, thereby preventing the turnover that decreases the overall quality of a teaching staff, teacher pay directly affects teacher quality.

Teacher Quality and Student Performance

Researchers regularly focus on teacher quality because the literature overwhelmingly suggests that teacher quality is positively related to student performance (Harris & Sass, 2011; Rockoff, 2004; Ronfeldt, Loeb, & Wyckoff, 2013). Although teacher quality has been historically difficult to measure, nearly every study that compares the level of teacher experience to measures of student achievement has found that more experienced instructors help their students to attain higher scores than less experienced ones do. An “experienced teacher” is defined here as one who has spent several years in the education profession and more importantly several years at the same school. There is less definite evidence for the effect

OK'S STATE-MANDATED MINIMUM TEACHER SALARY

of instructor intelligence on student scores. In other words, smarter teachers are not necessarily better at increasing student test scores (Harris & Sass, 2011). Regardless, higher teacher quality does seem to have a positive outcome on student scores. And so, imperative to sustaining high student performance is determining how to guarantee that students are receiving instruction from quality teachers.

Researchers disagree on how to ensure teacher quality. Some argue that base pay increases would reduce teacher turnover, and thus maintain teacher quality (Hendricks, 2014). However, other researchers assert that targeted increases in pay could be more effective in raising student scores (Loeb & Page, 2000; Rockoff, 2004). Traditionally, salaries are dependent on years of experience as well as educational degree attained. Recent studies suggest that this might not be the most effective way to determine teacher pay in terms of student outcomes (Harris & Sass, 2011; Ronfeldt, Loeb, & Wyckoff, 2013). Instead, some research findings suggest that school districts should be encouraged to consider using educator performance, or more accurately, student performance that can be attributed to that teacher, to dictate pay (Ronfeldt, Loeb, & Wyckoff, 2013). Although researchers do not agree on the best way to increase teacher pay, there is consensus that doing so would help to ensure teacher quality, and thus student achievement.

Teacher Pay and Student Performance

Since according to the majority of the literature, increasing teacher pay leads to better teacher quality, and increased teacher quality leads to higher student performance, it should follow that teacher pay and student achievement are positively correlated. Researchers have measured student achievement in many ways, most often through performance on standardized tests, although graduation rates and even future job success have been used as well (Betts, 1995; Dolton & Marcenaro-Gutierrez, 2011; Hanushek, 1986; Loeb & Page, 2000). However, a review of the relevant research reveals that findings differ on whether or not a positive correlation exists between teacher pay and student achievement. In fact, many seminal studies of instructor salaries and their relationship to student performance found no significant relationship between the two (Hanushek, 1986; Betts,

1995). An analysis of data from the National Longitudinal Survey of Youth and the High School and Beyond survey revealed that graduates of schools where instructors were paid better did not earn significantly more money in their future jobs than graduates of schools where teacher pay was lacking (Betts, 1995). Although this is not a direct measure of student performance, it does indicate that any possible effects that teacher salaries had on these students had dissipated by the time they entered the labor force, which could mean that the effect of salaries was negligible in the first place.

More recent studies have contradicted these findings, arguing that the original studies which found no significant relationship were not accounting for all variables (Dolton & Marcenaro-Gutierrez, 2011; Loeb & Page, 2000). An international study compared the position of educators in a country's income distribution to pupil performance on internationally standardized tests. The analysis found that in countries where teachers are paid more, students are more academically successful (Dolton & Marcenaro-Gutierrez, 2011). This evidence supports researchers who believe that increasing teacher pay would lead to improved student outcomes.

Teacher Pay in Oklahoma

Teachers in Oklahoma receive very low salaries, especially when compared to teachers in neighboring states as well as comparable workers in the private sector, and this disparity leads to high rates of teacher turnover (Hendricks, 2014; Hendricks, 2015). To combat harmful salary inequalities within the state, Oklahoma recently enacted a mandatory minimum salary schedule (Maiden & Evans, 2009; 70 OK Stat § 70-5-141, 2016). Although some districts choose to pay their instructors more, even these slightly higher salaries are still paltry when compared with surrounding states and the national average (Hendricks, 2015). In 2015, the average teacher with five years of experience and a bachelor's degree only earned \$34,000 annually (Hendricks, 2015, p. 4). Since salaries in Oklahoma are still remarkably low despite the state-mandated minimum, it is possible that the minimum is insufficient and should be raised.

Although a substantial body of research explores the relationship between teacher pay and student

achievement, the debate is not settled, and contributions can still be made. Very little research has focused on Oklahoma, even though its educators are some of the lowest paid in the nation, and its students consistently perform poorly on nationally standardized tests (Hendricks, 2015). This research seeks to fill this gap in the body of knowledge by exploring a relationship between student test scores and varying salaries of different school districts and perhaps providing evidence that the state minimum salary schedule is not high enough.

Method

This study used publicly available data to compare district teacher salary practices with student performance on state standardized tests in an attempt to reveal a relationship between the two.

A list of 186 school districts in Oklahoma that did not use the state-mandated minimum salary schedule in the most recent fiscal year was provided to the researcher by Matt Holder, the Deputy Superintendent of Finance and Federal Programs at the Oklahoma State Department of Education. Although not expressly stated by Mr. Holder or the list, it can be inferred that these districts pay above the minimum, because paying below the minimum would be unlawful (70 OK Stat § 70-5-141, 2016). From this list of nonconforming districts, thirty were randomly selected using Google's built-in random number generator. Thirty was determined to be the best sample size because it is the minimum for a statistical test to be considered valid, and a volume much higher than thirty would become unmanageable. The random number generator provided numbers between 1 and 186, these numbers were recorded, and the district in the row number corresponding to the generated number was selected. Repeated numbers were re-generated until an original number was provided. Generating random numbers was necessary in order to avoid sampling bias that might have occurred if I did not randomly choose from the list of districts, such as convenience bias. The numbers could not be repeated because including a school district more than once could have skewed the data.

Following the same procedure, sixty districts were randomly selected from an edited list of 335 public

school districts in Oklahoma to represent the districts that pay the minimum salary. Sixty was determined to be the best sample size because it is statistically large enough, and roughly proportional to the number of minimum salary public school districts in Oklahoma, which is nearly twice the number of nonconforming districts. This list was created by taking the directory of all public school districts available on the State Department of Education's website and omitting those that appeared on the list of districts paying above state-mandated minimum as well as those districts that were identified as charter schools or independent learning centers. The 90 total selected school districts were separated into two categories, Minimum Salary districts and Above-Minimum Salary districts, and then placed in two spreadsheets alongside data on student achievement.

Specific salary data for the 2014–2015 school year were also collected for each of the 90 selected districts from Oklahoma Watch, a nonprofit investigative journalism website. This information would be used to determine the strength of the linear relationship between teacher salaries and student scores. The data originated from the Oklahoma State Department of Education. Oklahoma Watch presented two figures for each school district, average teacher salary and base teacher salary. Average teacher salary can be biased by the number of new instructors in a district, which is often related to its location. However, it was the best figure for this project, because there was little variation in the base pay among districts, meaning that no relationship between salary and student achievement would be visible, if one exists.

In this study, student achievement was represented by performance on state standardized tests from 2016, the most recent information available. These data were also obtained from the State Department of Education's website. The material is presented in a spreadsheet that breaks down the percentages of students scoring "Unsatisfactory," "Limited Knowledge," "Proficient," or "Advanced" on several different state tests. The figures are separated based on student grade, race, gender, and other characteristics.

This research intended to focus on the percentage of eighth grade students who passed the Oklahoma Core Curriculum Tests (OCCT) for Mathematics and Reading/Language Arts. The tests are standardized across the state, so students in each grade take

the same test as other students in their grade. Eighth graders were selected because eighth grade is the last year that students take such broad standardized tests like Math and Reading; afterwards tests focus on specific classes. Therefore, eighth grade students are the most representative of a district's success because they have been under the influence of its policies for the longest amount of time. Unfortunately, since many schools in Oklahoma have a very small student population, some information was redacted by the Department of Education in order to protect student identities. Thus, due to the limited availability of some data, the researcher instead used the percentage of students scoring satisfactorily on the Math and Reading tests in the highest grade for which data were available. For example, if no data were recorded in the eighth grade, data from the seventh grade tests were used instead.

Scores of "Proficient" and "Advanced" are considered passing; scores of "Limited Knowledge" and "Unsatisfactory" are not. Because the data were provided for four possible scores, and not simply "Passing" or "Failing," the percentages of students scoring in the top two categories were added in order to determine the percentage of students who passed the tests. In some cases, data were provided for the number of students who achieved a score of "Proficient" but not "Advanced," and visa versa. Because the data were redacted to protect a small number of individuals, meaning the concealed percentage was also small, the difference was considered negligible, and the non-redacted percentage was used to represent the total percentage of students passing the test. Two school districts were omitted from the research altogether, because their student populations were so small that all percentages were redacted, and thus no viable information was available to analyze. Both were in the group of districts that pay the state-mandated minimum.

The data on student performance were entered into two spreadsheets alongside the corresponding districts and analyzed using a two-sample t test. Then the districts were aggregated into a single spreadsheet where average teacher salary was compared with student achievement data using Pearson's correlation coefficient. Results are presented in the following section.

Results

As a whole, the mean scores for the Math OCCT ($M = 49.29$) were significantly lower than the mean reading scores for the 90 total selected districts ($M = 67.86$). A two-sample t test was conducted comparing math scores of students whose teachers are paid the minimum salary and students whose teachers are paid above the minimum. These tests are used to compare the means of two samples in order to determine if there is a statistically significant difference between them. The t tests revealed no significant difference between the two groups (schools that pay only the minimum and schools that pay above it) $t(58) = 0.04, p = 0.48$, meaning that student performance on OCCT math tests is likely not dependent on teacher salary. However, the two-sample t test conducted with OCCT reading scores revealed a very significant difference between students from minimum paying districts and students from districts that pay above the minimum $t(83) = 3.68, p = 0.002$. Although this test does not prove causation, it is clear that a relationship exists between student performance on Oklahoma reading exams and their teachers' salaries. A table of all 90 districts and their respective test scores and average teacher salaries is included in the Appendix.

A Pearson product-moment correlation coefficient was computed to assess the relationship between teacher salary and student performance on state standardized mathematics tests. These tests are used to determine the strength of the correlation between two variables, in this case teacher salary and student performance. This test revealed no statistically significant relationship between salary and student achievement on the OCCT math test $r(86) = .03, p = .39$. These data are displayed as a scatterplot in Figure 1.

When the same test was conducted with reading scores instead of math scores, a significant relationship was revealed $r(86) = .23, p = .02$, as illustrated in Figure 2. This means that teacher pay and student performance on reading scores were significantly correlated.

Findings

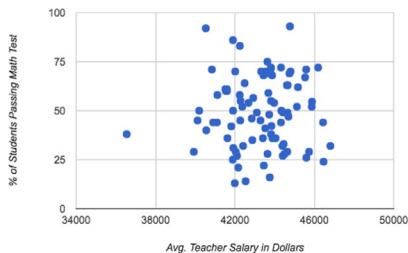


Figure 1. Average teacher salary vs percentage of students passing math test. This figure illustrates the correlation between teacher pay and student performance on state standardized math tests.

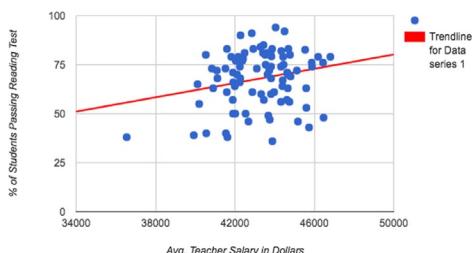


Figure 2. Average teacher salary vs percentage of students passing reading test. The red line represents the linear relationship between the two variables. This figure illustrates the correlation between teacher pay and student performance on state standardized reading tests.

Discussion

Bearing in mind that this research only proves a correlation between teacher pay and student achievement and not a causal relationship, any assumptions that follow regarding the meaning and/or implications of these results should be considered with caution, for they are the educated speculation of the researcher.

Through a series of t tests and Pearson product-moment correlation coefficient computations, this study found that the percentage of students passing the Oklahoma standardized reading tests is greater in school districts where educators are paid above minimum salary. The study also found a significant positive correlation between teacher salary and student performance on standardized reading tests but not on standardized math tests. The relationship between teacher salary and student achievement on reading tests found in this study supports the general consensus among researchers that increasing teacher pay could improve student performance on standardized tests (Dolton & Marcenaro-Gutierrez, 2011; Loeb and Page, 2000). However, because one of the tests showed no relationship, this conclusion might not be generalizable to all forms of standardized tests. Based on the literature, it can be inferred that as the pay increased, the overall quality of the instructors increased as well (Hanushek, Kain, & Rivkin, 1999; Hendricks, 2014; Rockoff, 2004). Thus the positive relationship between teacher pay and student achievement found in this study could be due to the increase in teacher quality, caused by higher pay, that is known to be related to student performance (Harris & Sass, 2011; Rockoff, 2004; Ronfeldt, Loeb, & Wyckoff, 2013).

Minimum salary schools versus above-minimum salary schools. T tests comparing student performance on reading tests in districts that pay only the state-mandated minimum salary to student performance in districts that pay above the minimum salary found that students do perform better where their teachers are paid more. This test most directly questions the effectiveness of the minimum salary required by the state because it compares results associated with this minimum to results produced by schools that pay above it. Because students performed better where salaries were higher than the minimum, these results could indicate that the minimum salary is too low. Unexpectedly, the t tests did not produce similar results for the math tests. Student performance on Mathematics OCCTs was not related to whether a school district paid at or above the minimum teacher salary. A similar trend was found in a 2011 study, which determined that teacher quality had an effect on middle school math scores performance,

but not reading (Harris & Sass, 2011). This study, although it focuses on teacher quality instead of teacher pay, contradicts my findings that reading is correlated to teacher pay and math is not. The reason for the divergence in these results is unknown. The lack of a relationship between salary and math scores could be considered evidence in favor of the current minimum salary because such an important subject is seemingly unaffected by teacher salaries. However, assuming that the higher reading results in above-minimum districts were caused by the higher teacher salaries (a speculation which is *not* fully supported by the results of this study), any improvement in scores due to increased pay should be enough encouragement to raise the minimum.

Average salary versus student scores. Further research as to the effects of teacher salary in Oklahoma on student performance on standardized tests showed a positive correlation between the two variables. Pearson product-moment correlation coefficient computations comparing the average teacher salaries during the 2014–2015 school year in all 90 selected districts to the percentage of students passing the Math OCCT in 2016 found once again no statistically significant correlation between salaries and math scores, but the same test performed on the Reading OCCT scores found a very significant positive correlation. As teacher salaries increased, so did the percentage of students passing the reading test. This evidence supports the widely-held belief that higher teacher salaries positively influence student performance, despite the negligible relationship between salaries and math scores (Dolton & Marcenaro-Gutierrez, 2011; Loeb & Page, 2000). The evidence also supports the conclusion that raising the state minimum salary could improve student performance, especially in reading, because higher pay is correlated to increased student test scores.

Alternative Explanations

As mentioned above, although the correlation between teacher pay and student scores is promising, this research does not prove causation. This study assumes that increases in teacher pay are directly connected to increases in student outcomes via improvements in educator experience, but there are other potential

explanations for this trend. For example, it is possible that the increases in teacher pay and student scores, instead of having a causal relationship, could actually be the result of the same situation. Differences in the overall budget for a school district could lead districts to pay their teachers more *and* to spend more money on programs for their students, simply because they have more money to spend. For example, perhaps one district with a large budget pays their teachers above the minimum salary and also funds a successful reading program for their students. When compared with another district that pays the minimum salary and does not have any special programs, the teacher pay and student scores would be positively correlated, but independent of one another. Another possible explanation for the trend revealed in this research is that some students have the resources to prepare for tests outside of the classroom. Because their preparation is independent of the instructor, their success on the exams does not reflect any influence teacher pay might have on student performance. Potential alternate explanations for the results of this study exist because the research was not able to explore all aspects of the problem, and these limitations leave some uncertainty.

Limitations

This study was limited by multiple factors. Most importantly, it only sought to explore correlation not to prove a causal relationship. This means that the trends discovered in this research could be attributed to a number of causes, not only the ones inferred by the researcher. Any implications or policy recommendations stemming from this research must be considered with these restrictions in mind.

Further, this study did not consider the potential effect that the geographic location or school district income level had on the data. Research shows that urban and rural schools, as well as schools with high levels of student poverty, often have difficulty retaining talented teachers (Hanushek, Kain, & Rivkin, 2004; Hendricks, 2015; Ronfeldt, Loeb, & Wyckoff, 2013). It is possible that the average salaries used to find a correlation between teacher pay and student scores were biased by the high number of new and untrained instructors in low-income, rural, and urban districts who receive lower salaries than their more experienced peers.

Finally, this study used data from a very short window of time. Some researchers choose to analyze data over long periods of time in order to capture broad changes in the district (Hendricks, 2014). In their 2000 study of teacher compensation and graduation rates, Loeb and Page model their changes over a 10-year period in order to observe long-term results of increasing teacher salaries (Loeb & Page, 2000). Because the purpose of this study was to analyze the effectiveness of Oklahoma's newly implemented minimum salary schedule, collecting data over a long period of time would not have been appropriate. Therefore, any long-term effects that might exist as a result of changing Oklahoma educator salaries were not captured by this study.

Implications and Future Directions

As stated above, all conclusions based on this research are conjecture, due to the lack of evidence. Keeping this in mind, the correlation between teacher salary and student scores revealed by this research does imply that the Oklahoma state minimum teacher salary could be too low, based on the fact that students perform better on reading tests in districts that compensate beyond this minimum. This conclusion is further supported by the evidence that teacher pay is positively correlated to student performance on standardized reading tests. The results of this study support the assumption of the relevant literature that teacher pay influences student outcomes. Based on these conclusions, as well as the conclusions of other researchers who have also proven that increasing teacher salaries could be beneficial to students, I recommend that Oklahoma's policymakers consider raising the minimum salary to at least the level of the surrounding states in order to prevent instructors from leaving Oklahoma in search of more money.

The trends uncovered in this research, as well as this study's limitations, provide multiple topics for future researchers to pursue. One important question to address is why teacher salaries are related to reading scores in Oklahoma but not to math scores. The state of Oklahoma does emphasize the importance of its reading tests, but what is the connection to teacher pay? Could this be attributed to the differences in the

kinds of help required by students in each subject? In other words, does reading require more or different student-teacher interaction that is impacted by the quality of educators? Further, is this trend related to the substantial gap between the average percentage of students passing math tests ($M = 49.29$) and the average percentage of students passing reading tests ($M = 67.86$)? Researchers could also explore the potential geographic differences not considered in this study as well as consider changes to Oklahoma teacher salaries over time.

Conclusion

Because successful education is an important component of a successful society, and because teachers are a large part of ensuring educational success, it should be the duty of policymakers to ensure that instructors are of the highest quality. This study revealed that students tend to perform better when their teachers are paid more, especially in reading. This information helped answer some questions about Oklahoma's new minimum salary schedule. Taking the results of this study into account, as well as the fact that teacher quality is known to be related to teacher pay, raising Oklahoma's minimum teacher salary could help secure educational success for the state. It is strongly recommended that more research be conducted as to the causes of the relationships uncovered in this study so that it may be determined what educational policies will benefit Oklahoma students the most.

References

- Augenblick, J., Myers, J., & Anderson, A. (1997). Equity and adequacy in school funding. *The Future of Children*, 7(3), 63-78. doi:1. Retrieved from <http://www.jstor.org/stable/1602446> doi:1
- Betts, J. (1995). Does school quality matter? Evidence from the National Longitudinal Survey of Youth. *The Review of Economics and Statistics*, 77(2), 231-250. doi:10.2307/2109862
- Dolton, P., & Marcenaro-Gutierrez, O. D. (2011). If you pay peanuts do you get monkeys? A cross-country analysis of teacher pay and pupil performance. *Economic Policy*, 26(65), 5-55. doi:10.1111/j.1468-0327.2010.00257.x

OK'S STATE-MANDATED MINIMUM TEACHER SALARY

- Hanushek, E. (1986). The economics of schooling: Production and efficiency in public schools. *Journal of Economic Literature*, 24(3), 1141-1177. Retrieved from <http://www.jstor.org/stable/2725865>
- Hanushek, E. A., Kain, J. F., & Rivkin, S. G. (1999). *Do higher salaries buy better teachers?* Cambridge: National Bureau of Economic Research, Inc. doi:<http://dx.doi.org.ezproxy.lib.ou.edu/10.3386/w7082>
- Hanushek, E., Kain, J., & Rivkin, S. (2004). Why public schools lose teachers. *The Journal of Human Resources*, 39(2), 326-354. doi:10.2307/3559017
- Harris, D. N., & Sass, T. R. (2011). Teacher training, teacher quality and student achievement. *Journal of Public Economics*, 95(7-8), 798-812.
- Hendricks, M. D. (2014). Does it pay to pay teachers more? Evidence from Texas. *Journal of Public Economics*, 109, 50-63. doi:10.1016/j.jpubeco.2013.11.001
- Hendricks, M. D. (2015, October 6). An empirical analysis of teacher salaries and labor market outcomes in Oklahoma. Retrieved February 27, 2017, from http://www.ossba.org/wp-content/uploads/2015/11/Teacher_Pay_FINAL_revised_cw.pdf
- Loeb, S., & Page, M. E. (2000). Examining the link between teacher wages and student outcomes: The importance of alternative labor market opportunities and non-pecuniary variation. *Review Of Economics & Statistics*, 82(3), 393-408. doi:10.1162/003465300558894
- Maiden, J., & Evans, N. (2009). Fiscal equity of teacher salaries and compensation in Oklahoma. *Journal of Education Finance*, 34(3), 231-246. Retrieved from <http://www.jstor.org/stable/40704357>
- No Child Left Behind (NCLB) Act of 2001, Pub. L. No. 107-110, § 115, Stat. 1425 (2002).
- Rockoff, J. (2004). The impact of individual teachers on student achievement: Evidence from panel data. *The American Economic Review*, 94(2), 247-252. Retrieved from <http://www.jstor.org/stable/3592891>
- Ronfeldt, M., Loeb, S., & Wyckoff, J. (2013). How teacher turnover harms student achievement. *American Educational Research Journal*, 50(1), 4-36. Retrieved from <http://www.jstor.org/stable/23319706>
- Springer, M. G., Liu, K., & Guthrie, J. W. (2009). The impact of school finance litigation on resource distribution: A comparison of court-mandated equity and adequacy reforms. *Education Economics*, 17(4), 421-444. doi:10.1080/09645290802069269
- Turner, C. (2016, April 18). Why America's Schools Have A Money Problem. Retrieved July 21, 2016, from <http://www.npr.org/2016/04/18/474256366/why-americas-schools-have-a-money-problem> 70 OK Stat § 70-5-141. (2016)

Appendix

Table 1. Student outcome and salary data for 90 school districts in Oklahoma.

This table contains the 90 school districts used for this research, along with the percentage of students in those districts who passed the Math OCCT and the Reading OCCT, as well as the average teacher salary for the 2014–2015 school year in those districts. Numbers marked by an asterisk (*) represent scores from grades other than the eighth grade. The grade used is stated in parentheses next to the district name. Boldfaced districts are those that pay above the minimum salary schedule.

District Name	% Passing Math	% Passing Reading	Average Salary 2014–2015 (\$)
ALINE-CLEO (6)	50	55*	40199
ALVA	21	79	42166
ANDERSON	72	60	43817
ARDMORE	31	66	41918
ATOKA	52	77	42371
BANNER	75	81	43636

OK'S STATE-MANDATED MINIMUM TEACHER SALARY

BARTLESVILLE	68	83	43873
BISHOP	93	80	44772
BOSWELL	27	67	44408
BRISTOW	55	74	43820
BROKEN ARROW	42.2	79.2	43838
BUFFALO VALLEY (7)	36	38*	41623
BURNS FLAT-DILL CITY	58	68	41118
CANUTE	28	92	44500
CARNEGIE	38	68	43822
CHECOTAH	50	82	44339
CHICKASHA	28	70	43642
CHOCTAW-NICOMA PARK	56.5	83	42923
COMANCHE	49	79	44428
DAVENPORT	45	68	42268
DENISON	60	83	41599
DIBBLE	50	50	41906
DRUMMOND	63	57	44618
EARLSBORO	24	48	46466
ELMORE CITY-PURNELL	36	81	43411
FELT (7)	92*	80*	40532
FORGAN (7)	86*	71*	41901
FORT COBB-BROXTON	32	79	46808
FOYIL	58	66	42243
FREDERICK	49	73	43103
FRINK-CHAMBERS	71	81	43796
GANS	61	61	41592
GLENPOOL	47	83	44695
GRACEMONT	60	40	41545
GRAHAM-DUSTIN	26	53	45599
GREENVILLE (6) (7)	38*	38*	36547
GUYMON	13	64	41992
IDABEL	48	72	43728
JENNINGS	44	63	40903
JONES	64	81	42489
KILDARE (5)	40*	40*	40556
KREMLIN-HILLSDALE	44	72	41092
LEEDEY	29	77	42044
LIBERTY	71	73	40839
LONE WOLF	33	75	44455
MANNSVILLE (6)	29*	43*	45734

OK'S STATE-MANDATED MINIMUM TEACHER SALARY

MARBLE CITY	62	46	45175
MARLOW	72	74	44322
MARYETTA	49	70	44654
MCALESTER	44	76	46440
MEEKER	35	61	42878
MERRITT	68	85	43439
MILL CREEK	70	50	42014
MOORE	67	82.6	45536
MORRIS	70	75	43550
MOSELEY (7)	63*	63*	44662
MOUNTAIN VIEW-GOTEBO	36	94	44051
NOBLE	52	76	45870
OAKS-MISSION	16	47	43754
OKEENE	44	56	44320
OSAGE (6)	45*	65*	40117
PADEN	71	63	45590
PERKINS-TRYON	45	84	43288
POCOLA	27	70	42106
POND CREEK-HUNTER	52	72	45120
PUTNAM CITY	54.6	74	45884
RAVIA (6)	72*	79*	46191
RED OAK	36	36	43888
RIVERSIDE (7)	69	56*	44747
ROLAND	70	69	44801
SALLISAW	41	80	43528
SASAKWA	29	71	44636
SAYRE	59	49	43684
SHADY POINT	29	39	39927
SNYDER	46	91	42849
SOPER (7)	25*	57	41891
SPERRY	32	78	42410
STRINGTOWN	55	90	42282
STROTHER	54	61	43976
STROUD	32	64	44392
SWINK (7)	69*	81*	43705
THACKERVILLE	83	74	42248
WAGONER	42	79	41814
WAPANUCKA	54	46	42682
WAURIKA	22	57	43456
WELEETKA	70	60	43323
WESTERN HEIGHTS	14	50	42538
WESTVILLE	61	73	41522

An Investigation into the Short-Term Effects of Music Therapy for Patients with Probable Alzheimer's Disease or Another form of Dementia

Owen Clute

This study aimed to address the question: to what extent are weekly music therapy sessions able to improve social interaction and heighten moods in patients suffering from different stages of Alzheimer's disease? The study examined the progress of four participants from the O'Neill Centre in Toronto, Canada during 11 music therapy sessions over the course of six weeks. Results were measured using standardized tests prominent in the field: The Bristol Activities of Daily Living Scale (BADLS), and Global Deterioration Scale (GDS). Although both scales showed no improvement amongst participants, positive patterns were observed by the lead researcher.

Keywords: Alzheimer's Disease, dementia, music therapy, Bristol Activities of Daily Living Scale, Global Deterioration Scale

The study was approved by a Research Ethics Board.

Alzheimer's disease is the most common form of dementia, a general term for memory loss and other intellectual abilities serious enough to interfere with the daily life (Alzheimer's Association, 2016). It is described by scholars as, "a devastating neurological disorder primarily affecting the elderly. The disease manifests with progressive deterioration in cognitive functions, leading to loss of autonomy" (Lambert et al., 2013, p. 1452). Since it is a progressive disease, this means it deteriorates over time and is ultimately responsible for death. Currently, there is no cure for Alzheimer's, and it is unknown if any precautions can be taken to prevent Alzheimer's (Alzheimer's Association, 2016). Although there is no cure, there are some methods of treatment that can improve quality of life for those suffering with Alzheimer's and other forms of dementia. One treatment method being explored is music therapy. The suffering caused by Alzheimer's can often be noticed from first symptoms which include: changes in mood, withdrawal from activities, confusion with time or place, and new problems with words or writing (Alzheimer's Association, 2016). Early stages of Alzheimer's can generally

be recognized by negative symptoms such as, "little interest in self-care, work and household tasks, social and family activities, and emotional needs of others" (Reichman, Coyne, Amiraneni, Molino, & Egan, 1996, p. 424).

Alzheimer's has also been linked to lead to other forms of mental illness, and vice versa. As Levy, Cummings, Fairbanks, and Bravi (1996) describe, "In addition to the intellectual abnormalities of Alzheimer's disease, most patients exhibit neuropsychiatric disturbances at some time during the course of the illness. Depression, psychosis, and agitation are among the most common neuropsychiatric abnormalities of the disorder" (p. 1438). In a study conducted by Ropacki and Jeste (2005), they found that psychotic symptoms are quite common amongst patients with Alzheimer's disease. After examining 55 studies in the field, they concluded that "psychosis was reported in 41% of patients with Alzheimer's disease, including delusions in 36% and hallucinations in 18%" (Ropacki & Jeste, 2005, p. 2022). Similarly, a one-year study conducted by Levy, et al. with 181 probable Alzheimer's patients found that "recurrence rates of neuropsycho-

atric symptoms during the 1-year period were 85% for depression, 93% for agitation, and 95% for psychosis" (Levy et al., 1996, p. 1438). The link between Alzheimer's and other mental illness' progression is interesting to note as many of the symptoms listed previously are mutual. The negative effects of Alzheimer's are abundant and severe, and treatment for relief is desperately needed. The hope of this study was to provide a form of relief for some patients with Alzheimer's disease, through group based music therapy sessions.

This study was designed to test the extent to which weekly music therapy sessions could improve social interaction and heighten moods in patients suffering from different stages of Alzheimer's disease. This study was conducted in accordance with the O'Neill Centre Seniors Home in Toronto, Canada and collected both qualitative and quantitative data from four patients suffering from Alzheimer's or another similar form of dementia. The data in this case study was largely collected by a caregiver who reported on patients' improvement or decline in quality of life based on patient's conversations and social interactions. The caregiver also administered assessment tests that are already prominent in similar literature: the Bristol Activities of Daily Living Scale (Bucks, Ashworth, Wilcock, Siegfried, 1996) and Global Deterioration Scale (Reisberg, Ferris, de Leon, & Crook, 1982). The caregiver was the same for all participants. The literature review ahead provides a closer look at other studies in the related field and their differences and similarities to the current study.

Literature Review

This review of literature will examine multiple studies that hypothesize social improvement and interaction amongst participants with forms of dementia, in addition to some studies with different intended outcomes. Many studies do not take the exact approach of the current study. Examples of studies in the field with different goals or approaches include: Hanser, Butterfield-Whitcomb, Kawata, and Collins, (2011) who examined the effects and tolls of caregiving more closely than the actual effects of music therapy for patients with Alzheimer's (Hanser et al., 2011); Takahashi and Matsushita, (2006) who examined cortisol levels in the different participants saliva

and blood pressures in order to draw conclusions over a two-year period of music therapy (Takahashi & Matsushita, 2006); and Ledger and Baker, (2007) who examined the effects of group music therapy over the course of one year on, "agitation manifested by nursing home residents with Alzheimer's disease where a non-randomised experimental design was employed with one group receiving weekly music therapy and another group receiving standard nursing home care" (Ledger & Baker, 2007, p. 330). All of these studies are slightly different from the current study and therefore the gap in research is revealed.

Therefore regardless of success amongst certain other studies, one reason the current study addressed a gap in that it offered new data in a unique case study form. The current study examined if improvement in social behaviour could occur in a small sample size, in an isolated population. Although certainly limited, this study's small sample size and short-term therapy with residents at the O'Neill Centre is new research consisting of a modified method and adds something new to the academic conversation of previous literature. Even though this study differentiated in some ways from past literature, it also closely emulated some of the procedure carried out by other leading researchers (Brotons & Marti, 2003; Hanser et al., 2011; Levy et al., 1996; and Gregory, 2002)

In past studies, unrelated from dementia, music therapy has been examined as a possible treatment for heart disease, certain types of cancer, and other terminal illnesses. It is described as successfully lowering anxiety and stress in a study done by Clark et al., (2006) examining the effects of music to reduce emotional distress during radiation therapy (p. 247). It is also described as being successful in a study by Mandel, Hanser, Secic, and Davis looking at the effects of music therapy on health-related outcomes in cardiac rehabilitation (2007, p. 176). As Mandel et al. (2007) describes, "The control group's mean systolic blood pressure increased, while that of the music therapy group decreased from pre to post-treatment" (p. 188). Music therapy has proven to be successful in many clinical trials, although there are also areas in which it has failed. Although music therapy was helpful in lowering stress in radiation therapy patients in the study conducted by Clark et al. (2006) it was found that "depression, fatigue, and pain were not appreciably affected by music therapy" (p. 247). This shows

MUSIC THERAPY FOR PATIENTS WITH PROBABLE ALZHEIMER'S

that if the current study provides positive results, then the music therapy would be acting on other cognitive factors besides depression. Music therapy is not usually able to help with any physical pain and is not a cure, only a treatment. It can act as treatment for symptoms like irritability and anxiety, which are common symptoms of dementia. According to a study conducted in the Journal of Music Therapy by Lipe, York, and Jensen, it concluded that over the past two decades, many research studies have discovered music therapy to be beneficial to participants, and the effects especially positive on those with dementia (Lipe, York, & Jensen, 2007).

For the most part, the results of music therapy studies in patients with dementia seem to have been successful. Success was noted in many studies, (Gregory, 2002; Brotons & Marti, 2003; Hanser et al., 2011; Larkin, 2001; Takahashi, & Matsushita, 2006; Bruer, Spitznagel, & Cloninger, 2007; and Zare, Ebrahimi, & Birashk, 2010) as well as others in the field. Silverman (2006) analyzed, "all the case studies published in the Journal of Music Therapy, Music Therapy, and Music Therapy Perspectives from 1964-2003" (p. 4). Silverman (2006) reviewed the results of 123 studies and he concludes that published case studies within the examined literature reveal that music therapy interventions have been successful in many different populations with a diversity of clinical techniques addressing each population's individual needs. These studies that noted success in their treatments have improved patient's ability to cooperate socially and integrate into society (Silverman, 2006).

Gregory (2002) examined the differences between a group of elderly adults with cognitive impairments and a group of college students and older adults in an Alzheimer's caregivers group. She had each group listen to three chosen music pieces separated by silent pauses. At each new song and at each pause, participants were asked to move a dial with a pointer to rest on either the name of the song or the word 'wait' (Gregory, 2002). These results indicated no differences between the college students and Alzheimer's caregiver group but noted significant decline in reaction time and correctness in the older adults group (Gregory, 2002). The rationale behind this study was to test the effectiveness of listening activities for older adults. The results of the college students and caregivers were combined since their results yielded no dif-

ferences. Two groups were then formed (college combined with caregiver and elderly adults with cognitive impairments) and their results were compared using a one-way analysis of variance (ANOVA) test. The current study also uses an ANOVA to compare early and later test scores for participants. Another study published in the field that used multiple ANOVA tests was conducted by Levy et al., (1996).

In a study conducted by Brotons and Marti (2003), 14 participants with a probable Alzheimer's diagnosis underwent music therapy with a personal caregiver who administered standardized testing (Brotons & Marti , 2003). The caregivers were also tested in order to record their emotional state and to see if their social interaction improved or declined during the course of the study (Brotons & Marti, 2003). The relatively small sample size used by Brotons and Marti (2003) is one aspect that is also used in the current study. The current study uses a sample size of four participants. Although a small sample size is a limitation to the findings, it is important to still be examined in order to minimize a gap in research.

In a study conducted by Hanser, et al., (2011), she examines the impacts of music therapy for participants and their caregivers. This study is similar to Brotons and Marti method in that it analyzes impacts on participants with Alzheimer's as well as caregivers. Hanser's study also involved 14 participants just like Brotons and Marti (2003). The methodology of these two studies was to use standardized testing methods to benchmark the participants' progress. This process is similar to the current study and this study uses some of the same standardized tests; the Bristol Activities of Daily Living Scale, and the Global Deterioration Scale (Bucks et al., 1996); (Reisberg et al., 1982).

Another study conducted in the related field - yet very different from Brotons and Marti (2003) and Hanser et al., (2011) - is by Takahashi and Matsushita (2006). Takahashi and Matsushita (2006) explored the long-term effects of music therapy on patients with dementia over a two year period. They monitored changes by measuring cortisol levels in the different participant's saliva and blood pressures (Takahashi & Matsushita 2006). The study had a music therapy group and non-music therapy group that was also monitored and there was a significantly lower systolic blood pressure shown in the group participating in the music therapy (Taka-

hashi, & Matsushita 2006). The rationale behind this study was to see if long-term therapy could be a factor in improving heart health and well being amongst elderly patients with dementia (Takahashi, & Matsushita 2006).

It is also worthy of mention that some studies have found music therapy to show no improvement or little improvement for those with dementia. In a study by Sim and Chung, they concluded that although music therapy is an effective means of improving the emotional state of elderly people suffering from dementia, "the effect of music therapy on the cognitive function and behavior of elderly dementia patients is not significant statistically" (Sim & Chung, 2001, p. 1). Sim and Chung conducted their study over the course of one month approximately and met with their participants for sessions 6 times per week (Sim & Chung, 2001). Sim and Chung had three original hypotheses and their first hypothesis which had assumed the recipients of music therapy would have had a higher cognitive function level than the other was rejected because it was not significant statistically (Sim & Chung, 2001). The second hypothesis was also rejected and it had assumed the group receiving music therapy would have had a higher behaviour level than the control group (Sim & Chung, 2001). Sim and Chung's third original hypothesis was supported and was that the music therapy recipients would have a higher emotion level than the control group (Sim & Chung, 2001). Acknowledging the original hypotheses sometimes failing is an important part of research as it still provides important literature and closes gaps in the field.

Lots of research has been done on music therapy and its relation to dementia and Alzheimer's disease; however, the current study furthers the academic discussion and also provides newfound research. Factors such as study population size, study location, study duration, and study content and data collection all differ from previous research and therefore address a gap and provide new research. The method will be further discussed in the next section of this study, as there are further differences and multiple other sources of data collection.

The findings above indicate that research has been done in this field yet many gaps exist within. This current study will help to narrow those gaps and broaden the academic understanding of Alzheimer's disease and how its effects on patients can be improved through the uses of music therapy.

Method

Subjects

Four participants formed the group of patients being tested. All four participants were women and their average age was 90.5 years old, comprised of individual ages: 84, 90, 92, and 96. All of the participants are residents of the O'Neill Centre in Toronto, Canada. Each participant was from a different floor of the residence and they did not know each other well to begin with.

The research team was made up of one head researcher (the author), the head caregiver at the O'Neill Centre, and support from additional caregivers at the O'Neill Centre.

Instruments

Standardized testing was administered at two points over the course of the study. After a few initial meetings between the lead researchers and the participants, musical preferences were established and the first tests were then completed after a few listening sessions. The same caregiver completed all the tests for all of the participants. The tests used to collect information on the participants were:

Bristol Activities of Daily Living Scale (Bucks, Ashworth, Wilcock, Siegfried, 1996) ("Designed to reveal the everyday ability of people who have memory difficulties of one form or another" (Bucks et al., 1996, p. 1).)

Global Deterioration Scale (Reisberg, Ferris, de Leon, & Crook, 1982) ("Provides caregivers an overview of the stages of cognitive function for those suffering from a primary degenerative dementia such as Alzheimer's disease" (Reisberg et al., 1982, p. 1).)

In addition to the series of tests above, an analysis of variance (ANOVA) test was to be conducted afterwards to analyze changes in results, but the results yielded were too similar to conduct the ANOVA (this is explained in the results section below). A one-way ANOVA test would have compared the results between participants first and second test scores. Two ANOVA tests were to be completed to analyze differences between Bristol Activities of Daily Living Scale results and separately to analyze Global Deterioration Scale beginning and end results. As well, the head re-

MUSIC THERAPY FOR PATIENTS WITH PROBABLE ALZHEIMER'S

searcher made notes on patients' response, comments, feedback, and participation in sessions.

The tests and scales chosen for this study were partially based on past credible studies conducted in the field. Credit to these scales and their uses is provided by Sheehan (2012) when he describes, "These scales are used to reduce uncertainty in decision-making, for example in screening for cognitive impairment, making diagnoses of dementia and monitoring change" (Sheehan, 2012). Sheehan reviews over thirty existing scales and standardized tests relating to the field of study of dementia and cognitive decline (Sheehan, 2012). The use of these particular scales is also justified by their frequency of appearance in other peer-reviewed studies in the field. Studies conducted by Levy et al., (1996), and Gregory, (2002) both use analysis of variance (ANOVA) tests to compare their results.

Procedure

The principal researchers met with the four participants chosen to be involved in the therapy one week before beginning the sessions. The participants' musical interests were discussed and input was given on how they would like sessions to run. It was decided that the therapy sessions should consist of a mixture of recorded music, live music, and dance/movement. This input was given by the head caregiver as well as the four participants. The participants' initial input suggested an overwhelming popularity for country music, however later suggestion found interest in Italian Opera, violin symphonies, and music by The Beatles.

The study took place at the O'Neill Centre in Toronto, Ontario, Canada in accordance with O'Neill Centre residents. The O'Neill Centre is situated in an urban environment and the home's stages of care

range from retirement care to intensive care. The facility provided a quiet room for all sessions to take place. All of the music therapy sessions were completed in a group format. Even though some of the participants' musical preferences differed, the study was carried through in this format and a wide variety of musical genres were played and performed. The study consisted of a total of 11 music therapy sessions. The sessions took place twice weekly for 6 weeks and for the most part consisted of participants listening to music played off an iPhone, recorded music from a computer, listening to live violin music, and moving to rhythmic beats. Three out of the four participants were in a wheelchair, and the fourth required a walker, so their dance and movement was restricted.

Results

Table 1 shows the levels each participant was first evaluated at and then re-evaluated at on the Global Deterioration Scale (GDS). Each participant's evaluation remained the same over the course of the study. The GDS was developed by Dr. Barry Reisberg and it provides caregivers with an overview of the stages of cognitive function of those suffering from a type of primary degenerative dementia such as Alzheimer's disease (Reisberg et al., 1982). The evaluation guideline is laid out in the form of a table and broken down into 7 stages (Reisberg et al., 1982). Stages 1-3 are generally recognized as the pre-dementia stages or early stages (Reisberg et al., 1982). Stages 4-7 are considered varying stages of dementia (Reisberg et al., 1982). Each stage comes with a description and list of characteristics that an individual in each respective stage might be showing (Reisberg et al., 1982). The results above in Table 1 show that participants in the

Table 1

The Global Deterioration Scale for Assessment of Primary Degenerative Dementia

	Participant I	Participant II	Participant III	Participant IV
First Evaluation	Level 2	Level 5	Level 3	Level 3
Second Evaluation	Level 2	Level 5	Level 3	Level 3
Improvement Y/N?	Same	Same	Same	Same

current study were measured in a range of levels 2-5, with participant 1 receiving a level 2, participant 2 receiving a level 5, and participants 3 and 4 receiving level 3s.

Since participants in the current study only received evaluations relevant to levels 2, 3, and 5, this section will lay out a description for those sections only. Level 2 is described as "very mild cognitive decline (age associated memory impairment)" and lists some characteristics which include, "(a) forgetting where one has placed familiar objects; (b) forgetting names one formerly knew well" (Reisberg et al., 1982, p. 1). Level 3 is described as, "mild cognitive decline (cognitive impairment)" and lists some characteristics which include, "(a) patient may have gotten lost when traveling to an unfamiliar location; (c) word and name finding deficit becomes evident to intimates; (d) patient may read a passage or a book and retain relatively little material; (e) patient may demonstrate decreased facility in remembering names upon introduction to new people; (f) patient may have lost or misplaced an object of value; (g) concentration deficit may be evident on clinical testing" (Reisberg et al., 1982, p. 1). Level 5 is described as, "moderately severe cognitive decline (moderate dementia), the patient can no longer survive without some assistance" (Reisberg et al., 1982, p. 2). Level 5 of the GDS describes characteristics of a patient in this category as, "unable during interview to recall a major relevant aspect of their current lives, eg., an address or telephone number of many years, the names of close family members, the name of the high school or college from which they graduated" (Reisberg et al., 1982, p.2).

Table 2 shows the results of each participant's evaluation on the Bristol Activities of Daily Living Scale (Bucks et al., 1996). The questionnaire was completed by the head caregiver overseeing the study and is de-

signed to reveal the everyday ability of people suffering from memory difficulties in one form or another (Bucks et al., 1996). As the table reveals, similar to Table 1, there are no changes in the participants' test scores from first evaluation to second evaluation. The scale consists of 20 questions and is designed to reveal the abilities of people with different kinds of memory difficulties. There is no final addition to give a score at the end of the scale but each question is ranked as level a) to e), a) being the best scenario and e) being "not applicable" (Bucks et al., 1996). The lead researcher designed a system allocating 1 point to answer e) all the way up to 5 points for answer a). Therefore a score for each participant's 20 questions could be assigned out of 100. These percentages are what is represented above in Table 2.

Analysis of Variance

This study was originally going to incorporate an analysis of variance in order to compare differences noticed between original and later test results. The analysis is not necessary and cannot be completed since the tables above (Table 1 and Table 2) show no differences in participants' first and second evaluations. Therefore, an analysis of variance would reveal nothing. Although there were no changes in test scores, changes were observed in participants' moods and involvement in the therapy.

Observations

The standardized test results outlined above give some indication of quantitative evidence and result. The lead researcher also noted and documented some

Table 2
Bristol Activities of Daily Living Scale

	Participant I	Participant II	Participant III	Participant IV
First Evaluation	78%	43%	78%	83%
Second Evaluation	78%	43%	78%	83%
Improvement Y/N?	Same	Same	Same	Same

MUSIC THERAPY FOR PATIENTS WITH PROBABLE ALZHEIMER'S

commentary from observing the participants and their mood and changes throughout the duration of the study. After the first therapy session, the feedback from participants was: happier songs and better songs to dance to or move along to. This feedback was provided after listening to a mix of country music, choral music, and jazz piano. Most of the participants appeared to enjoy the session (although comparable to later sessions the first session was not very successful).

During some sessions, participants would ask an opera or song's title multiple times, or the singer's name multiple times. These participants' forgetfulness was obvious, yet their asking and interest does provide some reason and evidence to believe their social interaction may have improved. It is important to remember that Alzheimer's has no cure and its horrible effects were present, but the mood of participants improved dramatically from session to session most times. While the general trend of the therapy was progress (based on researcher observations), some sessions had a less positive outcome than others.

The sessions tended to improve when participants voiced their opinions more often. There was a cycle of progress where; the participants would provide feedback, the lead researcher would listen and act, and the participants would better enjoy the next session and then want to give more feedback. The difference from start to finish is quite noticeable and some of this must be accredited to the lead researcher becoming closer with the participants over the course of the study. Being able to laugh and have fun and discuss the music provided a more open atmosphere that had the participants thanking the lead researcher at the end of each session and often asking when he would be back and with what new music.

Other than verbal feedback and conversation progressing to become more positive and more often, the lead researcher also observed as the sessions went on and the music choice became more suited to the participants' likings, they began to move their feet and legs and arms and began to tap the beat or dance along more often. This involvement and awareness from the participants was encouraging as it shows their enjoyment and suggests possible minor improvement in mood.

By the end of the 11 sessions, participants seemed more engaged and excited for sessions. They would look forward to a new section of La Traviata Opera

or new songs from the Beatles. The involvement and social interaction amongst these participants visibly improved over the period of the sessions. Of course, there are many other factors in the participants' daily lives and many limits exist in the study. The greater impact and explanation of these results as well as their limitations are discussed more fully below in the discussion section.

Discussion

This study holds merit for multiple reasons. First, regardless of any findings and results stated above, this process provided lots of entertainment to four elderly women suffering in different states of dementia. The second reason this study holds merit is that research in this specific field has now grown and the gap has decreased. The discussion section will give an overview of the findings importance and their relation to other studies, discuss the studies limits, and give a direction for future research.

Importance of Results

The results of this study confirm some of what has already been conducted in the field of music therapy for Alzheimer's and other forms of dementia. The results confirm some positive improvement in participants' social interaction and mood during sessions; however, the results of the assessment tests indicate no improvement in physical abilities or cognitive decline. This result was generally expected. There was no expectation for music therapy to improve cognitive decline shown in participants, since Alzheimer's is progressive, but the hope was to see improvement in mood and social interaction. Improvement in physical characteristics laid out in the Bristol Activities of Daily Living Scale was not shown, most likely due to the tool not being sensitive enough. It would be interesting to see if participants' scores and evaluations in the Bristol Activities of Daily Living Scale would have improved or changed with one or two more months added to the study's duration. It is interesting, however, to note that the participants' scores compared from Table 1 and Table 2 align with what each test suggested. Participant 1 scored the best on both standard-

ized tests (level 2 on the GDS and 78% on the Bristol Activities of Daily Living Scale). A lower level on the GDS is best and a higher percentage on the Bristol Activities of Daily Living Scale is best. Juxtaposed to participant 1, participant 2 scored the worst on both tests with a level 5 on the GDS and a 43% on the Bristol Activities of Daily Living Scale. Participants 3 and 4 both scored similarly on the GDS and the Bristol Activities of Daily Living Scale. Consistency for the participants between the two different tests is reassuring that the two scores are accurate and similar.

Limits

One of the most significant limits of this study was sample size. With only four participants this study is unable to accurately comment on an entire population of patients suffering from Alzheimer's disease and other forms of dementia. This study can however comment on a small population at the O'Neill Centre in Toronto, Canada.

Another limitation of the current study was its duration. Although this study was short term, it probably would have been advantageous for the therapy to be continued for a longer period. The therapy consisted of 11 sessions over the course of almost 6 weeks. Most weeks had two therapy sessions per week although one week due to scheduling conflicts could only consist of one therapy session.

This study also had unforeseen limitations that must be accounted for. During multiple sessions there was a sick participant and as a result not all participants attended all therapy sessions. This could affect the individual's data and if the study had occurred over a longer period of time this would become less of a limit perhaps since one missed session would equate to a smaller percentage of therapy sessions missed.

Another limit is in the study design. With minimal time and resources, a control group was not able to be incorporated in the study. A non-music control group would have been able to magnify any changes recorded by the music therapy group.

Directions for Future Research

As discussed in the limitations, this study consisted of a small sample size over a relatively short period. It would be beneficial for future research to carry out similar styles in design and method but with a larger sample size over a longer period of time. Although the results of the current study were fairly inconclusive, the observations provide a positive outlook for any study that would emulate a similar research design over an extended period. Another interesting direction for future research could be to examine the capacity of music therapy to enhance the mood of elderly people in general and not just those with cognitive decline such as dementia. The observations of this study suggest that positive boosts in mood and social engagement could occur in any population that carried out a similar procedure.

Conclusion

Although no significant results were discovered and no revolutionary findings occurred, there were improvements seen over the course of the study in the participants' moods, social interaction, and engagement. Returning to the original research question of this study, to what extent are weekly music therapy sessions able to improve social interaction and heighten moods in patients suffering from different stages of Alzheimer's disease? Improvement was seen in respects to the research question, and weekly music therapy sessions are a factor in somewhat improving the moods and social interactions of participants at the O'Neill Centre in Toronto, Canada. Due to the limits of this study improvement cannot be noted in any large-scale conclusions, but the sample size of this study did see some improvement.

References

- Alzheimer's Association. (2016). What is Alzheimer's? *The Alzheimer's Association*. http://www.alz.org/alzheimers_disease_what_is_alzheimers.asp
- Alzheimer's Association. (2017). 10 early signs and symptoms of Alzheimer's. *The Alzheimer's Association*. <http://www.alz.org/10-signs-symptoms-alzheimers-dementia.asp>
- Brotos, M., & Marti, P. (2003). Music therapy with Alzheimer's patients and their family caregivers: A pilot project. *Journal of Music Therapy*, 40(2), 138-50. Retrieved from <http://search.proquest.com/docview/223551423/CFF6C51579534548PQ/1?accountid=36317>
- Bucks, R.S., Ashworth, D. L., Wilcock, G. K., Siegfried, K. (1996); Assessment of activities of daily living in dementia: Development of the Bristol Activities of Daily Living Scale. *Age Ageing*. Retrieved from <https://academic.oup.com/ageing/article/25/2/113/22333/Assessment-of-Activities-of-Daily-Living-in>
- Bruer, Robert A, ARCT,M.P.E., M.T.A., Spitznagel, E., PhD., & Cloninger, C. R. (2007). The temporal limits of cognitive change from music therapy in elderly persons with dementia or dementia-like cognitive impairment: A randomized controlled trial. *Journal of Music Therapy*, 44(4), 308-28. Retrieved from <http://search.proquest.com/docview/223557188/F91491A123C5478APQ/1?accountid=36317>
- Clark, M., Isaacks-Downton, G., Wells, N., Redlin-Frazier, S., Eck, C., Hepworth, J., Chakravarthy, B. (2006). Use of preferred music to reduce emotional distress and symptom activity during radiation therapy. *Journal of Music Therapy*, 43(3), 247-65. Retrieved from <http://search.proquest.com/docview/223564890/2D00250F8F744D5DPQ/3?accountid=36317>
- Gregory, D. (2002). Music listening for maintaining attention of older adults with cognitive impairments. *Journal of Music Therapy*, 39(4), 244-64. Retrieved from <http://search.proquest.com/docview/220170051/57847FB8596F4AFCPQ/1?accountid=36317>
- Hanser, Suzanne B,EdD., M.T.B.C., Butterfield-Whitcomb, J., Kawata, Mayu,H.H.P., M.T.B.C., & Collins, B. E. (2011). Home-based music strategies with individuals who have dementia and their family caregivers. *Journal of Music Therapy*, 48(1), 2-27. Retrieved from:<http://search.proquest.com/docview/865046137/8C265B7221324972PQ/4?accountid=36317>
- Lambert, J., Ibrahim-Verbaas, C., Harold, D., Naj, A. C., Sims, R., Bellenguez, C., . . . Del Zompo, M. (2013). Meta-analysis of 74,046 individuals identifies 11 new susceptibility loci for alzheimer's disease. *Nature Genetics*, 45(12), 1452-8. Retrieved from <http://search.proquest.com/docview/1470089724/A21C681FA7234737PQ/5?accountid=36317>
- Lancioni, G. E., Bosco, A., De Caro, M. F., Singh, N. N., O'Reilly, M. F., Green, V. A., Ferlisi, G., Zullo, V., D'Amico, F., Addante, L.M., Denitto, F., & Zonno, N. (2015). Effects of response-related music stimulation versus general music stimulation on positive participation of patients with Alzheimer's disease. *Developmental Neurorehabilitation*, 18(3), 169. Retrieved from: <http://web.b.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=8&sid=9c0af984-cdc1-4206-9d26-09454ef4d410%40sessionmgr120>
- Larkin, M. (2001). Music tunes up memory in dementia patients. *The Lancet*, 357(9249), 47. Retrieved from: <http://search.proquest.com/docview/199095376/EAD1DF990BF04893PQ/1?accountid=36317>
- Ledger, A. J., & Baker, F. A. (2007). An investigation of long-term effects of group music therapy on agitation levels of people with Alzheimer's Disease. *Aging & Mental Health*, 11(3), 330. Retrieved from: <http://web.b.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=10&sid=9c0af984-cdc1-4206-9d26-09454ef4d410%40sessionmgr120>
- Levy, M. L., Cummings, J. L., Fairbanks, L. A., Bravi, D., & al, e. (1996). Longitudinal assessment of symptoms of depression, agitation, and psychosis in 181 patients with alzheimer's disease. *The American Journal of Psychiatry*, 153(11), 1438-43. Retrieved from <http://search.proquest.com/docview/220464730/771406AE95848DAPQ/7?accountid=36317>
- Lipe, Anne W,PhD., M.T.-B.C., York, Elizabeth,PhD., M.T.-B.C., & Jensen, E., M.S. (2007). Construct validation of two music-based assessments for people with dementia. *Journal of Music Therapy*, 44(4), 369-87. Retrieved from <http://search.proquest.com/docview/223549179/8C265B7221324972PQ/3?accountid=36317>
- Mandel, S. E., Hanser, S. B., Secic, M., & Davis, B. A. (2007). Effects of music therapy on health-related outcomes in cardiac rehabilitation: A randomized controlled trial. *Journal of Music Therapy*, 44(3), 176-97. Retrieved from <http://search.proquest.com/docview/223557647/2D00250F8F744D5DPQ/6?accountid=36317>

MUSIC THERAPY FOR PATIENTS WITH PROBABLE ALZHEIMER'S

- Music Therapy Association of Ontario. Therapist Credentials. *Music Therapy Association of Ontario*. Retrieved from <http://www.musictherapyontario.com/page-1090436>
- Reichman, W. E., Coyne, A. C., Amirnani, S., Molino, B., Jr, & Egan, S. (1996). Negative symptoms in alzheimer's disease. *The American Journal of Psychiatry*, 153(3), 424-6. Retrieved from <http://search.proquest.com/docview/22046513/6A51D66FFEC74767PQ/3?accountid=36317>
- Reisberg, B., Ferris, S.H., de Leon, M.J., and Crook, T. (1982). The global deterioration scale for assessment of primary degenerative dementia. *American Journal of Psychiatry*. Retrieved from <https://www.fhcra.org/members/qi/clinadmin/global.pdf>
- Ropacki, S. A., & Jeste, D. V. (2005). Epidemiology of and risk factors for psychosis of alzheimer's disease: A review of 55 studies published from 1990 to 2003. *The American Journal of Psychiatry*, 162(11), 2022-30. Retrieved from <http://search.proquest.com/docview/220491901/771406AE95848DAPQ/1?accountid=36317>
- Sheehan, B. (2012). Assessment scales in dementia. *Therapeutic Advances in Neurological Disorders*, 5(6), 349–358 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3487532/>
- Silverman, M. J. (2006). Forty years of case studies: A history of clinical case studies in the journal of music therapy, music therapy, and music therapy perspectives. *Music Therapy Perspectives*, 24(1), 4-12. Retrieved from <http://search.proquest.com/docview/199554426/1CB5282492F84CF2PQ/4?accountid=36317>
- Sim H.M., Chung S.H., (2001). The effect of music therapy on cognitive function, behavior and emotion of dementia elderly. *The Journal of Korean Academy of Adult Nursing*. Retrieved from <https://www.koreamed.org/SearchBasic.php?DT=1&RID=0094JKAAN%2F2001.13.4.591>
- Takahashi, T., & Matsushita, H. (2006). Long-term effects of music therapy on elderly with Moderate/Severe dementia. *Journal of Music Therapy*, 43(4), 317-33. Retrieved from <http://search.proquest.com/docview/223549934/F91491A123C5478APQ/2?accountid=36317>
- Zare, M., Ebrahimi, A. A., & Birashk, B. (2010). The effects of music therapy on reducing agitation in patients with Alzheimer's disease, a pre-post study. *International Journal Of Geriatric Psychiatry*, 25(12), 1309. doi:10.1002/gps.2450. Retrieved from <http://web.a.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=f41c247e-c693-4a6d-a6f6-65c5f87e9b51%40sessionmgr4007&vid=8&hid=4001>

Computer Simulation of Genetically Modified *Aedes aegypti* Release Methods

Gregory Schwartz

Aedes aegypti mosquitoes are largely responsible for the spread of Dengue Fever and Zika virus. Field trials of genetically modified male *Aedes aegypti* which produce non-viable offspring are planned in the United States. It is critical to determine the best release method which controls the wild mosquito population and minimizes the use of modified mosquitoes. A computer simulation was developed to test various release methods under different conditions. The simulation compared favorably with known field data from Brazil. All the variable release methods tested produced a 95% reduction ($p < 0.001$) in the wild mosquito population. Both a slower changing release method and a more rapidly adjusting method without a minimum release allowed for a late increase in wild mosquito numbers. The rapidly adjusting method with a minimum released controlled the wild mosquito population while using 17% and 19% less genetically modified mosquitoes in dry and wet conditions respectively ($P < 0.001$).

Keywords: *Aedes aegypti*, mosquito, Zika, genetically modified

Introduction and Literature Review

Mosquito-borne diseases cause 700 million infections and over one million deaths each year. The increasingly mobile society and climate changes have led to a resurgence of mosquito-borne disease in previously disease-free areas. Dengue Fever is now reported in Texas and Florida. Vector control programs in the 1960's had largely eliminated Yellow Fever and Dengue Fever in Brazil.¹ In 2015 there were an estimated 1.5 million Dengue infections in Brazil. Fear of Zika and Dengue weighed on both athletes and spectators at both the FIFA world championships and 2016 Olympics.²

The mosquito species *Aedes aegypti* is largely responsible for the spread of Dengue Fever, Chikungunya, and Zika virus.³ Female *A. aegypti* are highly

evolved hunters that are particularly adept at spreading infection.⁴ Female mosquitoes require a blood meal to obtain the necessary protein to reproduce. The mosquitoes live and breed around humans often travelling only a few meters during a lifetime. While able to feed on a variety of mammals, they prefer human blood. The female detects carbon dioxide, lactic acid, and octanol given off by humans. They bite frequently at ankles and back of knees to avoid observation. An anticoagulant in the saliva prevents clotting allowing for the rapid withdrawal of blood. *A. aegypti* are siphon-feeders that take small amounts from several different bites greatly increasing their potential to spread infection. A single female can produce over 500 eggs during its one-month lifetime.

Mosquito control efforts have had varying degrees of success. Early efforts with mosquito netting and draining breeding areas were particularly effective

SIMULATED GENETICALLY MODIFIED AEDES AEGYPTI RELEASE METHODS

against certain species of mosquitoes. Insecticides proved effective in controlling an explosion in spread after World War II. Unfortunately, the development of resistance to insecticides, adaptation, and globalization has allowed the spread of *Aedes aegypti*. According to the FDA even a well-organized mosquito control program is often ineffective.

Efforts to control mosquito populations and reduce use of potentially dangerous insecticides have led to several new techniques. Biological control using natural enemies such as mosquitofish has been used on a limited scale. Spores of bacterium *Bacillus thuringiensis* which disrupt larval digestion could be dropped from the air.⁵ Mosquitoes have been infected with the bacterium *Wolbachia pipientis* rendering them infertile. Radiation which had been used to make other insects sterile damaged the mosquitoes making this technique ineffective.

A genetically engineered mosquito has been developed by Oxitec. The OX513A strain of *Aedes aegypti* has two genetic changes.⁶ A fluorescent marker allows for rapid determination of native and modified mosquitoes. Inserted is a gene that produces a protein called tTAV (tetracycline repressible activator variant). When produced the protein ties up cellular machinery leading to cell death. Exposure to tetracycline in sufficient concentrations during breeding suppresses the protein allowing for normal reproduction. The males are separated from the females based on their smaller size. The males are released into the environment. The males fertilize native female mosquitoes and the eggs which have the tTAV gene don't survive.

Trials using OX513A to control *Aedes aegypti* have been done in the Cayman Islands, Panama, and Brazil.⁷ Studies have shown a reduction of mosquito populations of 90% in small scale trials. One major hurdle has been the difficulty in producing and managing the large number of genetically modified mosquitoes needed. The study in Brazil had to be modified by cutting the test area in half to have sufficient OX513A mosquitoes.

The epidemic of Zika virus in Brazil and its spread to Florida has spurred interest in the planned field trial of OX513A in the Florida Keys.⁸ The trial is designed to see if effective suppression can be achieved and if continued monitoring and adjustment of modified mosquito releases can suppress the population for up to 22 months.

One of the critical concerns is what system for releasing the modified male mosquitoes will control the wild mosquito population but minimize the use of this limited resource. A system for monitoring the varying number of released OX153A has been proposed based on previous trials and formula-based models.

There are two basic types of epidemiologic models. Formula modeling began in the late 18th century with Thomas Malthus.^{9, 10} Formula-based models have been steadily improved and are heavily utilized in epidemiology.¹¹ With the advent of modern computers individual based modeling has been possible. In this type of modeling each individual in a population being studied is tracked.¹² These models are very data intensive and best for studying small populations.¹³

This study uses an individual-based computer model to study population control of *Aedes aegypti* in Key Haven, Florida using OX153A. It is hypothesized that monitoring and adjusting OX153A release will control a population of *Aedes aegypti* while minimizing the use of genetically modified mosquitoes.

Methods

Using Visual Studio2012 Release 4 C++, a program was written to simulate a human and mosquito environment. Multiple factors were used in the programming the simulation. Parameters included size of the environment, probability of biting and mating, aging of mosquitoes, number of offspring produced, immigration of mosquitoes, male detection range, and environmental dispersion.

The program first creates human and mosquito populations. Their locations, age, sex, and state of feeding are determined. As the simulation begins, the people move about their environment. The mosquitoes move based on multiple factors including a female proximity to human, male proximity to female, environmental changes such as wind and random movements. Then interactions within a 1 square meter area are checked for each mosquito including its success at biting or mating. If females have obtained enough human blood protein, then they can interact with males and produce offspring who are added to the mosquito population. At the end of each hourly cycle the mosquitoes age and eventually die.

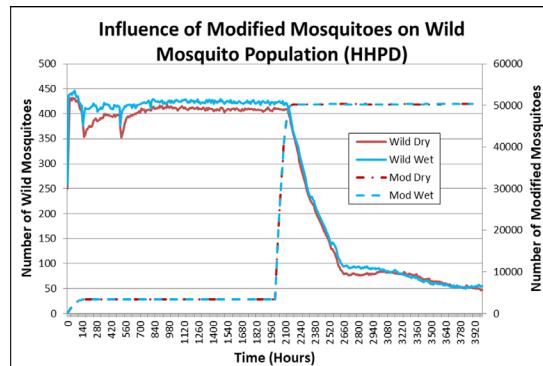
After 100 hours of simulation to allow for the simulation with humans and mosquitoes to reach homeostasis genetically modified mosquitoes are added to the environment. Of note, 100 hours were chosen because preliminary simulations showed 100 hours sufficient to create homeostasis. They are dispersed relatively evenly in the environment in numbers based on the method being tested for that simulation. Each hour the modified mosquitoes move around the environment and potentially mate with the female mosquitoes but the mating produces no viable offspring.

Simulations using high human population density were run for 4000 hours while the low population density environment was tested for 8000 hours. Methods tested in the low population density included fixed low releases of 75,000, 50,000, 25,000, and 10,000 (75K, 50K, 25K, 10K respectively) per hectare. Methods tested in the high population density environment, after the initial 100 hours, a fixed release at 20,000. After 2000 hours, the release was increased to 75,000. Variable method 10/10 releases 75,000 modified mosquitoes during the first 800 hours. After the initial 800 hours releases vary. If the ratio of modified matings is less than 2 times the number of wild matings than the number released is increased 10%. If the number of modified matings is 2 times or greater than number of wild matings, the number released is reduced by 10%. Method 50/20 No Floor (NF) also releases 75,000 during the first 800 hours. After which if the mating ratio is less than 2 times, the number released is increased by 50%. If the ratio is 2 times or greater, it is decreased by 20%. Method 50/20 is identical to Method 50/20 NF except the minimum release number is 7,500 due to the “Floor” parameter. In summary, 10/10 release method has a 10% increase or decrease with each adjustment while a 50/20 has a 50% increase or a 20% decrease of modified mosquitoes released.

The simulation was run with multiple different parameters including higher offspring production and different methods for determining modified mosquito release. Every 10 hours data was collected along with summary data at the end of the simulation run. The data was analyzed using Microsoft Excel. A P-value for significance was set at 0.01.

Results

The initial simulation used a high human population density (HHPD) of 460 per hectare. The simulation was run during wet and dry periods for 4000 hours. There was a statistically significant decrease in the wild mosquito population within 40 hours for both wet and dry situations (Dry 424 to 406 p < 0.001, Wet 433 to 415 p < 0.001) after the release of the modified mosquitoes. The wild mosquito population plateaued between hours 1000 and 2000 with a change of less than 1% in both dry (p=0.3) and wet (p=0.8) simulations (Graph 1). The increase in genetically modified mosquitoes at hour 2000 caused a precipitous statistically significant drop in the mosquito population. The final mosquito counts were down 89% in the dry simulation and 88% in the wet simulation both which were statistically significant (p<0.001).



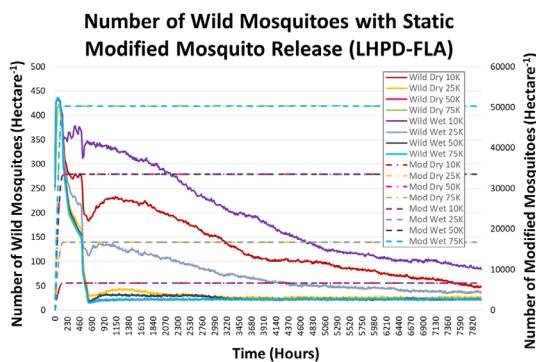
Graph 1- Introduction of a low number of genetically modified mosquitoes resulted in a small but statistically significant decrease in wild mosquito populations. Increasing the number of released modified mosquitoes caused a rapid decrease in wild mosquito populations by almost 90% (p-value < 0.001). Both wet and dry had similar results.

Next, the simulation was changed to a low human population density (LHPD) environment run for 8000 hours. Four fixed release strategies of modified mosquitoes were tested (75K, 50K, 25K, 10K) and produced a statistically significant decrease in wild mosquito populations within the first 20 hours (p<0.001) (Graph 2). The higher release methods continued to cause a rapid and sustained decrease in wild

SIMULATED GENETICALLY MODIFIED AEDES AEGYPTI RELEASE METHODS

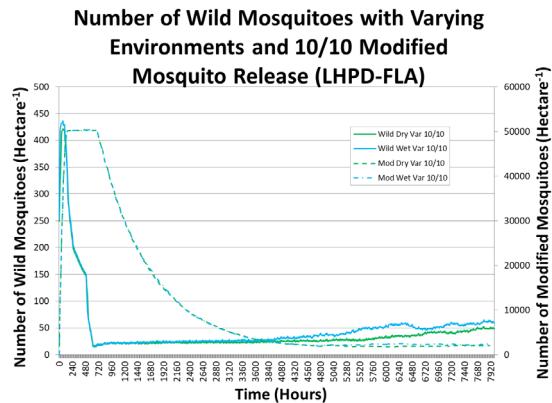
mosquito populations which leveled off around 600 hours. The lower fixed release methods (25K, 10K) also decreased the wild mosquito populations but at a slower rate which was slowed further during wet conditions. At 8000 hours there was a statistically significant difference between method 10K and both 50K and 75K ($p < 0.003$). There was also a statistically significant difference between 10K wet conditions and 25K wet conditions ($p = 0.002$).

increase which was statistically significant ($p < 0.001$) between 6000, 7000, and 8000 hours. The release method 50/20 NF (no floor) method achieved the same initial decrease but rebounded as the number of released modified mosquitoes decreased. The increase in wild mosquito numbers caused an increase in the number of genetically modified mosquitoes released but never reduced it to the level of the release method variable 50/20 with floor ($p < 0.001$).



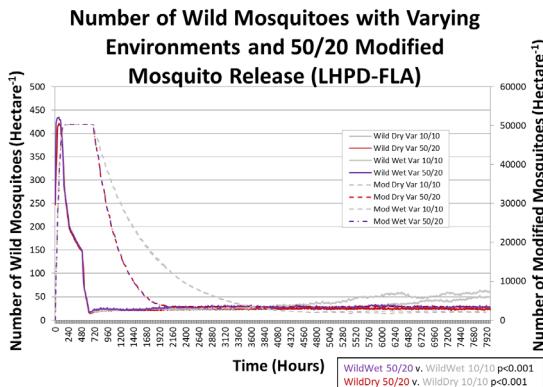
Graph 2- All produced statistically significant drop in the wild mosquito population (p -value < 0.001). High fixed release (75K, 50K) caused rapid sustained suppression of the wild mosquito population. Low fixed release (25K, 10K) produced a slower decrease in the wild mosquito population. Wet conditions did not affect high fixed release methods but further slowed suppression with low fixed release methods.

All six variable release strategies for the genetically modified mosquitoes caused a precipitous decrease in wild mosquito populations. (Graphs 3a, Graph 3b, Graph 3c and Graph 4) Within the first 20 hours after the modified mosquitoes were released there was a statistically significant drop in all scenarios ($p < 0.001$). By 1000 hours there was a greater than 95% decrease in the wild mosquito population. Release method variable 10/10 developed a statistically significant increase in both Dry and Wet scenarios ($p < 0.001$) late in the simulation. The release method 10/10 during wet condition had a more rapid increase in the wild mosquito population that plateaued between 6000 and 8000 hours, while the dry condition had a slower



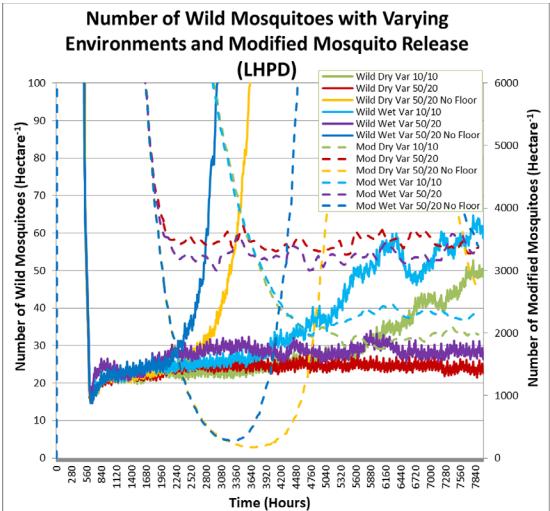
Graph 3a- Release method 10/10 allowed for a statistically significant late increase in wild mosquito populations (p -value < 0.001). Wet conditions allowed for an earlier and more rapid late increase with the 10/10 method that plateaued between 6,000-8,000 hours.

SIMULATED GENETICALLY MODIFIED AEDES AEGYPTI RELEASE METHODS



Graph 3b- Method 50/20 produced a rapid sustained suppression in both wet and dry conditions using the least number of genetically modified mosquitoes.

Graph 3c - Method 50/20 No Floor (NF) produced

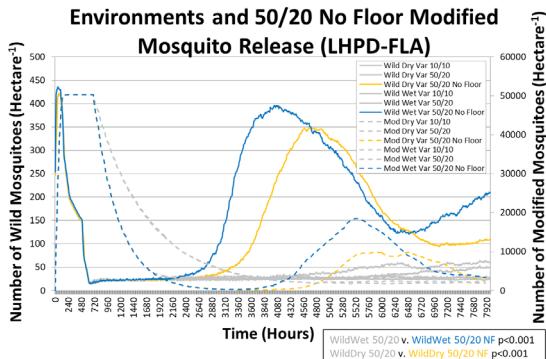


Graph 4 - Looking closer, the 50/20 No Floor release model produced a rapid decrease but allowed for a large rebound in wild mosquitoes. The 10/10 release model allowed for a late increase in the wild mosquito population.

The number of genetically modified mosquitoes used by each technique varied considerably. The variable methods used less modified mosquitoes than the fixed methods except 10K. Variable method 50/20 used 17% less genetically modified mosquitoes in dry conditions and 19% less in wet conditions compared to variable method 10/10 ($p<0.001$). Variable method 50/20 NF in dry conditions showed a trend to increased use of modified mosquitoes (4%, $p=0.060$) compared with variable method 50/20 and significantly more under wet conditions (24%, $p < 0.001$). The wet and dry conditions with floor changed the need for sterilized males by 1 to 2 percent.

Discussion

Computer simulation of the low human population density environment produced several results. The fixed releases using large numbers (75K and 50K) of modified mosquitoes were effective at controlling the population but used extensive resources. The lower fixed releases did significantly reduce the



a rapid decrease in the wild mosquito population with a large rebound in mosquito population as the number of released genetically modified mosquitoes decreased. Under wet conditions, method 50/20 NF had a more rapid and larger increase in the wild mosquito population.

SIMULATED GENETICALLY MODIFIED AEDES AEGYPTI RELEASE METHODS

wild mosquito populations but it was such a slow process that even after 8000 hours there were still significantly more wild mosquitoes compared to the high fixed methods. The 10K method used the least modified mosquitoes but had persistently elevated wild populations.

Variable method 50/20 suppressed the wild mosquito population throughout but Variable method 10/10 did not. After 4000 hours, there was a significant increase in the wild mosquito population during wet conditions. After 6000 hours, the wild mosquito population increased during dry conditions. Variable method 10/10 did not suppress the wild population as well and wet conditions allowed for a more rapid recovery of the wild mosquito population. Variable method 50/20 without a floor produced the same initial reduction in mosquito populations seen with the other variable methods. As the number of modified mosquitoes released dropped to low levels the wild mosquito population increased quickly with a more rapid increase during wet conditions. This caused a compensatory increase in the number of modified mosquito released which reduced the population but it did not achieve the low numbers seen with the other variable methods. Variable method 50/20 with floor was effective and used the least number of genetically modified mosquitoes.

The high-density simulations, similar to the field trial in Brazil during 2011-2012, demonstrated several key aspects of the population model. During the Brazil trial the number of genetically modified mosquitoes released was limited. The trial initially studied an 11-hectare area. The limited number of modified mosquitoes and large area caused the density of released mosquitoes to be low. During this time, there was limited suppression of the wild mosquito population. A similar response was shown in the computer model during the first 2000 hours of the simulation. In the Brazil field trial the area was reduced to 5.5 hectare and the concentration of released mosquitoes was sharply increased leading to a dramatic reduction of 90% in the number of wild mosquitoes. This was also seen in the high population density model after 2000 hours when the number of released mosquitoes was increased a similar amount. The similarity between the Brazil field trial and high population density simulations supports the accuracy of this computer model.

The simulations using low population density are based on an environment for a planned field trial in Key Haven, Florida. The planned study involves a “Range finding Phase” to reduce the population and a “Suppression phase” to maintain the effect. The first phase involves a fixed release based on initial human and wild mosquito populations. The second phase releases are to be based on ratio of modified to wild larvae found in traps. The low population density computer model suggests a rapid adjustment and higher floor in the number of released modified mosquitoes is likely to be more effective at controlling the wild mosquito population.

While the data did provide support for the hypothesis there are several limitations with the model and this study. Because of limited published field trial data, the model was only compared to the Brazil trial 2011-2012. Comparison with other field studies may show major discrepancies with the computer model. The study only looked at wet and dry conditions which are not a dichotomy but occur to varying degrees over time. The study also raised concern that Variable method 50/20 may not respond quickly enough to suppress an increase in wild mosquito populations and a more aggressive response to changes in the wild population may be needed. This could be studied by repeated simulations under more challenging environmental conditions. The study did not take into account more complex geographic and weather features which alter mosquito populations. Studies have suggested that some genetically modified mosquitoes can survive and possibly procreate. While only male genetically modified mosquitoes were included in the study, research has shown that genetically modified females are also released and their effects are not considered in this model.

This study leads to several other possible areas of research. The computer model could look at several different variable methods besides the two that were tested in this study including the effect of minimum release number. This may allow for further refinement and provide an optimal release method for genetically modified mosquitoes for a particular environment. A comparison of this model with other field trials would allow for further modification of the model for different environments. The model could also be used to track infectious transmission such as Dengue Fever or Zika and the effect of genetically modified mosquitoes.

Conclusion

The study supports the utility of this individual based computer model and the hypothesis that variable methods of release for genetically modified mosquitoes can control wild Aedes aegypti mosquito populations and reduce resource requirements. Optimizing the modified mosquito release strategy will allow for both the effective control of wild mosquito populations and reduce the number of genetically modified mosquitoes that need to be released. Using computer models will allow for testing many different strategies reducing the number of expensive and difficult field trials.

9. Cohen, J. (1995, July 21). Population Growth and Earth's Carrying Capacity. Retrieved September 2, 2014, Retrieved from http://www.montana.edu/screel/Webpages/conservation_biology/cohen.pdf
10. MacFarlane, A. (n.d.). Thomas Malthus and the Making of the Modern World. Retrieved September 2, 2014, Retrieved from http://www.alanmacfarlane.com/TEXTS/Malthus_final.pdf
11. Brauer, F., & Vez, C. (2001). *Mathematical models in population biology and epidemiology*. New York: Springer.
12. Lomnicki, A. (2011, January 1). Individual-based Models in Population Ecology. Retrieved September 2, 2014, Retrieved from <http://www.els.net/WileyCDA/ElsArticle/refId-a0003312.html>
13. Reynolds, C. (n.d.). Individual-Based Models. Retrieved September 2, 2014, Retrieved from <http://www.red3d.com/cwr/ibm.html>

References

1. Siqueira JB, Martelli CM, Coelho GE, et al. (2005) Dengue and Dengue Hemorrhagic Fever, Brazil, 1981–2002. *Emerging Infectious Diseases*.11(1):48-53. doi:10.3201/eid1101.031091.
2. Dengue Virus Net (n.d.) *Aedes aegypti* Retrieved from <http://www.denguevirusnet.com/aedes-aegypti.html>
3. Encyclopaedia Britannica (n.d.) *Aedes*. Retrieved from <https://www.britannica.com/animal/Aedes>
4. LaFrance, A. (2016, April 25). The Sneak-Attack Mosquito. *The Atlantic*. Retrieved from <http://www.theatlantic.com/science/archive/2016/04/aedes-aegypti/479619/>
5. Pollack, A. (2016, January 30). New Weapon to Fight Zika: The Mosquito. *The New York Times*. Retrieved from www.nytimes.com/2016/01/31/business/new-weapon-to-fight-zika-the-mosquito.html?_r=0
6. Oxitec (n.d.) Retrieved from <http://www.oxitec.com/>
7. Carvalho DO, McKemey AR, Garziera L, Lacroix R, Donnelly CA, Alphey L, et al. (2015, July 2). Suppression of a Field Population of *Aedes aegypti* in Brazil by Sustained Release of Transgenic Male Mosquitoes. *PLOS Neglected Tropical Diseases* Retrieved from <http://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0003864>
8. Center of Veterinary Medicine, United States FDA Department of Health and Human Services. (2016, August 5). *Environmental Assessment of Investigational use of Aedes Aegypti: QX513A* Retrieved from <https://www.fda.gov/downloads/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/GeneticallyEngineeredAnimals/UCM514698.pdf>

Motivation in Pursuing Advanced Degrees in STEM Fields Among Domestic and International Students

Pranshu Adhikari

The United States has seen a sharp increase in the number of international students pursuing and receiving advanced degrees (Master's or Ph.D.) in STEM fields. While much literature has been published about the disproportionate number of international students pursuing and receiving advanced degrees in STEM fields, none have attempted to explain the reason why this phenomenon occurs. The purpose of this study was to identify if there was a difference between the reason domestic students and international students were pursuing and receiving advanced degrees in STEM fields. While the findings showed no statistically significant relationship between the student's status (as a domestic student and an international student) and the reason they chose to pursue an advanced degree in STEM, there was an overwhelming number of respondents from both the domestic student pool and international student pool that indicated that their primary reason in choosing to pursue an advanced degree in STEM was due to their interest in the field.

Keywords: STEM, international students, Master's, Doctorate, domestic student

Introduction

The number of students choosing to pursue advanced degrees (a Master's or Ph.D.) has been steadily rising for quite some time. More students are finding value in higher education for various reasons. The Organization for Economic Co-operation and Development, or the OECD, is an organization that promotes economic development and publishes various reports about demographics in developed and developing countries. Many OECD countries have seen an unexpectedly high increase in the number of students that pursue higher education (OECD, 2006). This trend is expected to grow, as many jobs now require an advanced degree. In particular, careers in science, technology, engineering, and math (collectively referred

to as STEM) fields often require a tertiary education; an advanced degree is not an option but is required to succeed in the field. Therefore, many students who are pursuing STEM pursue a higher education.

In the United States, there is a large gap between the number of domestic students pursuing advanced degrees in a STEM field and the number of international students pursuing advanced degrees in a STEM field. While much literature has been published on the disproportionate number of international students in the field, there has not been an attempt to study why that is. This paper aims to understand if there is any difference in the reason domestic students pursue advanced degrees in STEM fields and international students pursue advanced degrees in STEM fields.

For the purposes of this paper, STEM includes any field in astronomy, chemistry, computer science, en-

gineering, geoscience, life science, materials research, mathematical sciences, and physics. Social sciences, STEM education, and medical fields are not included in this definition. Additionally, domestic students were defined as those who completed their high school education in the United States and international students were defined as those who completed their high school education outside the United States.

Literature Review

Much of the relevant literature regarding this subject concerns the reason students first became interested in STEM fields. With growing concern of a shortage of individuals in science, technology, engineering, and math fields, there has been a large movement that pushes for greater STEM education in the K-12 school system in the United States (Xue & Larson 2015). Many are concerned with the low number of domestic students enrolled in graduate school for STEM degrees and therefore advocate for a greater attempt to increase students' interest in STEM fields (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine 2007). The primary goal of gathering relevant literature in the field was to understand the reason individuals became interested in STEM fields, thereby making a distinction between an individual being interested in STEM and an individual actually pursuing STEM. The findings were used to create a survey that listed all the possible reasons individuals pursued an advanced degree in a STEM field.

Interest in STEM Garnered by School

Many researchers argue that the most significant factor in helping generate interest in STEM for students is hands-on experiences (Chachashvili-Bolotin, Milner-Bolotin, & Lissitsa 2016). Employing teaching methods that actively engage the students is closely tied to providing hands-on experiences to students. Such experiences can come in the form of school activities and/or extracurricular activities.

The teaching method is an important factor in garnering interest in STEM in school. Evidence regarding the effectiveness of inquiry-based and investigative-based learning has long been prevalent in the schol-

arly community (Markowitz, 2004). Students learn and retain information better when they are actively engaging with the material they are studying. This is especially true in a STEM field, where students must attempt to understand the ways in which the physical world works. By engaging with the learning materials, students are able to relate to the information better (VanMeter-Adams, 2014). They have a reason for trying to understand the material. If a student was taught about these concepts in isolation, then there would be no context in which the student could use their knowledge, rendering it useless.

Many students also choose to participate in STEM related activities outside of school. The hallmark of extracurricular activities is that they are voluntary; because they are voluntary, many of the students who choose participate in these programs already have a basic level of demonstrated interest in a STEM field. Otherwise, they would not be participating in those activities. Before participation in such activities, many students had preconceived ideas of STEM as a field that was heavily focused on a system of strict guidelines (Richmond & Kurth, 1999). When those students were exposed to activities that expected them to think critically and act creatively, there was a definite shift in their thinking of what a STEM career meant (Richmond & Kurth, 1999). These experiences allowed students to consider STEM as a field that focused on exploration and creativity, not a field that focused on rigid guidelines and rules. Because the ability to be creative in their career path was important to those students, they were able to view STEM as a viable career path for them.

Some students are involved with STEM fields at a much younger age than other students. A review of the literature, however, illustrates that the age at which a student is exposed to STEM does not play a significant role in their level of interest for the subjects in the field, as long as the student becomes interested before they must choose a career path (Chachashvili-Bolotin, Milner-Bolotin, & Lissitsa, 2016). There is a great difference between the experiences that can be offered to someone that is in elementary school versus someone who is of high school age. For example, the only opportunity an elementary school student might have is the opportunity to attend a STEM promotion fair that has games and activities for the student to do, while a high school student has the opportunity

MOTIVATION IN PURSUING ADVANCED DEGREES IN STEM FIELDS

to partake in an internship at a research laboratory or attend a STEM-based summer program (Quagliata, 2015). Older students have more opportunities to get engaged with STEM simply because of the number of years they have been exposed to the field.

Interest in STEM Because of Possible Economic Opportunities

It has become common knowledge that those with degrees in STEM usually earn much more than individuals who do not have a STEM degree. Data collected and published by the National Center for Education Statistics clearly shows that there is a substantial difference in the salary for those with a Bachelor's degree in STEM and those with a Bachelor's degree in a Non-STEM field; for those who work full-time, the difference is more than \$15,000 (Cataldi, Siegel, Shepherd, & Cooney 2014). This figure is greater for those with advanced degrees. The total lifetime earning for an individual with a bachelor's degree is even more if they have an advanced degree. Individuals with a bachelor's degree can expect to make around \$2.27 million in their lifetime, while individuals with a doctoral degree can expect to make around \$3.25 million in their lifetime; this difference of approximately a million dollars is a significant gap (Carnevale, Rose, & Cheah 2011).

These statistics are not limited to STEM, but trends for STEM fields follow the same model. Therefore, economic opportunities might be in the forefront of a student's mind when deciding on whether or not they want to pursue an advanced degree. Low-income students often want to pursue a STEM field because it has the most payback. Students with such a background often feel obligated to pursue a career that ensures financial security i.e. STEM (Lichtenberger & George-Jackson, 2013).

With the increased dependence on technology today, employers look for those with experience and some skill in STEM. More than half of the employers surveyed in a study conducted by National Association of Colleges and Employers said they planned on hiring graduates with bachelor's degrees in STEM fields (Koc, Koncz, Tsang, & Longerberger, 2016). There is an increased need for individuals with a STEM degree in today's workplace, allowing for more opportunities to be available to graduates with STEM degrees. STEM has become a financial safety net; a

graduate with a STEM degree has a greater chance of finding a job in his/her field than someone who majors in a non-STEM field.

Different Experiences Among Foreign and Domestic Students

In order to analyze the motivations behind wanting to join the STEM field, it is important to establish that foreign nationals have significantly different experiences in the United States than those who grew up in the U.S., no matter their reason for residence in the country. At the most general level, foreign nationals are likely to earn less than their native-born counterparts (Takei, 2011). This is especially true within the first few years the individual is in the United States. The individual takes time to get settled and adjusted to the new cultural norms of America (Jiang, 2010). Moving to a country with a different culture and possibly a different language than what the individual grew up in can be jarring and could have a profound affect on their experience.

As various studies have shown, international students typically get more advanced degrees in STEM fields than their native counterparts. Although domestic students are regularly shown to receive about 73% of total advanced degrees in the United States, they only receive approximately 50% of advanced degrees in STEM-related fields (Han, 2016). International students are also more likely to receive more grants than their native counterparts (Corley & Sabharwal, 2007). These grants are used to conduct research, which increases their standing as a professional in their respective field.

It is difficult to make a generalizing statement for the whole population because each group (domestic students and international students) has totally varied previous experience. Doing so would invalidate the different experiences of each group. What is clear, however, is that domestic students and international students have differing experiences in the United States as is apparent through the need of international students to familiarize themselves with American society and the discrepancy in the number of advanced degrees awarded to both groups. Therefore, it is critical that domestic and international students are evaluated as two separate groups.

Research Gap

A substantial body of research has attempted to gauge the reasons why individuals choose to pursue a STEM field. Additionally, it has been shown that international students pursue and earn advanced degrees in STEM fields in much larger numbers than in any other field. However, there have not been studies that have tried to find if there are any differences in motivation to pursue an advanced degree in a STEM field among international students and domestic students. There seem to be many assumptions made by the general public on the relationship between nativity status and the reason for pursuing an advanced degree in a STEM field. The purpose of this study is to discover if such a relationship exists and if so, what that relationship is. As noted previously, international students and domestic students have quite a different experience in the United States. Therefore, their motivations and interest in pursuing advanced degrees will be evaluated separately.

Method

Previous studies attempting to determine a population's reason for pursuing STEM-related careers took a survey approach to arrive at their conclusions. Such an approach is one of the best methods that allows the researcher to make conclusions about the way a population thinks and acts during current times, which is why the same approach was taken when conducting this research project.

The survey used to collect the data was modeled after a survey conducted Maltese, Melki, and Wiebke (2014) from Indiana University titled "The Nature of Experiences Responsible for the Generation and Maintenance of Interest in STEM" that attempted to analyze the primary reason individuals became interested in a STEM field. The survey was modified to fit the needs of the research, as this research targeted a different demographic than the population surveyed by the original survey. The modified survey asked individuals where they completed their high school education -- to distinguish between international and domestic students -- and their primary and secondary reason for choosing to pursue an advanced degree in a STEM field. This was done to ensure all individu-

als taking the survey had the same definition of "domestic student" and "international student" for the purposes of this research study; if not, the data would have been skewed. In the data analysis, individuals who completed their high school education in the United States were categorized as domestic students and those who completed their high school education outside the United States were categorized as international students.

The research procedures, methods, and the survey were approved by the Institutional Review Board, or IRB, of Norman Public Schools in order to ensure ethical research practices.

The same survey was used for both international and domestic students. It was not possible to distinguish between international students and domestic students based on publicly available information. Participants indicated their status as international or domestic student on the form. This also allowed for a more random sampling of the data.

The surveys were sent via email to individuals at institutions of higher education that were likely to have access to the faculty and to graduate students (as my research focused on those two groups) in STEM fields. Institutions of higher education were chosen through a multistage random sampling method by using the Forbes "Top American Colleges" list of the top colleges in the nation. With the time constraints that were in place, it was not practical to select institutions of higher education from a spreadsheet of all such institutions in the United States. Therefore, a college ranking list was used to determine the institutions that would be sent the survey. More specifically, the Forbes list was chosen instead of other college rankings because of its focus on post-graduate success. As this research was primarily concerned with the work individuals do in their graduate studies, the Forbes list was the most practical (Howard 2016). Additionally, the ranking of liberal arts colleges, as well as research universities within the same ranking system done by Forbes, allowed for a greater and more randomized sample to choose from.

After that process was complete, it was clear that there needed to be contact with certain individuals at each institution that would distribute the survey. It would have decreased the validity of the research if the survey was sent to individual graduate students or professors at the university. Therefore, it was decided that

MOTIVATION IN PURSUING ADVANCED DEGREES IN STEM FIELDS

sending the surveys through an intermediary would be the best option. The intermediary would have to be someone who had a position at the institution that allowed them access to professors and/or graduate students in STEM fields. For most of the institutions selected through the multistage random sampling, such an individual was one who held the position Departmental Chair or Departmental Head, or the equivalent, of a STEM department. Additionally, the survey was also sent to the Department's Administrative Assistant or Executive Assistant, or the equivalent, as individuals in those positions have access to professors and/or graduate students in their department. The email addresses for these individuals was publicly available on each institution's website. Individuals at institutions that did not have email address of faculty publicly available or institutions that clearly stated that available email address were only to be used by students of the institution were not contacted.

Due to the time constraints of this research project as well as the vast scope of higher education institutions that were chosen, it was not practical to receive an approval from each institution's Institutional Review Board. Therefore, the participants were informed

that their participation in the survey would also serve as their consent to taking the survey. This meant that there were no consent forms that were used while conducting this research project as participation was also understood to be consent. (Please consult the Appendix for the survey used.)

Results

Data were analyzed based on whether the participant completed their high school education in the United States or outside the United States. Participants that completed their education in the United States were classified as "domestic students" while participants that completed their education outside the United States were classified as "international students". Participants were asked to choose the primary reason they chose to pursue an advanced degree in a STEM field as well as a secondary reason they chose to pursue an advanced degree in a STEM field. These responses were then analyzed separately for domestic students and international students. The figures below display the results of the survey.

Fig 1. Domestic Students Primary Reason

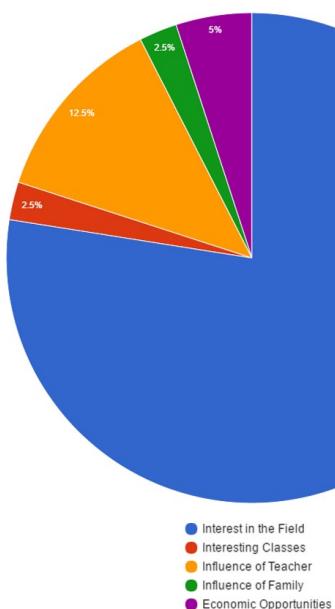
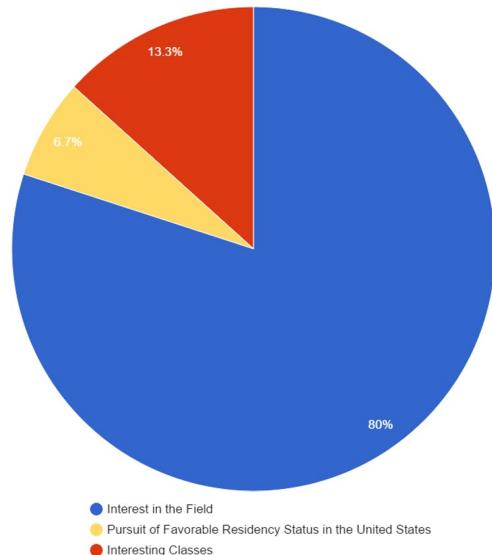
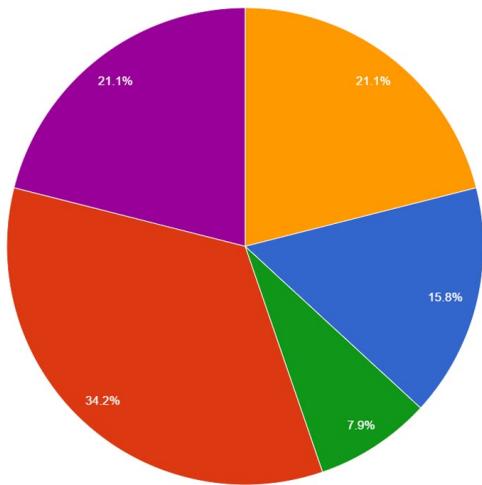


Fig 2. International Students Primary Reason

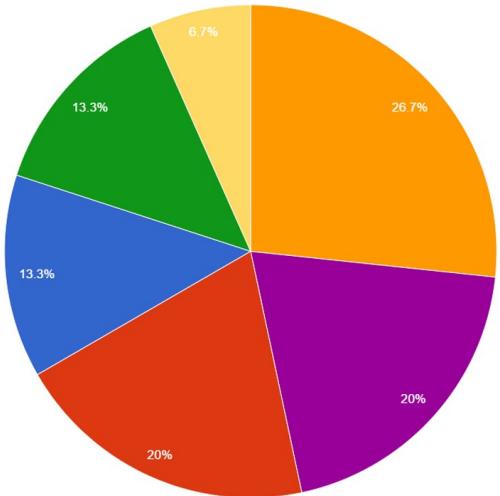


MOTIVATION IN PURSUING ADVANCED DEGREES IN STEM FIELDS

*Fig 3. Domestic Students
Secondary Reason*



*Fig 4. International Students
Secondary Reason*



Key for above graphs.

- Influence of Teacher
- Economic Opportunities
- Interesting Classes
- Interest in the Field
- Influence of Family
- Pursuit of Favorable Residency Status in the United States

	A	B	C
1 - Economic Opportunities	0 (0%)	2	2
2 - Influence of Teacher	0 (0%)	5	5
3 - Influence of Family	0 (0%)	1	1
4 - Interesting Classes	2 (1	3
5 - Interest in the Field	12	31	43
6 - Pursuit of a Favorable Residency Status	1	0	1
	15	40	55

Fig 5. Table of values where A represents the number of international Students and B represents domestic students that chose each option for their primary reason. C represents the total number of students (both international and domestic) who chose each option.

MOTIVATION IN PURSUING ADVANCED DEGREES IN STEM FIELDS

	A: Primary	B: Primary	A: Secondary	B: Secondary
1	--	5%	20%	21.1%
2	--	12.5%	26.7%	21.1%
3	--	2.5%	13.3%	7.9%
4	13.3%	2.5%	20%	34.2%
5	80%	77%	13.3%	15.8%
6	6.7%	--	6.7%	--

Fig 6. This chart shows the corresponding percentage of participants in each group who selected each option. This chart displays the values that are present on the graphs.

	A	B
1	0.545	1.45
2	1.36	3.64
3	0.273	0.727
4	0.818	2.18
5	11.7	31.3
6	0.237	0.727
	p = 0.150	

Fig 7. Contingency table that shows the expected values using Fisher's Exact Test.

Discussion

The p value calculated using the Fisher Exact Test as shown in Figure 7 was shown to be statistically insignificant. As a p value of over 0.05 indicates weak evidence against the null hypothesis, it is clear that statistically, there is no evidence to show that there is any relationship between the two variables. Weak evidence against the null hypothesis indicates that the results collected are either due to coincidence or chance and are not related in a significant way. The Fisher Exact Test was used in place of a chi-squared test because of the small sample size (the sample size of this survey was 55); both tests produce the same results.

Although the results were shown to be statistically insignificant, it is possible to look at the trends found from the survey and analyze that data. The primary reason for most people in pursuing an advanced degree in STEM was interest in the field. In fact, for both domestic and international students, approximately 80% of respondents indicated that this was a primary motivation. This trend is surprising, as international students and domestic students have very different experiences in the United States, a phenomenon discussed in the Literature Review section of the paper. The survey leads to the conclusion that the differing experiences of domestic and international students makes no difference in their reason for pursuing an advanced degree in a STEM field.

Such a conclusion can have many valid explanations. International students might have decided their career plans before coming to the United States. This would explain why their social and educational experiences in the United States had little to no effect on their reason to pursue an advanced degree -- because their reason to pursue such a degree was already well established before they came to the United States. However, as this was not the focus of the research project, a more concrete and valid statement cannot be made.

Another interesting trend to identify are the graphs that show the secondary reason for pursuing an advanced STEM degree. Specifically, it is interesting to note that the option for "economic opportunities" was chosen as a secondary reason for pursuing an advanced STEM degree by both domestic and interna-

MOTIVATION IN PURSUING ADVANCED DEGREES IN STEM FIELDS

tional students in similar proportions (approximately 20% of respondents from each group chose this option). Even so, it was not the principal secondary reason for either group. This suggests a break from the popular belief that those who pursue STEM fields typically do it for the economic opportunities that are present in the field. Pay for those in STEM fields is much higher than in any other field and this trend is expected to continue (Carnevale, Rose, & Cheah, 2011). Even so, the survey shows that economic opportunities were deemed to be an advantage in obtaining an advanced degree in STEM, but were not the primary reason individuals pursued the field. This challenges the popular notion that STEM graduates and those in STEM fields simply do it for the economic security or job opportunities that are provided to them by an advanced degree in a STEM field.

Research conducted by the OECD has shown that more international students are pursuing and receiving advanced degrees in STEM fields than domestic students. This leads to the conclusion that currently in the United States of America, there are more international students in the STEM field than domestic students. Such a difference in the number has many implications.

First, there is one of diversity. It is no question that the more diverse a group, the more innovative and successful the group is. Places that advocate for collaboration among individuals from various parts of the world (such as the European Organization for Nuclear Research, or CERN, and the Fermi National Accelerator Laboratory, or Fermilab) are often at the forefront of the research done in the STEM field. Such collaboration allows for professionals and individuals to create large projects that have meaningful impacts on society. It is much more likely that such a discovery or massive finding will be achieved through collaboration among individuals rather than work done by a single person. For example, the recent detection of gravitational waves was a massive collaborative effort among groups from all around the world, as evidenced by the fact that the list of credited authors and collaborators in the paper that was published on the topic spanned more than five pages (Abbott, 2016).

Another implication of the difference in number between domestic students and international students is related to an option presented in the survey and one that previous researchers have found to be instrumen-

tal in getting students interested in STEM: the influence of STEM classes. Almost all respondents except one said that they had taken a STEM-related class in high school. STEM education in the United States lags behind many countries, as measured by the low scores in science and mathematics by the United Scores on tests such as the Programme for International Student Assessment, or PISA (Kelly, Nord, Jenkins, Chan, & Kastberg, 2013). This lag in providing quality, current, and interesting STEM education to students could be a potential reason why domestic student do not dominate these fields. Because these classes in the United States are not taught in a manner that allows students to engage with the material, students do not become interested in the field. For many students, interesting classes are a precursor to having a genuine interest in the field. Within this criterion, the results of the survey might have been skewed as participants might have become interested in their respective field through engaging classes.

While distributing the surveys, there was an unforeseeable limitation. Some of the individuals that were emailed were concerned with the fact that the link to the survey was fake or would have led to viruses. This concern was discovered when some recipients of the email contacted the faculty advisor of this project asking if the research project was real and serious. Many others might not have taken the time to inquire and simply disregarded the email. The low number of survey results is perhaps a reflection of the hesitation from those who received the emails because they were worried that it was a scam. In order to combat any such questioning of validity, further correspondence stressed the fact that the project had been approved by an Institutional Review Board before being conducted. Additionally, the use of an intermediary, while necessary to establish credibility, might have led to the low amount of survey responses.

While this research project answered a few questions about why domestic and international students choose to pursue an advanced degree in a STEM field, it led to more questions that were not within the scope of this particular research project. For example, it is clear that the survey (found in the Appendix) did not ask any demographic questions such as the participant's gender, race, ethnicity, or age. As the focus of the research project was not on gender, race, ethnicity, or age, these questions were not included in the survey.

MOTIVATION IN PURSUING ADVANCED DEGREES IN STEM FIELDS

Including those questions would have been unnecessary because the research question did not attempt to link such variables with an individual's motivation in pursuing STEM; it only attempted to link where they studied for high school with their reason for pursuing STEM. However, an interesting research study could be conducted to assess if the age of participants had an effect on their reason for pursuing an advanced STEM degree. The answers could also vary depending on the race or gender of the individual. Gender would be an interesting demographic to study along with this phenomenon because there is a large push to increase the number of women in STEM, as it is still a male-dominated field. Therefore, it would be interesting to see if there are any differences in motivation based on gender among domestic and international students.

cause of the need for technical skills in this increasingly modern world. The number of international students in the United States is currently helping fill that demand but there is likely to be a push for more domestic students to enter the STEM field. There is also likely to be a shift in the reasons students pursue STEM fields because of the push to engage students in STEM fields earlier in their academic careers.

Conclusion and Future Directions

This study attempted to answer “why” to a phenomenon that has been present for quite some time. In doing so, it was concluded that statistically, there was no difference why a domestic student and why an international student pursued an advanced degree in a STEM field. While that is the case, interesting conclusions can still be drawn from observed trends. Both groups pursued advanced degrees in STEM primarily because of an interest in the field and economic considerations were secondary to both groups. The results found through this research helps lead to a greater understanding of the current trend in higher secondary education in STEM fields. These findings are a step in fully understanding why there are a disproportionate number of international students receiving advanced degrees in STEM fields.

Future researchers might attempt to explore if gender played any significant role in the reason student pursued an advanced degree in a STEM field by conducting a similar study to see if there is a relationship between gender and the reason an individual pursues an advanced degree in STEM. Other demographic indicators and their correlation to the primary reason individuals want to pursue an advanced degree in a STEM field might also be of interest.

The number of people pursuing STEM fields is projected to grow in the coming decades. The current demand for STEM professionals has been rising be-

References

- Abbott, B. P. (2016). Observation of gravitational waves from a binary black hole merger. *Physical Review Letters*, 116(6), 1. doi:10.1103/PhysRevLett.116.061102
- Cataldi, E. F., Siegel, P., Shepherd, B., & Cooney, J. (2014). Baccalaureate and beyond: A first look at the employment experiences and lives of college graduates, 4 years on (B&B:08/12) (NCES 2014-141). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC. Retrieved from <http://nces.ed.gov/pubsearch>
- Carnevale, A. P., Rose, S. J., & Cheah, B. (2011). *The college payoff: Education, occupations, lifetime earnings*. Washington, DC: McCourt School of Public Policy. Retrieved December 7, 2016, from <https://www2.ed.gov/policy/highered/reg/hearulemaking/2011/collegepayoff.pdf>.
- Chachashvili-Bolotin, S., Milner-Bolotin, M., & Lissitsa, S. (2016). Examination of factors predicting secondary students' interest in tertiary STEM education. *International Journal Of Science Education*, 38(3), 366-390. doi:10.1080/09500693.2016.1143137
- Corley, E. A., & Sabharwal, M. (2007). Foreign-Born Academic Scientists and Engineers: Producing more and getting less than their U.S.-born peers? *Research In Higher Education*, 48(8), 909-940. doi: 10.1007/s11162-007-9055-6 OECD. (2006). Evolution of student interest in science and technology studies. *Organisation for Economic Cooperation and Development*, 1-8.
- Han, S. (2016). Staying in STEM or changing course: Do natives and immigrants pursue the path of least resistance?. *Social Science Research*, 58165. doi:10.1016/j.ssresearch.2015.12.003
- Howard, C. (2016). Top colleges ranking 2016: The full methodology. Retrieved January 25, 2017, from <http://www.forbes.com/sites/carolinehoward/2016/07/06/top-colleges-ranking-2016-the-full-methodology/#416be03d59a8>
- Jiang, X. (2010). Chinese engineering students' cross-cultural adaptation in graduate school. *ProQuest LLC*. Retrieved from ProQuest Digital Dissertations.
- Kelly, D., Nord, C. W., Jenkins, F., Chan, J. Y., & Kastberg, D. (2013). Performance of US 15-year-old students in mathematics, science, and reading literacy in an international context. first look at PISA 2012. NCES 2014-024. *National Bureau of Economic Research*.
- Koc, E. W., Koncz, A. J., Tsang, K. C., & Longerberger, A. (2016). *Winter 2016 salary survey PA*: National Association of Colleges and Employers. Retrieved December 7, 2016, from <http://www.naceweb.org/uploadedfiles/content/static-assets/downloads/executive-summary/2016-january-salary-survey-executive-summary.pdf>
- Lichtenberger, E., & George-Jackson, C. (2013). Predicting high school students' interest in majoring in a stem field: Insight into high school students' postsecondary plans. *Journal of Career And Technical Education*, 28(1), 19-38.
- Maltese, A. V., Melki, C. S., & Wiebke, H. L. (2014). The nature of experiences responsible for the generation and maintenance of interest in STEM. *Science Education*, 98(6), 937-962.
- Markowitz, D. G. (2004). Evaluation of the long-term impact of a university high school summer science program on students' interest and perceived abilities in science. *Journal of Science Education and Technology*, 13(3), 395-407.
- National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: The National Academies Press. doi:<https://doi.org/10.17226/11463>.
- Quagliata, A. B. (2015). University festival promotes STEM education. *Journal of STEM Education: Innovations and Research*, 16(3), 20-23.
- Richmond, G. & Kurth, L. (1999). Moving from outside to inside: High school students' use of apprenticeships as vehicles for entering the culture and practice of science. *Journal of Research in Science Teaching* 36: 677-697.
- Takei, I., & Sakamoto, A. (2011). Poverty among Asian Americans in the 21st century. *Sociological Perspectives*, 54(2), 251-276.
- VanMeter-Adams, A., Frankenfeld, C. L., Bases, J., Espina, V., & Liotta, L. A. (2014). Students who demonstrate strong talent and interest in STEM are initially attracted to STEM through extracurricular experiences. *CBE - Life Sciences Education*, 13(4), 687-697.
- Xue, Y., & Larson, R. C. (2015). STEM crisis or STEM surplus? Yes and yes. *Monthly Labor Review*, 1-15. doi:10.21916/mlr.2015.14

Copy Number Variation in Salivary Amylase: A Participant-Based Study on Genetic Variation

Elizabeth Phillips

Amylase (AMY1) is an enzyme found in the mouth that is used to help digest carbohydrates. It has been found that the copy number of AMY1 has been positively associated with protein levels within an individual and also that individual's population. This information can correspond to the positive ancestral linkage of high starch consumption within agricultural and hunter-gatherer societies. A high starch consumption means that the AMY1 enzyme will be more prevalent within their bodies, and the presence of AMY1 could both help bodies process starches better and prevent future conditions or intestinal diseases. The amylase gene is conclusively connected to the AMY1 copy number production. I hypothesized that individuals within a population will have a similar copy number of the AMY1 gene to each other. Twenty-five high school students located in Norman, Oklahoma were asked to retrieve buccal swabs from the inside of their cheek. DNA then was abstracted from these samples, and a quantitative polymerase chain reaction (qPCR), a machine used to detect the amount of genetic material found in the DNA, was completed in order to determine the copy number within each salivary sample. The qPCR was completed two different times in order to ensure correct results when the data was presented. Results indicated that the copy number within the population were similar to each other, and ranged from 1-12. This means that individuals located in this population have a lower production of amylase, and this provides indication that they are more likely to become obese than in previous research papers located in Arizona. Research shows that a smaller production of AMY1 may contribute to the chances of obesity in the future.

Keywords: AMY1, obesity, copy number variation

Introduction

Salivary a-amylase is an enzyme found in the mouth that processes and breaks down carbohydrates. A-amylase is coded and produced by the AMY1 gene presented on the 1p21 chromosome in a DNA sequence.¹ The AMY1 gene has one of the highest copy number variations in a human DNA sequence, ranging from 1 to 18 diploids.² Copy number is defined as the number of times the section of a gene is repeated in a DNA sequence. Studies have shown a positive correlation between copy number of the AMY1 gene

and the production of salivary a-amylase.³ As copy number of the AMY1 gene increases, this means that more salivary a-amylase is produced. The same thing occurs to low copy number variation in retrospect to amylase. Understanding how amylase is produced and found in society could help the human population by having a positive comprehensive effect in which it changes the body and its functions. It is important to understand this because low copy number has been associated with a predisposition to obesity.⁴ Identifying key aspects in copy number variation within salivary amylase such as evolution, geographical location,

1. Yang, Ze-Min, Jing Lin, Long-Hui Chen, Min Zhang, Wei-Wen Chen, and Xiao-Rong Yang. 2015. "The roles of AMY1 copies and protein expression in human salivary α -amylase activity." *Physiology & Behavior* 138, 173-178. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

2. Ibid. 1-2.

3. Perry, George H., Nathaniel J. Dominy, Katrina G. Claw, Arthur S. Lee, Heike Fiegler, Richard Redon, and Anne C. Stone, et al. 2007. "Diet and the evolution of human amylase gene copy number variation." *Nature Genetics* 39, no. 10: 1256-1260. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

COPY NUMBER VARIATION IN SALIVARY AMYLASE

as well as exercise could help provide reasoning as to what plays an important role in its production.

Amylase Copy Number V. AMY1 Gene

Copy number variation has been directly linked to the production of salivary amylase, as well as the AMY1 gene. By showing the breakdown of starch viscosity and the amount of AMY1 present in an individual, it is shown that there is a positive correlation between the amount of salivary α -amylase produced in comparison to the AMY1 gene.⁵ In order to find copy number of the AMY1 gene, a quantitative polymerase chain reaction (qPCR) is performed. A qPCR is used to amplify and detect or quantify a targeted DNA molecule, which occurs through DNA replication by a series of temperature changes around 25-35 times. Mentioned previously, if there is a lower copy number of the AMY1 gene, then this means that there will most likely be a lower production of salivary amylase in general. This correlation would apply to the AMY1 gene with a higher production as well, meaning a higher output of salivary α -amylase.⁶

Evolution

During the evolutionary process, how genes become different, copy number can be influenced by “selective pressures”.⁷ Selective pressure includes purifying selection, gene duplication, and positive selection. Purifying selection, or negative selection, is the

removal of alleles from a section of DNA that could be potentially harmful. Gene duplication is when a specific section of DNA is replicated. Positive selection is when new beneficial genetics arise in order to benefit a population as a whole.⁸ These selective pressures provide fundamental information in order to better understand evolution in either populations or individuals.

Copy number variation can occur for multiple reasons; however, one of the more prevalent reasons is evolution. One idea is that cultural evolution is one of the more rapidly moving genetic changes. This has been happening, recently due to new innovations and cultural changes and this makes human genes adapt to their environment.⁹ In the past three decades, there has been an increase in starch production due to a greater consumption of foods such as beer, fruit juices, corn syrup, and manufactured food. The increase in starch consumption has made α -amylase enzymes overcompensate for the change in dietary needs.¹⁰ The production of amylase is not just because of the circumstances that are placed in the environment, stress levels, and circadian rhythm. Amylase has evolved independently over the years, and these populations are found from all over the world.¹¹

There is a considerable amount of starch consumption variation among different human populations. George Perry took a sample size of 50 European-Americans and compared their copy number to high starch consumption populations: the Japanese and the Hadza hunter-gatherers. The higher starch popu-

4. Falchi, Mario, Julia Sarah El-Sayed Moustafa, Petros Takousis, Francesco Pesce, Amélie Bonnefond, Johanna C Andersson-Assarsson, and Jane Skinner, et al. 2014. “Low copy number of the salivary amylase gene predisposes to obesity.” *Nature Genetics* 46, no. 5: 492-497. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

5. Mandel, Abigail L., Catherine Peyrot des Gachons, Kimberly L. Plank, Suzanne Alarcon, and Paul A. S. Breslin. 2010. “Individual Differences in AMY1 Gene Copy Number, Salivary α -Amylase Levels, and the Perception of Oral Starch.” *Plos ONE* 5, no. 10: 1-9. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

6. Ibid. 1256.

7. Feng, Zhang, Gu Wenli, Matthew E. Hurles, and James R. Lupski. 2009. “Copy Number Variation in Human Health, Disease, and Evolution.” *Annual Review Of Genomics & Human Genetics* 10, no. 1: 451-481. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

8. Ibid. 1-2.

9. Richerson, Peter J., Robert Boyd, and Joseph Henrich. 2010. “Gene-culture coevolution in the age of genomics.” *Proceedings Of The National Academy Of Sciences Of The United States Of America* 107, no. S2: 8985-8992. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

10. Van der Maarel, Marc J.E.C., Bart van der Veen, Joost C.M. Uitdehaag, Hans Leemhuis, and L. Dijkhuizen. 2002. “Properties and applications of starch-converting enzymes of the α -amylase family.” *Journal Of Biotechnology* 94, no. 2: 137. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

COPY NUMBER VARIATION IN SALIVARY AMYLASE

lations were compared to the low starch consumers including Biaka and Mbuti who are rainforest hunter-gatherers. Perry's findings suggest that copy number of individuals are more likely comparable in dietary habits than in geographical proximity.¹² Perry suggested that "natural selection may have influenced AMY1 copy number in certain human populations."¹³ This observation could suggest a change in the AMY1 gene between populations, suggesting the gene is either becoming more predominant or becoming eclipsed.

Evolutionary changes have affected the a-amylase production among dogs as well. Taking samples from multiple breeds of domesticated dogs and comparing the results to wolves, there was a positive correlation between an increase in amylase production. Domesticated dogs seemed to have an increase in starch-rich diets, and over time the copy number variation changed to compensate for the change in diet.¹⁴ Reiter's findings suggest that this type of dietary intake affects humans as well, not just dogs. Changes in their copy number becoming a positive correlation with starch intake after domestication mean that humans are the reason that amylase production has changed.

Multiple perspectives show how amylase copy number can change because of genetic variation, evolution, and geographical location. Other factors play a key role in the significance of amylase copy number, as well as salivary a-amylase production.

Obesity

There appears to be a link between obesity and salivary amylase levels. It has been found that the AMY1 gene is one of the largest genetic influences on obesity

as a whole.¹⁵ Recent research has found that each copy of the AMY1 gene reduces the risk of obesity by 1.2 fold, which appears to contribute a genetic risk of 11% to the development of obesity.¹⁶ This information suggests that the higher one's amylase production, the less predisposed an individual is to become obese. On the other hand, the lower the amount of amylase a person produces, the higher their predisposition is to becoming obese. Understanding how amylase plays an important role in obesity can help to prohibit the overall effect, making the human population understand why and how it works.

A different study looked at the AMY1 gene and how it corresponded to individuals who were in the normal weight range for their age, and those who were considered obese. By this comparison, it was found that individuals who had a lower copy number were significantly more likely to be obese.¹⁷ This study showed that the difference in the AMY1 gene becomes about an eightfold difference in risk compared to individuals with the most copy number, and those with the least.¹⁸ Amount of AMY1 gene is an important factor in human health, especially when considering the ties that it has to obesity. However, recent studies have suggested that there could be a possible change in the production of salivary a-amylase, combating the risk of obesity.

Amylase is influenced by other factors than the AMY1 gene, "Physical exercise is a strong activator of the sympathetic nervous system".¹⁹ The amount of saliva produced in an individual is obtained through the sympathetic nervous system. Studies have predicted that exercise may be a factor that could help stimulate the production of salivary a-amylase. One study

11. Ibid. 2.

12. Ibid. 1258.

13. Ibid. 1258.

14. Reiter, Taylor, Evelyn Jagoda, and Terence D. Capellini. 2016. "Dietary Variation and Evolution of Gene Copy Number among Dog Breeds." *PLoS ONE* 11, no. 2: 1-19. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

15. Usher, Christina L, Carlos N Pato, Michele T Pato, Mark I McCarthy, David M Altshuler, Robert E Handsaker, and Andres Metspalu, et al. 2015. "Structural forms of the human amylase locus and their relationships to SNPs, haplotypes and obesity." *Nature Genetics* 47, no. 8: 921-925. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

16. Ibid. 921.

17. Ibid. 492-493.

18. Ibid. 492.

19. Ligtenberg, Antoon J.M., Henk S. Brand, Petra A.M. van den Keijbus, and Enno C.I. Veerman. 2015. "The effect of physical exercise on salivary secretion of MUC5B, amylase and lysozyme." *Archives Of Oral Biology* 60, no. 11: 1639-1644. Academic Search Elite, EBSCO-

investigated this hypothesis: eight well-trained males were asked to perform a 60-minute cycle exercise. Afterward, saliva was retrieved from each participant in order to test for amylase. Findings showed that exercise did not change the saliva concentration but did increase the salivary amylase production by five-fold.²⁰ This finding is supported by previous work.²¹

Previous Research

Previous research has been conducted on adults in order to determine the amount of salivary a-amylase produced. However, a more diverse genetic testing could assist researchers in understanding the gene that is present with amylase. All of the previously stated research has been adults, both male and female, from a variety of races. Animal testing also has proved to be beneficial in understanding the interaction of the AMY1 gene with amylase. Studies done on bonobos, also known as apes, has shown that sex identification plays a role in the production of salivary amylase.²² While this study does not specify how this could relate to human interaction, like the previously mentioned studies done on humans, it can provide more in-depth information on how salivary amylase performs.

When discussing genetic research findings, genotypic differences among races is often a confounding issue. While this could be beneficial, it is also important to take into consideration the background information of each individual. Researchers have looked at salivary samples from individuals with a similar starch consumption, and have found that this is more reliable than race.²³ It is important to analyze more than ethnicity when considering copy number variation, due to outside factors that could counteract an accurate representation of the population as a whole. With this being said, the defined European-American samples found in Perry's paper were only located in

Arizona and were most likely only adults. There is a lack of diversity within the sample size when considering the youth, and also different European-Americans found in different parts of the country. For this research purpose, high school students, specifically located in Norman, Oklahoma will be included as participants. Looking at this information could provide more in-depth analysis of starch consumption in different geographical locations and how that affects the production of salivary a-amylase.

Identifying age and comparing geographical location in comparison to George Perry's paper could help to further understand the presence of the AMY1 gene. Interpreting data collection in the production of amylase of high school students in comparison to adults in Arizona could either support or disprove Perry's hypothesis, that dietary needs play a more important role than geographical proximity. Further understanding of the AMY1 gene could help researchers develop more perspectives towards the genetic predisposition of obesity.

Methods

An ex post facto research design on genetic variation within salivary amylase was approved by the Internal Review Board (IRB) at Norman Public Schools (NPS). The current ex post facto study was conducted between February 2017 to March 2017.

Collection Protocol

To begin collection, safety measures were taken in order to ensure samples were taken as per the protocol and patient health identification was protected. Gloves were worn for the duration of the collection process to ensure no cross-contamination occurred, as well as keep the researcher safe. Materials included

host (accessed January 9, 2017).

20. Walsh, N.P., A.K. Blannin, A.M. Clark, L. Cook, P.J. Robson, and M. Gleeson. 1999. "The effects of high-intensity intermittent exercise on saliva IgA, total protein and alpha-amylase." *Journal Of Sports Sciences* 17, no. 2: 129-134. Academic Search Elite, EBSCOhost (accessed January 9, 2017).

21. Ibid. 1639-1640.

22. Behringer, Verena, Claudia Borchers, Tobias Deschner, Erich Möstl, Dieter Selzer, and Gottfried Hohmann. "Measurements of Salivary Alpha Amylase and Salivary Cortisol in Hominoid Primates Reveal Within-Species Consistency and Between-Species Differences." *PLoS ONE* 8, no. 4 (2013). doi:10.1371/journal.pone.0060773.

COPY NUMBER VARIATION IN SALIVARY AMYLASE

a buccal swab, 2mL containers to put the buccal swabs in, and both demographic questionnaire and anonymous consent form.

Students were asked to review the full disclosure letter addressed to them, and they were asked to sign an informed consent form if they were willing to consent to participate. To see disclosure, please refer to Appendix A. Then, if they chose to participate in the study, they were asked to fill out demographic questions. Within the demographic questionnaire, there will be a random number written on it corresponding to their sample number in order to ensure anonymity as well as the correct demographic information. To see demographic questions, please refer to Appendix A as well. An announcement was made to students in a class about the study, and if they wished to participate they came into another room and give us their samples. Students approached me one at a time in order to minimize exposure to other students and to keep track of the samples. They were then asked to swab their cheek for 30 seconds with a sterile Catch-All Sample Collection Swab without it touching their teeth. Samples were then put in a container and a number was written on the swab to correspond with the demographic questions. The privacy of the students were not exposed throughout this process, which was reassured in the consent form. The swabs were then placed in a 2 mL tube, frozen, and transported to a lab located at the University of Oklahoma under the direction of Cecil Lewis. Here, the samples were kept in a fridge to maintain appropriate conditions.

DNA Extraction

In order to minimize risk to the researcher as well as the DNA, an overhead LED light was used, preventing DNA from being exposed to the elements. Different pipette covers were used for each sample to guarantee that there was no DNA corruption. One blank sample was used as an outlier to make sure that there was no DNA corruption throughout this process.

DNA was extracted using the QIAamp DNA mini extraction kit. This kit allows for DNA extraction by using heat lysis as well as chemical lysis. A lysis is a method used to break open a cell membrane and extract DNA. With this, the steps include adding the different chemicals to the DNA and incubating the sample at 56 degrees Celsius. Multiple chemicals were

added, vortexed, and centrifuged (in order to push the solid unwanted material to the bottom and the DNA to the top). This continued four more times, as well as including filtration steps, this allowed proper separation of the DNA from unwanted cellular material. Final DNA extracted samples were placed in a 2mL sample collection container with the identification number written on top. After this, they were placed in a freezer so that way they are kept safe from any unwanted harm.

Quantitative Polymerase Chain Reaction (qPCR)

The DNA was thawed out for approximately 10-15 minutes. Next, a probe kit was utilized to assure that the salivary samples would amplify in the qPCR machine. Samples were then put in a labeled container that would fit into the qPCR machine. One sample was left blank as a control, as well as one sample having a known copy number (*E. coli*). Amplification occurred through multiple heating and cooling processes (about 25-35 times) within a qPCR machine, until the exact concentration of the AMY1 gene was detected. The amplification process within a qPCR lasted roughly 1 to 2 hours. Data was then collected on a computer to show/display the amplification process and the copy number presented within each sample. Information found was then interpreted and put in a spreadsheet and various graphs. At the end of the data collection, samples were destroyed through proper disposal into a biohazard waste container.

Results

Numerical information is presented below for the copy number of the AMY1 genes. This information was gathered and put together within an Excel spreadsheet. The graphs will be shown through the format of copy number being presented on the x-axis, and proportion of individuals with that copy number being shown on the y-axis. Each graph will be divided up in relation to race, however this data could also show repetition of people who are more than one race. Graphs will then be compared to those found in the supplement of George Perry's paper regarding a similar topic.

COPY NUMBER VARIATION IN SALIVARY AMYLASE

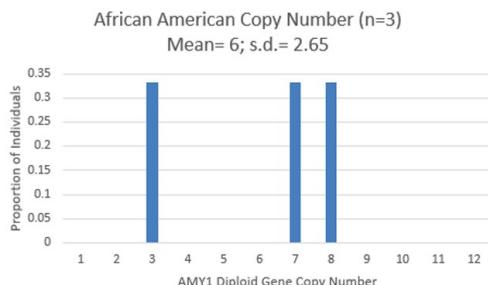


Figure 1

This graph shows the copy number present with high school students who consider themselves African American. It is shown that there was a limited sample in this test group, however the mean copy number is close to that presented in George Perry's paper.

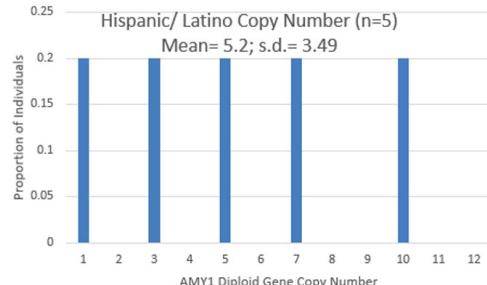


Figure 2

This graph shows the copy number presented with high school students who consider themselves Hispanic or Latino. The sample size while still on the small size is at five, and shows a great variety between the copy number presented within the group as a whole.

Discussion

Race Relation

When considering the data collection there was not a lot of variation within race. Caucasian being the highest group of samples is simple in comparison to George Perry's paper. The mean copy number found within high school Caucasians (European-Americans) was 5.33 (Figure 4), while the copy number found in Perry's paper was 6.80 (Figure 6).

This shows that high school European-Americans located in Oklahoma tend to have a lower copy number than adults in Arizona. While there are limitations considering the smaller sample size, it is still valid to look at the correlation between races as well as the copy number as a whole. With this being said there was a computed p-value of 2.26×10^{-5} . This shows that since the p-value is smaller than a reasonable cut off, it is concluded that they are different i.e. sufficient evidence against the claim that the Arizona and Oklahoma means are equal. The p-value was found using the separate (unpooled) variances for inferences in two-population means. Even with a small sample size through the p-value it is shown that there is a difference between copy numbers in Arizona, and

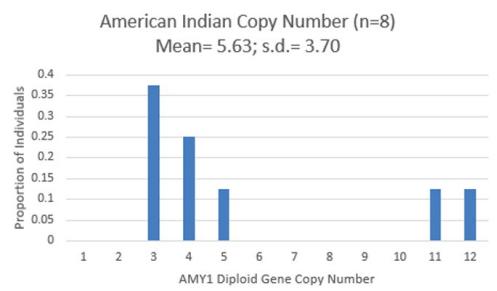


Figure 3

This graph shows the copy number presented with high school students who consider themselves American Indian. This group of data has copy numbers which are closer together and more correlated. The two most common copy numbers were three and four, showing the similarity between copy number within this group.

Oklahoma. Looking at Perry's values shows that the closest mean copy number within race is the African American subgroup. The copy number for this group was 6, which means it is the closest to Perry's being 6.80. It would be expected that Caucasians would have the closest copy number to the European-American group found in Perry's paper; however, this was not the case. While the African American group had a very small sample size it still shows an accurate representation when comparing race in genetic studies

COPY NUMBER VARIATION IN SALIVARY AMYLASE

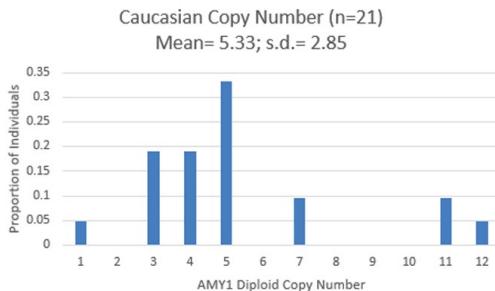


Figure 4

This graph shows the copy number presented with high school students who consider themselves Caucasian. The data group presented shows a wide variety of individuals tested with 21 test subjects. Overall there is a widespread of copy numbers, however there seems to be a closely correlated amount between three and five.

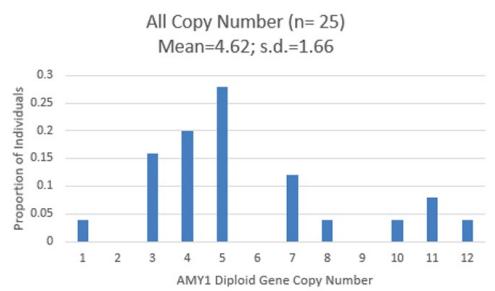


Figure 5

This graph represents all of the high school test subjects who were tested. Overall it is the best representation of data considering that it has the highest amount of individuals, as well as having the most accurate amount of correlation for each section of individuals. In comparison it shows the most accurate representation for copy number presented in high school students.

Overall the sample size was cut in half compared to the paper done by George Perry, especially when looking at race individually. Looking at the copy number of high school students as a whole shows a better representation of the copy number variation presented in Norman.

like this one. There is no correlation between race and copy number considering that Caucasian would have the closest copy numbers in relation to Perry's European-Americans, this was however not true. Considering this it would be most beneficial to look at high school students as a whole in comparison to the copy number found in Perry's paper. Given the numerical values it is realistic to believe that copy number is found in relation to geographic location, specifically when considering dietary intake of individuals.

Copy Number Variation

Relating the information gathered from the experiment to previous studies is important when considering the future implications of these findings. When looking at Figure 5 and Figure 6 together it is shown how copy number variations range from either 1-12, or 1-15. Considering this information and the graphic information when looking at the proportion of individuals, it is shown that copy number variation has a wide range, and is very widespread within the samples provided. While the mean in Figure 5 is 4.62 copies, and the one in Figure 6 is 6.80 copies, there is much diver-

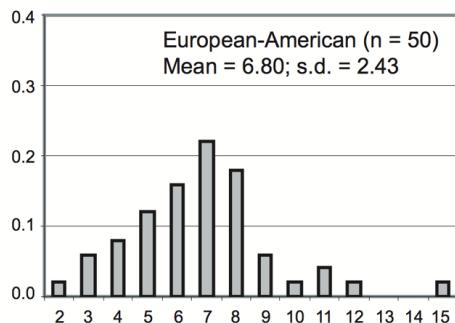


Figure 6

This graph represents the copy number variation found in European Americans done by George Perry. Individuals in this paper ranged from age, and were located in Arizona. The mean copy number appears to be higher than the copy number found in Norman, Oklahoma.²⁴

23. Ibid. 1256-1257.

24. Perry, George. "Supplementary information for: GH Perry, NJ Dominy, KG Claw, AS Lee, H Fiegler, R Redon, J Werner, FA Villanea, JL Mountain, R Misra, NP Carter, C Lee, and AC Stone Diet and the evolution of human amylase gene copy number variation." *Nature*

COPY NUMBER VARIATION IN SALIVARY AMYLASE

sity in the population who maintain the copy number variation itself. A random sample of the copy numbers within Perry's paper is presented within Table 1 and shows how there is a variation within copy number, however, the majority of copy numbers are between 6-8. This means that there is no definite copy number that will fit as a generic number for the population that it is in. Considering this information the results found from the high school students in Oklahoma are accurate, despite their wide range in variation.

Looking at each figure individually, it is shown that race is not a significant variable, and all Norman High students in Oklahoma seem to have a lower copy number. Perry's adult samples from Arizona tend to

have a higher copy number of about two each time. This information could provide a possible correlation between starch consumption being a factor in the lower copy number being presented in Oklahoma. Oklahoma could tend to consume less starch in the past than in Arizona, with this genetically speaking their copy number would not have had a chance to become higher.

Obesity Risk

Oklahoma as a whole tends to have a lower copy number than Arizona. As this is shown there has been a positive correlation between low copy number and

Supplementary Table 1. qPCR, protein quantification, and aCGH data for high- and low-starch population samples.

Population	Sample	Starch level (high/low)	Diploid <i>AMY1</i> copies (qPCR)	Standard Deviation	Diploid <i>AMY1</i> copies (integer)	<i>AMY1</i> protein mg/mL	Chr1tp-6D2 log2 ratio	Chr1tp-30C7 log2 ratio
European-American	EUR001	High	7.30	0.50	7	2.83		
European-American	EUR002	High	4.26	0.49	4	1.65		
European-American	EUR003	High	7.10	0.93	7	3.85		
European-American	EUR004	High	4.91	0.21	5	1.09		
European-American	EUR005	High	8.15	0.78	8	1.63		
European-American	EUR006	High	11.73	0.55	12	5.17		
European-American	EUR007	High	6.50	0.38	6	3.24		
European-American	EUR008	High	8.44	0.70	8	2.80		
European-American	EUR009	High	5.73	0.39	6	3.30		
European-American	EUR010	High	8.36	0.93	8	4.28		
European-American	EUR011	High	7.63	0.45	8	2.91		
European-American	EUR012	High	6.89	0.51	7	2.89		
European-American	EUR013	High	11.20	0.80	11	3.76		
European-American	EUR014	High	6.18	0.31	6	2.65		
European-American	EUR015	High	7.94	1.12	8	1.70		
European-American	EUR016	High	5.56	0.76	6	3.20		
European-American	EUR017	High	8.53	0.75	9	2.96		
European-American	EUR018	High	9.67	0.56	10	4.87		
European-American	EUR019	High	7.46	1.00	7	4.00		
European-American	EUR020	High	3.41	0.56	3	0.93		
European-American	EUR021	High	2.21	0.50	2	0.22		
European-American	EUR022	High	5.27	0.54	5	1.65		
European-American	EUR023	High	9.14	0.64	9	2.72		
European-American	EUR024	High	7.64	0.22	8	2.46		
European-American	EUR025	High	5.87	0.36	6	1.35		

Table 11

This table shows random samples taken from Perry's paper, which show a closer look at the genetic variation presented within each individual. The table allows for an expanded look into each person's individual copy number. Overall the sample size was cut in half compared to the paper done by George Perry, especially when looking at race individually. Looking at the copy number of high school students as a whole shows a better representation of the copy number variation presented in Norman.

Genetics. September 9, 2007. Accessed September 18, 2016. <http://www.nature.com/ng/journal/v39/n10/extref/ng2123-S1.pdf>.

25. *Ibid.* 7.

26. "Oklahoma." Oklahoma State Obesity Data, Rates and Trends: The State of Obesity. Accessed March 11, 2017. <http://stateofobesity.org/states/ok/>.

27. "Arizona." Arizona State Obesity Data, Rates and Trends: The State of Obesity. Accessed March 11, 2017. <http://stateofobesity.org/states/az/>.

a higher chance at obesity. Individuals with a lower copy number will not be able to process starches as well as those with a higher copy number, this is why they have a higher chance at obesity. Through this information it is accurate to assess that high school students in Oklahoma, as most likely the population as whole, will tend to have a higher chance of obesity. This assertion is back up by the statistics showing that Oklahoma has an obesity rate of 33.9% among adults.²⁴ In comparison the obesity rate of adults in Arizona is 28.4%.²⁵ Considering that Arizona has a higher copy number it is reasonable to see the correlation between Oklahoma having a higher chance of obesity than in Arizona. However, this information does not mean that people will necessarily become obese in Oklahoma, it means that they have a higher risk than people located in Arizona.

Limitations and Future Research

Limitations within this study mainly included sample size. The sample size taken was of 25 high school students in Oklahoma. With this it was not possible to have more than 25 samples given the amount of time available. However, there was not a wide range of diversity within different races, while this was not a big factor in the research proposal, it would have been beneficial to have a bigger group of different races, as well as a wider age group in order to have a more concrete view of Oklahomans as a whole. In comparison to Perry's sample size of 50, the sample size of 25 within this research presented a good beginning representation within Oklahoma.

Future research within this subject could be presented within multiple options. Asking demographic questions such as weight and height and doing a Body Mass Index (BMI), would help to provide a more concrete insight on the findings that this study showed. Looking at Oklahoma as a whole instead of taking a subsection of it in Oklahoma would be interesting. This would provide a wider scope to see if widespread copy number variation was different in the state of Oklahoma as a whole. As this is considered looking at adults in Oklahoma not only high school students could help to provide a deeper understanding of copy number. Any of these possible

scenarios could provide a deeper insight on copy number as a whole.

Conclusion

In conclusion, it is shown that the AMY1 copy number is in correlation between the production of salivary amylase. This is shown through multiple studies done by other researchers as well as within this study. Looking at previous studies done by George Perry, and taking similar samples within subgroups, I was able to compare the copy number of individuals. There seemed to be no correlation between race related groups, possibly because of the small sample size, but rather that each copy number appeared to be closely associated with starch ingestion within past generations. Through this information it was shown that high school students in Norman, Oklahoma tend to have a lower mean copy number than adults in Arizona. This is shown in correlation of the mean value, as well as the p-value being 2.26×10^{-5} , showing that Oklahoma and Arizona have a difference in copy number. With this, Oklahomans may have a greater chance at becoming obese than individuals in Arizona. Information like this can help to combat obesity by providing the public with a deeper insight on the need for them to protect their bodies with healthy food and exercise. As shown earlier in this paper exercise increases the production of salivary amylase. Understanding bodily functions like this could provide researchers with a deeper insight on the way in which bodies work, and the best way to protect them.

References

- "Arizona." Arizona State Obesity Data, Rates and Trends: The State of Obesity. Accessed March 11, 2017. <http://stateofobesity.org/states/az/>.
- Behringer, Verena, Claudia Borchers, Tobias Deschner, Erich Möstl, Dieter Selzer, and Gottfried Hohmann. "Measurements of Salivary Alpha Amylase and Salivary Cortisol in Hominoid Primates Reveal Within-Species Consistency and Between-Species Differences." *PLoS ONE* 8, no. 4 (2013). doi:10.1371/journal.pone.0060773.
- Falchi, Mario, Julia Sarah El-Sayed Moustafa, Petros

COPY NUMBER VARIATION IN SALIVARY AMYLASE

- Takousis, Francesco Pesce, Amélie Bonnefond, Johanna C Andersson-Assarsson, and Jane Skinner, et al. 2014. "Low copy number of the salivary amylase gene predisposes to obesity." *Nature Genetics* 46, no. 5: 492-497. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).
- Feng, Zhang, Gu Wenli, Matthew E. Hurles, and James R. Lupski. 2009. "Copy Number Variation in Human Health, Disease, and Evolution." *Annual Review Of Genomics & Human Genetics* 10, no. 1: 451-481. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).
- Ligtenberg, Antoon J.M., Henk S. Brand, Petra A.M. van den Keijbus, and Enno C.I. Veerman. 2015. "The effect of physical exercise on salivary secretion of MUC5B, amylase and lysozyme." *Archives Of Oral Biology* 60, no. 11: 1639-1644. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).
- Mandel, Abigail L., Catherine Peyrot des Gachons, Kimberly L. Plank, Suzanne Alarcon, and Paul A. S. Breslin. 2010. "Individual Differences in AMY1 Gene Copy Number, Salivary α -Amylase Levels, and the Perception of Oral Starch." *Plos ONE* 5, no. 10: 1-9. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).
- "Oklahoma." Oklahoma State Obesity Data, Rates and Trends: The State of Obesity. Accessed March 11, 2017. <http://stateofobesity.org/states/ok/>.
- Perry, George H., Nathaniel J. Dominy, Katrina G. Claw, Arthur S. Lee, Heike Fiegler, Richard Redon, and Anne C. Stone, et al. 2007. "Diet and the evolution of human amylase gene copy number variation." *Nature Genetics* 39, no. 10: 1256-1260. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).
- Perry, George. "Supplementary information for: GH Perry, NJ Dominy, KG Claw, AS Lee, H Fiegler, R Redon, J Werner, FA Villanea, JL Mountain, R Misra, NP Carter, C Lee, and AC Stone Diet and the evolution of human amylase gene copy number variation." *Nature Genetics*. September 9, 2007. Accessed September 18, 2016. <http://www.nature.com/ng/journal/v39/n10/extref/ng2123-S1.pdf>.
- Reiter, Taylor, Evelyn Jagoda, and Terence D. Capellini. 2016. "Dietary Variation and Evolution of Gene Copy Number among Dog Breeds." *PloS ONE* 11, no. 2: 1-19. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).
- Richerson, Peter J., Robert Boyd, and Joseph Henrich. 2010. "Gene-culture coevolution in the age of genomics." *Proceedings Of The National Academy Of Sciences Of The United States Of America* 107, no. S2: 8985-8992.
- Academic Search Elite, EBSCOhost (accessed January 9, 2017).
- Usher, Christina L, Carlos N Pato, Michele T Pato, Mark I McCarthy, David M Altshuler, Robert E Handsaker, and Andres Metspalu, et al. 2015. "Structural forms of the human amylase locus and their relationships to SNPs, haplotypes and obesity." *Nature Genetics* 47, no. 8: 921-925. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).
- Van der Maarel, Marc J.E.C., Bart van der Veen, Joost C.M. Uitdehaag, Hans Leemhuis, and L. Dijkhuizen. 2002. "Properties and applications of starch-converting enzymes of the α -amylase family." *Journal Of Biotechnology* 94, no. 2: 137. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).
- Walsh, N.P., A.K. Blannin, A.M. Clark, L. Cook, P.J. Robson, and M. Gleeson. 1999. "The effects of high-intensity intermittent exercise on saliva IgA, total protein and alpha-amylase." *Journal Of Sports Sciences* 17, no. 2: 129-134. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).
- Yang, Ze-Min, Jing Lin, Long-Hui Chen, Min Zhang, Wei-Wen Chen, and Xiao-Rong Yang. 2015. "The roles of AMY1 copies and protein expression in human salivary α -amylase activity." *Physiology & Behavior* 138, 173-178. *Academic Search Elite, EBSCOhost* (accessed January 9, 2017).

COPY NUMBER VARIATION IN SALIVARY AMYLASE

Appendix A

The informed consent as shown to participants is shown below as well as the demographic questions:

ANONYMOUS/CONFIDENTIAL RESEARCH

Dear Student:

I am a senior here at Norman High. I am conducting this research for my AP Capstone class, under the advisement of Sarah DeWitt. I am conducting a research study entitled Amylase Copy Number. The purpose of this study is look at amylase copy number of high school students in Norman, Oklahoma. Amylase is a salivary enzyme found in the mouth that processes and breaks down carbohydrates. Copy number is defined as the number of times the section of a gene is repeated in a DNA sequence. This corresponds with the amount of salivary amylase produced. However it would be beneficial to see the amount of amylase produced, given that small amounts have corresponded to obesity in previous studies. The data that I will be retrieving from this study will be compared to that in a previous study done by George Perry. I will compare the copy number found in high school students in Oklahoma to that in Perry's paper, which he looked at in a different part of the United States. This comparison will give me initial data in order to compare my research and data to. Perry's null hypothesis was that individuals of the same race will have similar copy numbers, however it was found that this was not the case. This will help to prove my hypothesis with copy number variation being present because of diet and evolution.

Your participation will involve filling out a paper with your demographic information, as well as providing 2 mL of saliva and should only take about 10 minutes of your time. Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time. The results of the research study may be published, but your name will not be used. Your identity will not be associated with your responses in any published format.

The findings from this project will provide information on amylase copy number, and the presence within different individuals, with no cost to you other than the time it takes for the survey.

If you have any questions about this research project, please feel free to call me, Elizabeth Phillips,

at [REDACTED] or [REDACTED]
[REDACTED]. Questions about your rights as a research participant or concerns about the project should be directed to the Institutional Review Board at Norman Public Schools at [REDACTED]
[REDACTED].

Thanks for your consideration!

Sincerely,
Elizabeth Phillips

Demographic Questions

The information used in this questionnaire will remain anonymous in association with your saliva. Please answer the following questions to your best abilities. You may leave a question blank if you do not feel comfortable answering it.

1. Subject Number : _____
2. Age: _____
3. Gender (Circle): Male Female
4. Ethnicity (Circle): African American Hispanic/
Latino Asian Caucasian American Indian/
Alaskan Native Other: _____
5. How many hours a week do you exercise? (Circle): 0 Hours 1-3 Hours 4-6 Hours More Than
6 Hours
6. How long has your family lived in Oklahoma
(Circle): 1st Generation 2nd Generation 3rd
Generation 4th Generation 5th Generation or
more

Twelve Shades of Green: Contrasting the Environmental Effectiveness of Power Generation Methods in 12 Developed Countries through the Lens of the Electric Vehicle

William Deo

Presently, there is an issue with the perception of power generation mixes across the developed world. It is widely believed that by implementing electric vehicles, we will be able to reduce our carbon emissions into the atmosphere. However, while it is true that transportation and power generation are the two largest emitters of carbon, the electrification of vehicles will simply lead to an increase in our demand for energy produced by fossil fuels. Through a comparative quantitative analysis, this study examines 12 developed and geographically diverse nations in an effort to understand the real virtual tailpipe emissions of an electric vehicle. Through the analysis, it was found that out of the 12 countries, only six would benefit environmentally from widespread electric vehicle implementation presently. Moving forward, this study highlights the importance of non-emitting power sources, emphasizing the benefits of nuclear power generation as a dependable and efficient energy source.

Introduction

The earth is on track to becoming an uninhabitable planet. Between the rise in temperatures, depletion of resources and dependency on faltering systems, we are at a crucial point in our society's development. While there are numerous issues that we must solve on our planet, one of the largest and most widespread issues is that of climate change. Presently, the two largest polluting factors in the realm of carbon emissions come from power generation and transportation (Hawkins et al., 2012). Numerous scientists point to the proliferation of electric vehicles to be our saving grace in this time of pollutants in our atmosphere – and while this does help delocalize these emissions from large urban centers, this does not positively impact our environment unless the power being generated to drive the vehicle is cleaner than that of simply driving a normal car.

This research paper aims to examine the environmental effectiveness of the power generation methods and mixes in place in 12 developed countries in

an effort to see what is the ultimately the best mix of resources to generate the cleanest power at a responsible cost. This paper examines this through the implementation of a comparative quantitative analysis method that works to take into account broad ranges of power generation methods as well as compare to a traditional automobile.

Review of the Literature

Electric vehicles have potential to reduce carbon emissions, local air pollution and the reliance on imported oil (Wilson, 2013). It is with little wonder that governments around the world have supported their roll-out in recent years with carbon-saving subsidies and other benefits to owners (Nikiforuk, 2015). Although there is a widespread understanding that electric cars have the potential to release our carbon emissions, their effectiveness depends on the type electricity that they use (Hawkins et al., 2012). Knowing that over 70% of our energy today is still tied to fossil fuels (García-Gusano et al., 2016), the carbon

reduction potential (the potential of emission reduction) of an electric car depends substantially on where it is used. However, presently it is not known the specific benefit or advantage of driving an electric car in a country is still partially, or fully, dependent on fossil fuels. This is what my research will demonstrate.

My research details an important gap in the field: how does the environmental effectiveness of vehicles vary across developed nations around the world. Environmental effectiveness must take into account manufacturing emissions, grid source emissions and grid loss emissions. All of which vary other than manufacturing emissions. This is valuable to evaluate which power generation mixes are most efficient for specific countries in different geographic areas for implementing electric vehicles to lower our carbon footprint. Presently, no piece of research has done this. Through adopting efficient generation methods that will be recommended through my research, we might be able to move too the most efficient electric vehicle future possible.

A survey of existing literature was conducted, and the intelligence garnered was grouped into three sections: the carbon emissions of electric cars, a comparison of electric and petrol cars and their respective sensitivity to energy use.

Carbon Emissions of Electric Cars

Lindly and Haskew (2002) reported on the impact of electric vehicles on global environmental change was one of the first studies in the field. A University of Alabama research report showed how, in regions of the world such as the mid-western United States, there would only be a decrease of 5-7% in carbon emissions though a shift to electric vehicles. The study concurred that it would ultimately be impractical to initiate such a shift to electric vehicles for such a small reduction. In 2015, Nikiforuk (2015) demonstrated that this was still the case, measuring the effectiveness of these vehicles to only be about 8.5-10% better than traditional gas-powered vehicles in the mid-west demonstrating that little has changed in the region towards clean power. This allows me to sufficiently demonstrate that there are regions of the world that are yet to adopt renewable methods of power generation and yet, there is still a benefit over traditional vehicles.

However, in other regions of the world, such as Norway, the benefit of implementing electric vehicles was up to 45% better than driving a traditional vehicle (García-Gusano et al., 2016). This was largely due to an environment that has become nearly free of fossil fuels leading to the cleaner production of energy (Wilson, 2013). Wilson (2013) also mentions the importance of different magnitudes of lost power occurring from different generation methods. In countries such as Paraguay, 100% of power is generated from hydroelectric sources (Shift Project, 2014) which has essentially zero margin of loss (Hawkins et al., 2012). Through analyzing these findings, I am able not only to connect the fact that there are different generation mixes that are more efficient, but also that there are regions of the world that have adopted essentially 100% *clean electric vehicles*.

However, this changes when examining a country like India. According to the 2014 Shift Project, in India, over 80% of energy is generated from coal and natural gas. Not only does this mean that there is a dramatic increase in the carbon emitted from the generation, but there is also a higher margin of loss (Hawkins et al., 2012). Thus, not only is there an increase in carbon emissions, but also an increase in electricity demand for the same amount of energy which results in an increased negative result. Xiao-Ling (2016) gave a similar result that shows that due to the dominance of coal generation in countries like India, South Africa, Australia, and China, grid powered electric cars actually produce comparable emissions to those of normal petrol vehicles with emissions ranging from 258-370 g of carbon per kilometer driven.

Further, S. Dotson, a professor of environmental engineering at the University of Waterloo, suggests in his report that progress is being made as countries like Canada and Brazil are adopting hydroelectricity along with countries like France adopting nuclear energy, all of which result in a range of 89-115 g of carbon per kilometer driven. However, Nikiforuk, while surveying research done by McGill University, reminds us that this is only the case in Western and industrialized countries as the vast majority of the world's energy is still generated from fossil fuels (Nikiforuk, 2015). As such, in an effort to move towards clean transportation, we must move away from traditionally methods used towards newer, more renewable technologies.

Electric Vehicles compared to Petrol Cars

When comparing petrol cars to electric vehicles to evaluate the climate benefits of electric vehicles, there are many factors to examine (Wilson, 2013). Lindly and Haskew (2002) estimated that the manufacturing emissions of a traditional vehicle are 40g of carbon per kilometer over a traditional lifespan. However, when contrasting this with the 70g from the electric vehicle generated by Notter et al. (2010), Patterson (2011), as well as Hawkins et al. (2012), this is significantly higher. This dramatic discrepancy in manufacturing emissions is due to the electric vehicle manufacturing footprint of 10.5 tons of carbon (Wilson, 2013). Notter et al. (2010) further investigated this, acknowledging that up to four tons of this carbon can be attributed to battery manufacture something that petrol vehicles do not require.

Through Wilson (2013), we are also able to see in terms of environmental effects, vehicles powered solely by hydroelectricity achieve an equivalent to one liter of petrol consumed over 100 kilometers driven nearly entirely attributed to manufacturing effects. However, countries using hydroelectricity and nuclear mixes are not far behind with equivalencies of 2.5 liters per 100 kilometers an efficiency better than the most efficient hybrid gas-electric vehicles available at market (Dotson, 2011). However, when countries like India and China are considered, their equivalencies are similar to new petrol power vehicles (Xiao-Ling et al., 2016). For instance, equivalencies range from 9-12 liters per 100 kilometers driven based on regional generation methods (Xiao-Ling et al., 2016). This is especially important to note as in my research, I attempt to provide a tangible figure that the general populous will easily understand.

However, one thing that these equivalency estimates do not account for are the relocation of pollutants to centralized locations (Lave, Hendrickson & McMichael, 1995). For instance, large cities often suffer from localized pollutants arising from vehicles (García-Gusamo et al., 2016). Lave, Hendrickson and McMichael (1995) suggest that as long as the equivalencies of these vehicles are equivalent or less than traditional vehicles, there is a positive environmental impact for large cities as pollutants are moved to power generation plants, often far from heavily populated areas. Therefore, resulting in a positive immedi-

ate environmental effect for the large cities. This is an immediate net positive effect for urban centers (where pollution is most wide-spread) and is an innate benefit for electric vehicles. However, this is difficult to implement into my research and as such, will be assumed as a pre-existing benefit.

Sensitivity to Energy Use

There is also discrepancy when it comes to the *wall-to-wheels* electricity use of a vehicle. For example, Wilson (2013) utilized a figure of 211 Wh/km (Watt-hours per kilometer) driven which is a mid-ranged figure similar to that of a Nissan Leaf (Wilson, 2013). However, other reports such as Dotson (2011) utilized a much lower energy use figure of 174 Wh/km which is similar to a small sized electric vehicle like the Scion iQ (Dotson, 2011). However, Hawkin (2012) demonstrated that for larger electric vehicles like the Toyota Rav4 EV up to 273 Wh/km is required. More recently, Lindly and Haskew (2002) examined the performance enhanced Tesla Model S P85+ which had a 231Wh/km, a very good energy consumption figure for a vehicle of its size. In my own research, this allows me to take into account the average vehicle that is being used in that specific environment. For example, in North America, we see increasingly large vehicles. However, in developing nations, we see the widespread use of much smaller vehicles. This is something that I must consider when factoring environmental efficiency to be regionally specific.

This concurs with Notter et al. (2010): battery technologies are advancing. Batteries are becoming more energetic in lighter packages. This combines for a net effect of a lower Wh/km required, proving that the future of environmental vehicles is becoming even more power efficient. This allows for an optimistic future and proves that more research is needed in the field. Since battery technologies are evolving nearly every year, research on effectiveness of electric vehicles must be constantly conducted to account for new advancements.

Overall, through a thorough survey of the literature it can be concluded that there is significant evidence that the environmental effectiveness of electric vehicles varies due to power generation methods. However, the gap that is missing in the body of knowledge, is exactly what is the difference and the specific advan-

tage to adopting renewable and zero-carbon power technologies. This is what my research attempts to discover: the specific quantifiable environmental advantages that the electric vehicle possesses as power generation mixes change.

Method

To achieve a richer understanding of the environmental effectiveness of electric vehicles a comparative quantitative analysis is employed. This method collects publicly available data in the effort to demonstrate a numerical contrast between multiple items or options. In this paper, this method is used to compare the different generation methods and mixes of methods to translate into a standard Litres / 100 Km driven figure. This is based on carbon emissions from power generation. Through comparing a relatively abstract figure of carbon emissions to the more common polluting factor of Litres / 100 Km, there will be a more tangible connection between pollution from power generation and driving electric vehicle.

Data is collected from a number of reputable resources and cross-referenced when possible to a pre-existing benchmark. This allowed for numerous measurements and the creation of an average which ultimately leads to a more reliable result. When gathering figures to contrast through the method, one of the most integral pieces of information to this analysis is the mix of power generation methods and technolo-

gies in the 12 nations that were closely observed. The number of countries examined (12) were chosen as these countries represent not only developed countries where these electric cars are most likely to be driven, but also represents a widespread geographic location where these systems are in place. In addition, through using this method, there is also a variation in the country's geographical features. Thus, when making recommendations, these can be widespread and have meaning for a large range of countries.

Secondly, it is necessary to know the amount of carbon emitted from the generation of a kilowatt of energy. Concurrently, it is necessary to know the amount of carbon emitted from the combustion of 1 litre of petrol in a similarly sized vehicle to the one that is being studied. Further, it is necessary to know the number of kilowatts of energy that are needed to drive 100 kilometres in the vehicle that is being examined. Finally, for a complete comparison, it is necessary to collect information about the carbon emitted from creating the two distinct vehicles.

Through using a quantitative method, the study will offer a more detached view and stress objectivity in the demonstration of results. Objectivity is extremely important given the heavily controversial and political repercussions of this subject with increasing, global impact. The method looks at relationships and establishes causes and effects between variables. The quantitative approach leads to overall more scientifically sound data and results as opposed to solely based on a restricted sample of qualitative test subjects. In

Country	Car Manufacturing	Grid Direct	Grid Indirect	Grid Losses	Total (g Co2/km)
India	70	242	20	38	370
South Africa	70	242	5	1	318
China	70	181	4	3	258
Turkey	70	114	7	13	204
United States of America	70	122	8	2	202
United Kingdom	70	107	6	6	189
Japan	70	98	4	3	175
Russia	70	80	3	2	155
Canada	70	40	3	2	115
France	70	20	2	1	93
Brazil	70	18	0	1	89
Paraguay	70	0	0	0	70
Carbon Emission		Fuel Economy		Total (g Co2/km)	
Traditional Car (Ford Focus)	2770 g Co2/L	6.6 L/100Km	0.066L/Km		182.82 g/KM

Figure 1: This table shows the total amount of CO₂ emitted per kilometer driven based on a country's power generation mix. This is contrasted with the emissions from a typical compact car, the Ford Focus.

this study, there was no involvement of human participants and as such, this research should not face any ethical qualms.

Finally, the analysis will break down the power generation methods by percentage of total generation in the country and will calculate each generation method's proportional impact of the total combined mix. This is shown in the equation below and will be repeated for all of the different power generation systems. This will be added to the set number of grams of carbon emissions from the generation of the vehicle itself. The Ford Focus was used as the benchmark gas vehicle for reasons explained in Appendix B.

$$\left(\frac{\text{CO}_2(\text{g})}{\text{kw}} \right) \circ \left(\frac{\text{kw}}{100\text{km}} \right) = \text{Virtual Tailpipe Emissions}$$

Results

Through the quantitative analysis, information was discovered that is rather contrary to the popular belief. In fact, as shown in the figure below, out of the 12 countries that were examined for environmental effectiveness of power generation systems, only 6 of them have improved environmental benefits when using them compared to traditional vehicles.

In the above table, it can be observed the clear contrast of where the electric vehicle falls in relation to the electric car. Here, the data for the electric vehicles was collected by examining a broad mix of electric vehicles (appendix b) which was then estimated to be on average the size of the Ford Focus. As such, the Ford Focus was used for control variable of the traditional vehicle.

To understand the implications are in the above chart it is important to note that while data is only available on a national scale, in large countries there is often a variance in how power is generated from region to region within the country itself. As such, in one region of the United States, power generation due to hydroelectricity, or wind might be the best available alternative, this might not be the case in another distinct region of the country.

However, it is important to see the trends of the countries that are leading the charge towards a clean, efficient future. For instance, out of the 12 countries surveyed, the cleanest energy came from Paraguay

(see Appendix). In Paraguay, 100% of the electricity comes from hydroelectric sources due to the geographical features of the country. In addition, Paraguay is a relatively small country with a relatively small energy demand. In fact, the demand for energy in Paraguay is only 10% that of France, or just 1% that of China (The Shift Project, 2014). As such, due to a unique circumstance, Paraguay is able to flourish in their essentially clean production of energy.

However, when looking for a solution that is more applicable to countries that do not have the same unique makeup of Paraguay, other renewable sources enter. For instance, wind energy and bio mass power generation both play a large role in the generation of clean energy in countries like Brazil and Canada. Yet, under examination, is a very expensive and land intensive generation process while bio mass energy generation requires a high amount of supervision and training; something that developing countries cannot afford. Yet, there must be a solution, an ideal alternative that is able safe, powerful and relatively inexpensive – this solution is nuclear energy generation.

Analysis

Through analyzing the data, it is easy to see that the generation methods some of these developed countries simply do not make it economically nor environmentally feasible to switch to electric vehicles. Essentially in most regions of even the developed world, we are still using sub-par generation methods that belong in the twentieth century. The power mixes were analyzed and as a result, nuclear power can be recognized as a resource that is readily available and safe, yet potent and can be implemented in any region.

Other potential alternatives included the implementation of widespread hydroelectric electricity generation; however, due to the nature in which it is generated, hydroelectric power can only be utilized in certain regions of the world with permissible geographical characteristics (McInnes, 2011). Further, other low-carbon sources of power generation such as solar and wind require too large of an upfront capital investment for these options to be realistically considered to power millions of homes on a constant basis (Comby, 2014). Besides large startup costs, there would also be subsequent large investments required

TWELVE SHADES OF GREEN

in massive battery systems as surplus power must be stored for times when the sun is not optimally positioned or instances where the wind is not blowing at a beneficial rate, in the correct direction for the turbine (Biello, 2013). As such, nuclear energy is, at present, the most viable method to decrease our carbon emissions without having to drastically alter our energy demands.

Nuclear energy is a way to potentially disassociate our dependence on the environment for energy. Due to the potency of the nuclear fuel and its ability to be used repeatedly once it is spent, there is essentially no reliance upon external factors here (Fountain, 2017). This energy source has a much smaller footprint as it requires much less material and refining than other types of traditional and especially alternative renewable solutions. By using nuclear energy in a widespread manner, we can drive down the costs as governments will be able to limit the number of designs through understanding which designs are the correct build and fit for their needs (Biello, 2013). Further, with widespread implementations, we can essentially eliminate our dependence of carbon and methane emission down to nearly atmospheric levels.

Many argue that the process of extracting the Uranium from the earth is process that is detrimental to the environment. However, it is important to note that this is the same process that is undergone to extract coal. In addition, the amount of fuel needed to be extracted is dramatically less when compared to the tons of coal being burned (Comby, 2014).

Presently, Nuclear energy is created through the process of Uranium fission, though new technologies are in development for Helium fusion processes (Levitian, 2016). Uranium has many isotopes, one of which, Uranium-234, has an extremely unstable nucleus. Through an extremely exothermic process, the nucleus breaks down resulting in the emission of heat, but also activating further chain reactions (Williams, 2013). These subsequent reactions operate on a factor of three such that each fission event is able to trigger three more if not moderated (Williams, 2013). This process of fission liberates large amounts of energy, which is then transferred to electric potential energy through the process of steam generation in a process similar to that in a coal fired generation plant. While this process, if not monitored properly, can lead to potential catastrophes, with proper control and moderation,

this source of energy could be the solution to our global energy crisis (Biello, 2013).

As an industrialized civilization, the amount of energy we require is constantly growing. Currently, over 85% of that energy is provided by burning fossil fuels like coal, oil and gas on a global scale. While there is potential for coal to last us for many centuries into the future, the amount of greenhouse gasses emitted especially carbon dioxide and carbon monoxide are not conducive to an environmentally sustainable nor efficient future (Comby, 2014). While natural gas developed as a byproduct of oil extraction, it has grown in popularity since through a completely clean combustion the only by products that result are Carbon Dioxide and Water; however, this is seldom the case (Levitian, 2016). Saying this, our reserves of natural gas are extremely limited and are unlikely to last into the 22nd century.

In burning coal and natural gas, we lance approximately 23 billion tons of carbon dioxide into Earth's atmosphere each year, roughly the equivalent to 4 400 tons per minute. While a fraction of this polluting gas is absorbed by vegetation, nearly 40% is absorbed by seas leading to detrimental ocean acidification (Fountain, 2017) which has its own resulting detriments. For the other percentage, totaling nearly 60%, it remains in the atmosphere – altering its compositions and affecting our global climate.

While this encompasses the broader and increasingly complex issue of global climate, climate change and global warming, it is important to realize that power generation is one of the largest contributors to greenhouse gasses, which is the main factor in climate altering effects. Presently, we only have this planet to live on. As we aim to keep our planet a viable and livable environment whilst ensuring the modern necessities we have become accustomed to, we are in need of the adoption of new energy sources (Comby, 2014).

Nuclear power checks all of the boxes when examining and probing for a substantial alternative to the dark destination that we are presently on track towards. Nuclear energy is much cleaner than is widely understood. It produces no carbon dioxide in its actual fission (energy generating) process along with no sulfur dioxide or nitrogen oxides, which are large contributors to ocean acidification. These gases are produced in dramatic excess when fossil fuels, such as coal, natural gas or petroleum, are combusted (Comby, 2014).

TWELVE SHADES OF GREEN

The major complaint when it comes to the issue of nuclear power is the waste that is created in the form of spent fuel. However, it is important to understand the *factor of one million*. In essence, this is the basic understanding that one gram of uranium yields as much energy as a ton of coal when combusted at standard efficiencies (McInnes, 2011). As such, nuclear waste is one million times smaller than fossil fuel waste and is entirely confined to the generation chamber – no escaping pollutants into the atmosphere and oceans (Anderson, 2015).

In countries where older methods of nuclear energy generation are in use such as the United States of America and Russia, spent fuel is simply stored in isolation or disposed of through a borehole disposal process. However, in countries such as Germany and France spent fuel is reprocessed to separate out the radioactive fission products while the remaining materials are recovered and recycled into new energy (Anderson, 2015). Further, technologies in Scandinavian countries and Canada utilize unenriched Uranium fuel in an extremely controlled manner to produce spent fuel that can be used numerous times and then stored in a pool for extended amounts of time, after this, they are safe for natural disposal (McInnes, 2011). Of course, the downside to this process being the relatively small yield of energy per generator due to the lack of enriched fuel.

Further, when examining the tremendous efficacy and potency of nuclear energy, it was found that a typical family of four over their entire lifespan would be hard-pressed to use more than a golf ball's size of uranium to power their lives. This is dramatically different from the tons of gas that are emitted through smoke stacks causing global warming, acid rain, smoke and other forms of atmospheric pollution (Comby, 2014).

Nuclear reactors are also reliable, durable and resilient meaning that they are available for often over 90% of the time of their service life. With under 10% of time being used for maintenance and refueling, this is better than the yield of any traditional source (Comby, 2014). Further, in the United States, improvements have been made so the lifespan of plants are designed for 40 years, which often are granted further 20-year extensions as they remain within safe operational parameters. Of course, while it is possible for traditional coal plants to surpass these figures, old plants would

not be near to the level of efficiency and levels of technology that comparable new plants would be at (Spencer, 2011). Essentially a detriment both economically and environmentally.

Continuing, the cost of the fuel in a nuclear plant is a small fraction of the price of the total energy, whereas fossil fuel prices are essentially at the will of the market due to a large portion of their generation costs going towards raw material expenses (McInnes, 2011). In addition, uranium is available in abundance on the crust of the earth. In fact, the element is more abundant than tin and large deposits exist in Canada and Australia all while new deposits and methods of extraction are being examined (Williams, 2013). Further, new technologies are evolving where uranium is collected from seawater where an estimated 4 billion tons could be extracted. Nuclear power stations are also more compact than any of its modern alternative generation methods (Spencer, 2011). A nuclear power station takes up just roughly the area of a small football stadium while solar farms and wind turbines both require square kilometres of land (Comby, 2014).

Most of the opposition when it comes to nuclear power is a result of the ignorance over two major misconceptions that are conveyed by ecological organizations with opinions grounded more so in ideology than fact. These misconceptions are: the amount of radiation absorbed by being in the vicinity of a power plant, along with the potential for disaster (Levitin, 2016). Campaigns have been established to harp on peoples' mystery towards radiation. A very small sector of the population is in fact cognizant of the fact that radiation is naturally occurring everywhere in our environment. In fact, moderate radiation amounts is natural and studies have shown it to be moderately beneficial to healthy human life (Anderson, 2015).

Everything around us is radioactive in nature to a certain degree and has been so for millions of years, long before our implementation of nuclear energy (Comby, 2014). In fact, when life first occurred on earth, geologists estimate that natural radiation levels were nearly twice what they are today (Anderson, 2015). Additionally, the human body is radioactive in itself. Our bodies contain about 8000 atoms disintegrating each second (Comby, 2014).

Further nuclear power is safe, and this needs to be emphasized. This has been demonstrated by the over 12, 000 combined years of reactor function which

TWELVE SHADES OF GREEN

have transpired over the past half century with only two major isolated incidents (Three Mile Island and Chernobyl) as well as only one extreme weather-related incident (Fukushima) (Comby, 2014).

In short, nuclear power is well positioned to be our future of our energy security. Through well designed, well-constructed, well operated and well-maintained facilities, nuclear energy is clean, safe, reliable, competitive and durable. Nuclear energy remains our best positioned resource as a society aiming to move towards a future free of greenhouse gas emitting sources while still maintaining high levels of efficiency and a high demand for electricity. Not only does nuclear energy provide us with an option that is viable for quick entry into our power grid with quick turnaround times, but it also offers a solution that is cost effective and is beneficial to economies in both the short and long term. As we see the trend of increasing energy demand, and there is no reason to foresee a slowing of this, we need to move with the vision of clean, safe, and efficient manners of electricity generation. Nuclear power can fulfill that vision.

Conclusion and Future Actions

The results of this study highlight the subpar levels of effectiveness that our current power generation systems have on the proliferation of electric cars on a global scale. From the viewpoint of the electric car it is obvious to see that if we continue down the path that we are currently heading, it will not be environmentally effective to implement electric cars. Therefore, if our society is aiming to move towards the implementation of these vehicles further research must be conducted into the specific regional benefits of these power generation methods. Furthermore, if this study was conducted on a broader scope that

would encompass not only the developed world, but countries that are now building robust energy grid systems, this might aid them in developing clean energy. Through this, they will not have to go through a revision process as much of the developed world has gone through and continues to go through. Further, the recommendations made through the research here are not necessarily the only actions possible for these countries; whereas, in certain countries other renewable sources may be advantageous.

Despite the unfavorable results that were discovered through the comparison of power generation methods, it is entirely possible for our society to become less carbon dependent in a relatively short period. By coupling the two largest environmentally polluting industries (power generation and transportation (Wilson, 2013) and implementing electric vehicles as well as environmentally responsible power systems we will be able to move towards a brighter, more green future in the spirit of progress.

Appendix A

This chart shows the breakdown of the percentage of energy from numerous sources. In the chart, the total amount of power generated can also be observed. These vary drastically within these developed countries from Paraguay at 57 TWh up to China at 5145 TWh. (Shift Project, 2014)

Country	Total 2014 (TWh)	% from Wind	% from Nuclear	% from Hydroelectric	% from Gas	% from Coal	% from Oil	% from Biomass	% From Others
India	1117	3.13%	2.95%	11.55%	7.97%	71.62%	0.00%	0.00%	2.78%
South Africa	243	0.00%	6.17%	0.41%	0.00%	92.59%	0.82%	0.00%	0.00%
China	5145	2.89%	2.55%	20.00%	1.77%	71.55%	0.00%	0.00%	1.26%
Turkey	223	4.04%	0.00%	17.94%	46.19%	30.04%	0.90%	0.00%	0.90%
United States of America	4255	4.28%	18.73%	6.09%	29.89%	37.88%	0.00%	0.00%	3.13%
United Kingdom	311	7.72%	18.65%	0.00%	29.59%	32.49%	0.00%	7.07%	4.50%
Japan	986	0.00%	0.00%	8.11%	43.41%	30.22%	11.97%	3.55%	2.74%
Russia	986	0.00%	17.14%	17.14%	48.89%	14.10%	2.64%	0.00%	0.30%
Canada	650	1.85%	15.54%	57.69%	10.15%	12.15%	0.00%	0.00%	2.62%
France	545	3.12%	76.33%	11.38%	2.94%	3.12%	0.00%	0.00%	3.12%
Brazil	526	0.00%	2.85%	69.58%	8.75%	0.00%	3.80%	10.84%	4.18%
Paraguay	57	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Appendix B

This chart shows the amount of energy used by the 11 most popular electric vehicles. From this, the Ford Focus EV measured closest to the average, because of this, the Ford Focus Petrol model was used as the baseline evaluator for a gas powered car (EPRG, 2016)

Vehicle	kWh/100 km
Nisan Leaf BEV	21.0
Chevrolet Volt PHV	17.0
Toyota Prius PHV	18.0
BMW i3	13.5
Ford Focus EV	19.6
Tesla Model S	22.5
Tesla Model X	23.2
Toyota Rav 4	25.2
Honda Fit EV	18.1
Kia Soul EV	18.3
Mercedes Benz B Class EV	20.5
Average:	19.7

References

- Anderson, R. (2015, February 27). *Nuclear power: Energy for the future or relic of the past?* Retrieved April 3, 2017
- Biello, D. (2013, December 12). *How nuclear power can stop global warming.* Retrieved April 3, 2017
- Comby, B. (2014, June 16). *The benefits of nuclear energy.* Retrieved April 3, 2017, from Ecolo.
- Dotson, S. (2011, June 1). Power Generation in Canada. *Power Physics*, 46-49. Retrieved October 10, 2016
- Fountain, H. (2017, March 27). *A dream of clean energy at a very high price.* Retrieved April 3, 2017
- García-Gusano, D., Iribarren, D., Martín-Gamboa, M., Dufour, J., Espagren, K., & Lind, A. (2016). Integration of life-cycle indicators into energy optimisation models: The case study of power generation in Norway. *Journal of Cleaner Production*, 112, 2693-2696. doi:10.1016/j.jclepro.2015.10.075
- Hawkins, T. R., Singh, B., Majeau-Bettez, G., & Strømman, A. H. (2012). Comparative environmental life cycle assessment of conventional and electric vehicles. *Journal of Industrial Ecology*, 17(1), 53-64. doi:10.1111/j.1530-9290.2012.00532.x
- Lave, L. B., Hendrickson, C. T., & McMichael, F. C. (1995). Environmental implications of electric cars. *Science*, 268(5213), 993+.
- Levitin, D. (2016, March 6). *Is Nuclear Power Our Energy Future, Or in a Death Spiral.* Retrieved April 3, 2017
- Lindly, J. K., & Haskew, T. A. (2002). Impact of electric vehicles on electric power generation and global environmental change. *Advances in Environmental Research*, 6(3), 291-302. doi:10.1016/s1093-0191(01)00060-0
- McInnes, C. (2011). Nuclear Power Can Help Fight Global Warming. *Opposing Viewpoints in Context*.
- McNally, R. (2003). High tech hopes: new transportation technologies may reduce vehicle emissions only marginally. *Alternatives Journal*, 29(3), 30
- Nikiforuk, A. (2015). When the rubber hits the road: the complicated truth behind electric cars. *Alternatives Journal*, 41(3), 59
- Notter, D. A., Gauch, M., Widmer, R., Wäger, P., Stamp, A., Zah, R., & Althaus, H. (2010). Contribution of li-ion batteries to the environmental impact of electric vehicles. *Environmental Science & Technology Environ. Sci. Technol.*, 44(17), 6550-6556. doi:10.1021/es903729a
- Spencer, J. (2011). Abandoning nuclear power would threaten economic security worldwide. *Opposing Viewpoints in Context*.
- The Shift Project. (2014, November 27). *Power Generation Mixes 2014.* Retrieved from The Shift Project.
- Williams, A. R. (2013). Nuclear power is the best way to address climate change. *Opposing Viewpoints in Context*.
- Wilson, L. (2013, February). Shades of green. *Shrink That Footprint*, 1-28. doi: 10.1002/9780470685532.ch5
- Xiao-Ling, Z., Jin, Z., Ying-Hua, G., Pei, S., Hui-Xia, J., Wei, F., & ... Jian-Jun, H. (2016). Comparative proteomic analysis of mature pollen in triploid and diploid *Populus deltoides*. *International Journal Of Molecular Sciences*, 17(9), 1-17. doi:10.3390/ijms17091475

Comparing Traditional AP Classes to Portfolio AP Classes in Effectiveness of Measuring Knowledge

Leanne Olona

High school students across the United States and internationally take Advanced Placement exams in May each year. These students also spend their school year enrolled in an Advanced Placement (AP) class in preparation for the exam. There is a lack of research on any correlation between a student's performance in class and performance on the exam. This study aims to compare the difference in correlation between traditional AP classes and portfolio AP classes. Second-semester grades and exam scores were collected from 2015 and 2016 from Norman High School students. Traditional classes had weak, if any, correlation, and portfolio classes presented no correlation. This lack of a relationship between class grade and exam score implies that students are unable to gauge their future exam performance based on class performance. Future researchers should compare data for a greater sample of students as well as regional samples.

Keywords: Advanced Placement, standardized testing, portfolio assessment, AP exams

Introduction

Almost all American high school students, parents, and teachers have heard about AP exams. Similar to honors classes, AP classes are designed to academically challenge students and offer potential college credit for those who perform well on AP exams. These classes are offered in all subject areas, English, Math, History, Science, as well as in Art and Music to name a few (AP Courses, n.d.). Most AP students hope to perform well on their exams and are likely to be disappointed when the result is not what they wanted. It is especially upsetting when a student receives a high grade in the class, but a low score on the test. This is because the relationship between class grade and exam score is unclear to students and parents. While there exists various research about AP exams, there is little to no current research over any connec-

tion between classroom grades and exam scores. On top of this, there is also a lack of research existing over the difference between traditional and portfolio AP classes. Traditional classes offer a single comprehensive sit-down exam at the end of the year in order to determine the AP exam score while portfolio classes decide the AP exam score based on a portfolio turned in by the student which consists of their work over the course of the year. To help take the first step to understanding the relationship between classroom performance and exam score, semester grade and exam score data from 2015 and 2016 school years at a high school in Oklahoma were compared to each other and the findings were discussed. While this sample size is only a small portion of the AP test-taking population, this research still provides new data for all members of the AP community. Standardized testing has been used for many different reasons to assess students, and

this research provides more insight into that conversation. In order to understand the results of the study, a discussion of current research precedes the results. Data were received from the local school district and are presented in graphs and tables. The results were discussed and a conclusion was reached based on the information provided.

Literature Review

As previously mentioned, almost all high school students in the United States are familiar with The College Board, an international testing company, and the Advanced Placement (AP) Testing that they offer. These high-stakes tests are designed to measure how much a student has learned in his or her AP class and scores them on a ranking from 1 to 5 (About AP Scores, n.d.). Colleges then determine how much credit they will give the student based on their own standards. Given that a 3 is a passing score, depending on the university, a 3, 4, or 5 can earn the student a certain amount of credit (About AP Scores, n.d.).

AP was created in 1953 by some of the top universities at the time, such as Harvard, Yale, and Princeton, with the initial intention to help high school seniors receive early college credit once they had completed their basic high school requirements (Fund, 1953; Casement, 2003). Today, AP classes are offered to all high school students, even freshmen. Students both domestically and internationally take AP tests every year, in addition to other standardized tests, such as the SAT and ACT. The growth of AP tests and other standardized tests have led to a discussion amongst researchers regarding the accuracy of these tests when it comes to measuring the knowledge of students.

Different Forms of Measuring Knowledge

In order to understand whether traditional AP classes or portfolio AP classes are more accurate in measuring what students know, it is important to look at various forms of testing measurements. While numerous types of testing exist, in regard to this research project, the most relevant forms to look into are IQ testing, GPA, Standardized Tests, and Portfolio Assessments.

IQ tests measure a person's "intelligence quotient". "IQ" is commonly used to refer to one's general intel-

ligence, but there are, in fact, several different theories on types of intelligence; for example, Howard Gardner is well known for his ideas on multiple intelligences. The literature suggests that the most relevant form of intelligence in relation to standardized and portfolio assessments is successful intelligence (Stemler, Grigorenko, Jarvin, & Sternberg, 2006; Sternberg, 1988; Sternberg, & Kaufman, 2011; Sternberg, 2015). Robert J. Sternberg (2011) is the leading voice in the discussion on successful intelligence and he states that intelligence is an abstract concept and "not a quality of mind, but an aspect of behavior" (p. 26). Essentially, intelligence is less of a personality trait and instead reflects the behavior of an individual in a specific environment, such as a classroom.

Grade point average (GPA) is a number that comes from the average grades a student has received up to a certain point in their education. It is "assumed that grades reflect learning" so GPAs are reliable in that sense (Anaya, 1999, p. 500). However, others argue that problems with GPA include concerns of validity and generalizability (Anaya, 1999). GPAs do not reflect the growth of students and they cannot be compared across schools because grading may vary (Anaya, 1999).

Standardized Tests

Background. Standardized tests have been around since the 1800's. After the 1970s, they grew in popularity and became a normal aspect of the modern American student's education (Bures, Barclay, Abrami, & Meyer, 2013; Longo, 2010; Strauss, 2013; Sternberg, 2015). One example of the growth of standardized testing is AP tests. Based on data archived from AP for the United States, 566,720 students took at least one AP exam in 1997, while 2,538,998 students took an AP exam in 2016 (AP Data, n.d.). In less than 20 years, the number of test takers increased by over 300%, not counting international test takers.

Some might be surprised to learn that the format of standardized tests has stayed roughly the same over the course of two hundred years (Sternberg, 1988; Sternberg, 2015). The literature surrounding this topic suggests that psychological theory has been modified and enhanced through different generations, but this did not translate to testing (Stemler, Grigorenko, Jarvin, & Sternberg, 2006; Sternberg, 1988; Sternberg,

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

2015). Many psychologists have found that students perform better on assessments when they can be creative and explain what they know as compared to filling in bubbles on an answer sheet (Sternler, Grigorenko, Jarvin, & Sternberg, 2006; Sternberg, 1988; Sternberg, 2015).

While some aspects of standardized tests may be revised and changed over time, they remain consistent in how they are administered. The premise behind standardized tests is that they are reliable and as the name suggests, are standardized. Due to this, the testing companies that exist, such as Pearson and College Board, are very large bodies that make profits off the Scantrons students use to test (Gonzalez, 2012; O'Brien, Winn, & Currier, 2014; Pennolino, & Oliver, 2015). Pearson controls most state standardized testing across the United States very strictly; they require teachers to become certified by a Pearson test, provide the tests for students to take, and sell schools Pearson review guides to help teachers and students prepare for these Pearson tests (O'Brien, Winn, & Currier, 2014; Pennolino, & Oliver, 2015). Recently, College Board reformed their SAT so that the questions would be more accessible to testers (Gumbrecht, 2014). However, students are still taking an exam for at least three hours in order to receive a score based off their skill on multiple choice tests (Gumbrecht, 2014). This shows that overall, there has been no substantial change in standardized testing.

Disadvantages and advantages to using standardized tests. Standardized tests are often criticized for discriminating against minority students and students of low economic background, as well as for only measuring what a student has memorized and not what they actually learned (Anaya, 1999; Bures, Barclay, Abrami, & Meyer, 2013; Levine, 1985; Longo, 2010; Pennolino, & Oliver, 2015; Valencia, & Calfee, 1991). Many outside factors can also influence how a student performs on a test. For example, if a student suffers from test anxiety, they may perform poorly on their AP test, despite maintaining an A in the AP class (Levine, 1985; Longo, 2010; Sternler, Grigorenko, Jarvin, & Sternberg, 2006; Valencia, & Calfee, 1991).

This is not to say that standardized testing only brings disadvantages to students, as there may be potential benefits associated with them. As previously stated, standardized tests have been around for many years. If used efficiently, they can help both state and

federal governments judge how well a school is teaching its students (Goertz, & Duffy, 2001; Riffert, 2005). It is also important to remember that when AP tests were first implemented, they were only offered to high school seniors to help them get ahead in their college education (Fund, 1953; Casement, 2003). This initial plan was noble, and AP classes were the best way to accomplish this goal at the time (Fund, 1953; Casement, 2003). However, given that many years have passed and standardized tests have grown in popularity and prevalence, it is important to be open to new ideas in order to fix the problems currently in place in the system.

Portfolio Assessments

Portfolio assessments are not new, but they are used much less in comparison to standardized tests. The literature seems to suggest that portfolios are better at measuring what students actually learn in a class (Bures, Barclay, Abrami, & Meyer, 2013; Mills, 2009; Perry, 1998; Valencia, & Calfee, 1991).

There are different variations of portfolio assessments. Research on electronic portfolios shows that they are a reliable method for evaluating literacy in elementary students (Bures, Barclay, Abrami, & Meyer, 2013). There is, however, a lack of research over how electronic portfolios might be implemented for high school students and how they might differ from subject to subject.

Other forms of portfolio assessments include formative and summative assessments. Formative assessments compile information and work from a student's daily work, whereas summative assessments are compiled of chapter quizzes and unit tests (Mills, 2009). Regardless of which type of portfolio is used, they all provide a convenient method for teacher and student alike to measure their progress over time (Perry, 1998; Valencia, & Calfee, 1991).

A difficulty that arises out of the portfolio assessments is the subjectivity of grading. Portfolios are much more time consuming for teachers to grade since they are not tests that may be run through a machine, nor do they have keys (Mills, 2009). The individuality involved in portfolios makes the grading process much more subjective. Supporters of portfolio assessments claim that when teachers are prepared with the right rubrics, it can make the grading process

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

flow much smoother (Bures, Barclay, Abrami, & Meyer, 2013). Given the right resources, portfolios can be graded efficiently.

AP Class Credibility

A few voices have questioned the credibility behind AP classes. Because many universities, in America and across the world, give potential credit based on AP scores, two important core issues are validity and reliability (Credit & Placement, n.d.). The exams given to students must be accurate in their grading system in order to be considered valid, whereas all AP classes should be teaching their students the same information in order to be considered reliable. Some of the literature brings up how some Ivy League schools, Dartmouth specifically, have stopped giving credit for AP classes because students could not demonstrate mastery of a subject that they supposedly had passed; which suggests that AP is no longer being viewed as valid or reliable (Strauss, 2013). AP seems to lose some of its integrity when people have looked into the details of how they handle grading.

The literature suggests that with more people taking AP tests each year, the pass rate should be changing. Whether it should be increasing or decreasing is debatable, but there is a general consensus that there should be change; yet, the average pass rate has not changed much at all (Casement, 2003; Strauss, 2013). AP scores seem to be created with a scaling method; AP graders determine how well a student performed individually but AP itself will only give about the top 60% of students a passing grade (Strauss, 2013). This method of grading can also be seen in some states with standardized testing, where perhaps only a certain number of students are supposed to pass so graders are encouraged to hand out less passing scores, regardless of the actual work of a student (Gonzalez, 2012).

AP World History is a traditional AP class in which students read chapters in books weekly and take notes to later study for period exams. In May, students take the AP World History Exam and answer multiple choice questions along with a few essays. Regardless of the quality of work and effort they displayed throughout the AP class, they will receive potential college credit based on the AP exam score alone.

Norman High School AP Classes

At Norman High School, there are two portfolio AP courses; Studio Art and Capstone. Studio Art students build a portfolio of their best works of art and submit that for AP graders in May. Capstone is a two-year course that is made up of Seminar and Research classes (Seminar students take a traditional exam in May which affects a portion of their AP score). Seminar students begin their AP test in January and create a group research project, an individual project, and take a sit-down exam in May. Research students create one intensive research project and presentation to receive their AP score.

Despite all the differing opinions that can be read in the literature, there is a lack of research on AP in general, and no notable research has been done over high school students in Norman, Oklahoma. Since there are only two AP portfolio courses, there is also a lack of information about how valid and reliable their AP tests are.

Methods

The lack of statistical comparison between AP class grades and AP test scores presents an opportunity to discover new information that can potentially improve how students are tested. With the number of students taking AP tests increasing every year, it is important to check that these tests are both valid and reliable. A growing interest in portfolio programs in American schools may present an alternative to the traditional AP tests. Grades and AP exam scores were collected from Norman High School, located in Norman, OK. With district approval, the data was received and statistically analyzed in order to look for correlation.

Norman High School (NHS) is a strong candidate to conduct this statistical research for a few reasons. It has a large student body population, around 2,000 students, and offers 19 AP classes. In 2015, 819 AP tests were taken by NHS students enrolled in an AP class and in 2016, the number grew to 1005. The optimal way to approach the research was to use a quantitative method to look for a correlational relationship between end of class grades and AP grades. Students often have strong feelings about their grades so in an

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

attempt to avoid possible bias from surveying students, the best way to reach a conclusion was strictly through data.

The years 2015 and 2016 were selected because they are the most recent and because of the scope of the project; 2 years of data is the most that could be analyzed in the amount of the time provided. Data was also limited to NHS for this reason. While 19 AP classes are offered, data from AP Physics C E&M and AP Latin were not used since the students in those classes are engaged in self-study and have no more than 10 students in each class. Students are allowed to take AP exams without being enrolled in the class, such as the AP Music Theory exam, which is irrelevant to this research and thus was excluded. Students in AEGIS Math and English take AP exams but since they are not enrolled in a traditional AP class and have a different class structure, their data is irrelevant to this research.

After receiving approval from the Norman Public Schools (NPS) institutional review board, an administrator within NPS provided me with the data for 1824 individual tests and corresponding semester grades.

AP teachers also were asked to provide a copy of their syllabus. This proved to be helpful in analyzing how a student received their end of semester grade in their course. Teachers were sent the request through an email and replied with attachments to their policies.

The data was first observed as a whole unit and separated simply by AP score. By approaching the data in this fashion, a general impression of the data was gathered before beginning a more in-depth analysis. This information was recorded and the data was then reorganized by traditional or portfolio. The end of semester grades was recorded, with A's changing to 95's, B's changing to 85's, etc. The results of the data analysis continue below.

Results

To consolidate the data collected, graphs for 2015 may be located in Appendix A. Similarly, graphs for 2016 may be located in Appendix B. The results section will refer to these graphs in terms of general trends, while providing figure number and appendix location for the reader. AP Exam Grade is represented

on the x-axis, and Semester Grade is represented on the y-axis. The size of the bubble on the plot is related to the percentage of students who received the respective AP Exam Grade and Semester Grade.

Overall

With no regard to AP exam, class, or type of class, two graphs were created in order to observe general trends from 2015 (Figure 1, Appendix A) and 2016 (Figure 1, Appendix B). It can be seen that a majority of students received 3's on their AP Exams and A's in the class than any other combination of score and grade. It can also be noted that only a few students were able to score 5's on the exam without receiving an A in the class.

Traditional

15 exams fall under the traditional type as well as 14 AP classes. AP Comparative Government had just two students in 2015 and makes it incomparable to 2016 data. For this reason, the data is omitted.

AP exam performance aside, students generally received A's and B's in their classes. This may be seen in Biology, Calculus AB and BC, Chemistry, Environmental Science, Psychology, and Spanish Language for both 2015 (Figures 2, 3, 4, 5, 6, 9, 12, 13, Appendix A) and 2016 (Figures 2, 3, 4, 5, 6, 9, 12, 13, Appendix B).

Classes that showed greater variance in class performance fell under the subject of English, English Language and English Literature, or History, Human Geography, US History, and World History. Even in these cases, most students did earn A's in their classes in both 2015 (Figures 7, 8, 10, 15, 16, Appendix A) and 2016 (Figures 7, 8, 10, 15, 16, Appendix B).

Portfolio

There was a total of 5 portfolio exams taken by NHS students. Research and Seminar are from the two-year Capstone program, while Studio Art is broken up into 2D, 3D, and Drawing. Since AP Research has only has one year of data to look at, the data is omitted.

Except for Seminar grades in 2016 (Figure 17, Appendix B), all students in portfolio classes earned an

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

A or B in their class. Studio Art students in 2015 did not perform strongly on the AP exam, and scored 3's or lower in 3D (Figure 19, Appendix A) and Drawing (Figure 20, Appendix A). A few students were able to score a 4 in 2D (Figure 18, Appendix A). Students in Studio Art in 2016 followed this trend except that Drawing students scored 4's and a 5 (Figure 20, Appendix B).

Correlational Coefficients for 2015 for Traditional Exams	
Correlational Coefficient*	AP Exam
+0.49	Biology
+0.46	Physics C: Mechanics
+0.43	AB Calc.
+0.40	English Language
+0.40	U.S. History
+0.38	World History
+0.37	English Literature
+0.33	Chemistry
+0.32	Human Geography
+0.31	U.S. Gov. and Politics
+0.25	Psychology
+0.15	BC Calc. Subscore
+0.14	Environmental Science
+0.11	BC Calc.
-0.12	Spanish Language

* = Rounded to 2 decimal places

Correlational Coefficients for 2015 for Portfolio Exams	
Correlational Coefficient*	AP Exam
+0.53	Seminar
0.00	Studio Art: Drawing
-0.41	Studio Art: 2D
-1.00	Studio Art: 3D

* = Rounded to 2 decimal places

Correlational Coefficients for 2016 for Traditional Exams	
Correlational Coefficient*	AP Exam
+0.63	Environmental Science
+0.57	Human Geography
+0.51	U.S. History
+0.49	World History
+0.47	Biology
+0.47	English Language
+0.39	U.S. Gov. and Politics
+0.35	English Literature
+0.31	Psychology
+0.30	AB Calc.
+0.30	BC Calc.
+0.30	BC Calc. Subscore
+0.30	Physics C: Mechanics
+0.29	Chemistry
+0.22	Spanish Language

* = Rounded to 2 decimal places

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

Correlational Coefficients for 2016 for Portfolio Exams	
Correlational Coefficient*	AP Exam
+0.68	Seminar
+0.50	Studio Art: 3D
+0.20	Studio Art: 2D
0.00	Studio Art: Drawing

* = Rounded to 2 decimal places

of correlation, while portfolio classes have almost no correlation. Most students in AP classes ended up receiving an A in their class which was expected since AP classes are intended for high achieving students. What stands out is that among students that earned A's in the class, most of them scored a 3 or lower on the exam, in both 2016 and 2015. The unique syllabi provided by AP teachers at NHS help explain why this may occur.

Traditional subject correlation. Traditional classes did have higher correlation than portfolios, but it was very weak. Since their grades include elements beyond testing, it is possible for students to obtain high final grades but not necessarily obtain high test grades during the semester.

Figure 3, in Appendices A and B, represents the data from AP Biology exams in 2016 and 2015. A majority of students finished their second semester with either an A or B in AP Biology but very few students were able to score a 5 on the exam. In the classroom, summative assignments account for 50% of the final grade, with five summative tests given in the second semester. Laboratory investigations and daily work each make up 25% of the final grade. For the student, this means that one poor exam grade will not have a major impact on their final grade, since they have four more exams and two other areas in the class in which they may succeed. Alternatively, the AP Biology Exam is split into two parts, multiple choice and free response, both of which make up 50% of the score. It appears that College Board has taken into account that students generally perform better when tests go beyond multiple choice, but half of the exam score still relies on a student's ability to bubble in answers (Stemler, Grigorenko, Jarvin, & Sternberg, 2006; Sternberg, 1988; Sternberg, 2015). All of these factors are possible reasons for why there is less than a +0.50 correlation between semester grade and exam score.

AP Physics C: Mechanics is represented by Figure 11 in both Appendices. The correlation coefficient was lower in 2016 than 2015, but both were less than +0.50, meaning that there was also a weak correlation between the semester grade and exam score. Students in the class must perform well in four different areas in order to have a high grade in the class. Daily work counts for 18%, homework is 20%, take-home tests are 25%, and in-class tests complete the 37%. While the average AP score and grade are usually a 3 and an

Correlation

In order to explore the relationship between AP Exam score and class grade, a Pearson product-moment correlation coefficient was computed for each exam. The correlation coefficient, r , represents how strong the relationship is between two different numerical values. The closer r is to 1, the stronger the relationship is to being positive. The closer the r value is to -1, the stronger the relationship is to being negative. If the r value is 0 or close to 0, there is little to no relationship. Below are tables that contain the correlational coefficients for each exam.

Discussion

Before beginning a discussion of the results above, it is important to understand that correlation is not related to causation. The data collected above is a small sample of the entire population of AP test takers. Any conclusions that are reached in this discussion are limited and not definitive. This is only an observation of data since no experiment was conducted. The goal of this paper is to discuss the correlation between NHS student's AP scores and their final classroom grades.

Findings

It can be seen that in general, there is little to no correlation between AP Exam scores and Semester Grade. Traditional classes have the highest amount

A, students in Physics C: Mechanics had more individuals score a 4 and A than any other combination. It is not clear as to why this varies from the overall average for both 2015 and 2016. Some possible reasons for this may be that the teacher taught the material well or the students were strong test takers, but further research must be conducted to be sure.

Portfolio subject correlation. Almost all of the students in portfolio classes ended the year with an A in the class. This is because the grades they received in the class were almost all participatory. The difficulty with grading portfolios presents itself here as teachers cannot help students gauge what their final grade may be because the teachers themselves do not know what the final product will be (Mills, 2009).

The AP Studio Art exam best exemplifies this trend. In all subsections of Studio Art, the class grade is based purely on if students turn in a piece of art each week, with no consideration for the quality of art. Figure 20 in both appendices represents the data from the Studio Art: Drawing exam and show that all students maintained an A in the class, yet had varying exam scores. In the year 2015, the highest exam score was just a 3. When testing for correlation, Studio Art: Drawing produced a score of 0.00. Most subjects had at least some level of correlation so it was surprising that this subject had none. This likely occurred because the weekly grades students receive in class are not representative of their final product. Participation grades will show no connection to assessment grades.

These findings support the problems universities like Dartmouth were having with students not showing complete mastery of subjects when they got to college (Strauss, 2013). Strong performance in the class does not guarantee a strong AP score and vice versa. In traditional and portfolio settings, it seems that students are not able to predict future AP test performance based on their class performance. This has heavy implications for all members of the AP community; as parents and students should be made aware that their in-class performance is a weak predictor of exam performance. Students that wish to excel on the exam will need to use other methods than work given by teachers. Teachers will find a very weak relationship between their assessment of students and College Board's assessment of the same students.

Alternative Explanations

As previously mentioned, the data collected came from a single high school. Since this is a sample of the population, it does not completely represent the whole group. It is possible that NHS employs several teachers who are not fit to teach AP, which would help account for the disparity between class performance and exam performance. Another possible explanation for the lack of correlation between the two variables is that students do not care about their AP exams. Class performance is associated with GPA while AP exams are a standalone test in which students face no real consequences for poor performance, so it is possible that students put more effort into the classroom and give up studying for the exams.

Limitations

This study is limited by several factors. It should be taken into consideration that data were requested from a single high school. Other factors may affect grades for students, such as test anxiety, socio-economic background, and any outside influences on a single student. Several AP classes at Norman High are taught by more than one teacher. Despite the teachers sharing a common syllabus, they each have their own unique teaching style. Not all students necessarily respond well to every teacher. To protect student privacy, all identifying information, including gender, ethnicity, and class rank were excluded from the data. These student demographics have proven before to be impactful on performance (Anaya, 1999; Bures, Barclay, Abrami, & Meyer, 2013; Levine, 1985; Longo, 2010; Pennolino, & Oliver, 2015; Stemler, Grigorenko, Jarvin, & Sternberg, 2006; Valencia, & Calfee, 1991).

Class size also varied greatly between each subject. Data from several AP classes were not included due to class sizes averaging less than 4 people. Some of the small classes, such as AP Latin and AP Physics C: Electricity and Magnetism, are also independent study environments, which did not apply to this study.

There were also a few outliers in the data. A few students were able to earn 5's on their exams while having less than B's in the class. On the other end, students in AP AB and BC Calculus had the highest ratio of students scoring 1's on the exam, with A's in

the class. It should also be noted that AP Seminar was an outlier amongst the portfolio classes as it exemplified a positive, fairly consistent statistical significance. Due to the scope of this project, this data could not be analyzed in more depth.

Future Research

The number of limiting factors in this study provides opportunities for future researchers to continue exploring this topic. Future researchers should consider looking at a larger sample size. It is not feasible to attempt to gather the data for the entire population of AP students, but depending on the timeline of the researcher's project, they may analyze data from more than one school, as well as in other geographic regions. Students in different areas may possibly find more or less correlation between their semester grades and AP exam scores. Researchers are encouraged to seek out data from various years in order to look for a comparison over time. This would provide better insight to understanding the reliability of AP grades. As AP continues to improve and revise its curriculum for portfolio classes, future researchers will have many opportunities to compare these classes to traditional classes.

Conclusion

The continuous growth of students taking AP tests should be an encouraging force for future research into the accuracy of the tests and also into how students are being assessed in the classroom. While this study was limited to one high school, the weak relationship between class performance and exam performance, in traditional or portfolio subjects, raises concerns. Traditional standardized tests currently dominate the assessment industry but it is not certain they will forever. Portfolio AP tests are new and College Board, teachers, and students are all working to adjust to them. Further research into better implementation of portfolio based assessments is very important. AP tests are intended to prepare students in the best way possible for college, and should be held accountable.

References

- About AP Scores. (n.d.). Retrieved June 03, 2017, from <https://apscore.collegeboard.org/scores/about-ap-scores>
- Anaya, G. (1999). College impact on student learning: Comparing the use of self-reported gains, standardized test scores, and college grades. *Research In Higher Education*, 40(5), 499-526.
- AP Courses. (n.d.). Retrieved June 14, 2017, from <https://apstudent.collegeboard.org/apcourse>
- AP Data – Archived Data – Research – The College Board. (n.d.). Retrieved January 04, 2017, from <https://research.collegeboard.org/programs/ap/data/archived>
- Bures, E. M., Barclay, A., Abrami, P. C., & Meyer, E. J. (2013). The reality of assessing 'authentic' electronic portfolios: Can electronic portfolios serve as a form of standardized assessment to measure literacy and self-regulated learning at the elementary level? / L'évaluation d'portfolio «authentiques». *Canadian Journal of Learning and Technology / La Revue Canadienne De L'apprentissage Et De La Technologie*, 39(4). doi:10.21432/t29g6w
- Carpentier, M. (2016, August 09). No Child Left Behind has been unsuccessful, says bipartisan report. Retrieved September 20, 2016, from <https://www.theguardian.com/education/2016/aug/09/no-child-left-behind-bill-unsuccessful-report-us-schools>
- Casement, W. (2003). Declining credibility for the AP program. *Academic Questions*, 16(4), 11-25.
- Credit & Placement. (n.d.). Retrieved June 06, 2017, from <https://apstudent.collegeboard.org/creditandplacement>
- Fund for the Advancement of Education. (1953). *Bridging the gap between school and college; A progress report on four related projects supported by the Fund for the Advancement of Education*. New York, NY: Fund for the Advancement of Education.
- Goertz, M.E., & Duffy, M.C. (2001). Assessment and accountability systems in fifty states: 1999-2000. CPRE Research Report.
- Gonzalez, S. (2012, June 4). Inside a 'scoring center' in the standardized testing industry. Retrieved November 03, 2016, from <https://stateimpact.npr.org/florida/2012/06/04/inside-a-scoring-center-in-the-standardized-testing-industry/>
- Gumbrecht, J. (2014, March 06). Major changes coming to 2016 SAT test. Retrieved June 15, 2017, from <http://www.cnn.com/2014/03/05/living/sat-test-changes-schools/>
- Levine, M. D. (1985). The measure of child. *Pediatrics*, 75(4), 791.

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

- Longo, C. (2010). Fostering creativity or teaching to the test? Implications of state testing on the delivery of science instruction. *Clearing House*, 83(2), 54-57. doi:10.1080/00098650903505399
- Mills, M. M. (2009). Capturing student progress via portfolios in the music classroom. *Music Educators Journal*, 96(2), 32-38.
- O'Brien, J., Winn, R., & Currier, K. (2014). Not all tests are created equal: Parental rights and standardized tests. *Journal Of Cases In Educational Leadership*, 17(2), 41-48.
- Pennolino, P. (Director), & Oliver, J. (Producer). (2015, May 3). *Standardized Testing* [Video file]. In YouTube / Standardized Testing. Retrieved October 23, 2016, from <https://www.youtube.com/watch?v=J6lyURyVz7k&t=889s>
- Perry, N. E. (1998). Young children's self-regulated learning and contexts that support it. *Journal Of Educational Psychology*, 90(4), 715-29.
- Riffert, F. (2005). The use and misuse of standardized testing: A whiteheadian point of view. *Interchange: A Quarterly Review Of Education*, 36(1-2), 231-252.
- Rotherham, A. J. (2012, January 6). In defense of No Child Left Behind. Retrieved January 04, 2017, from <http://ideas.time.com/2012/01/06/in-defense-of-no-child-left-behind/>
- Stemler, S. E., Grigorenko, E. L., Jarvin, L., & Sternberg, R. J. (2006). Using the theory of successful intelligence as a basis for augmenting AP exams in psychology and statistics. *Contemporary Educational Psychology*, 31(3), 344-376.
- Sternberg, R. J. (1988). Applying cognitive theory to the testing and teaching of intelligence. *Applied Cognitive Psychology*, 2(4), 231-255.
- Sternberg, R.J., & Kaufman, S.B. (2011). Tests of intelligence. In *The Cambridge Handbook of Intelligence* (pp. 20-38). Cambridge: Cambridge University Press.
- Sternberg, R. J. (2015, October 1). Successful intelligence: A model for testing intelligence beyond IQ tests. *European Journal of Education and Psychology*, 8(2), 76-84. doi:10.1016/j.ejeps.2015.09.004
- Strauss, V. (2013, February 22). Teacher questions value of AP program. Retrieved November 03, 2016, from <https://www.washingtonpost.com/news/answer-sheet/wp/2013/02/22/teacher-questions-value-of-ap-program/>
- Valencia, S. W., & Calfee, R. (1991). The development and use of literacy portfolios for students, classes, and teachers. *Applied Measurement In Education*, 4(4), 333-45.

Appendix A

There was a mix of numerical and categorical variables involved in the collection of data. AP Exam Grade refers to the score that a student received on their AP exam, ranging from 1 to 5. Semester Grade refers to the final grade that a student received in their AP class, ranging from 55 to 95. There was a total of 20 different AP exams, within 17 AP classes. AP Government is a yearlong class at NHS, but there are two separate exams, Comparative Government and U.S. Government. AP Studio Art is also offered to students at NHS for a year, but within the class students choose to take the 2D, 3D, or Drawing AP exam. The AP BC Calculus exam provides students with two scores; their BC score and AB subscore. This data was presented in two separate graphs. These 20 AP exams were also split up by type, either traditional or portfolio. Data is represented from 2015.

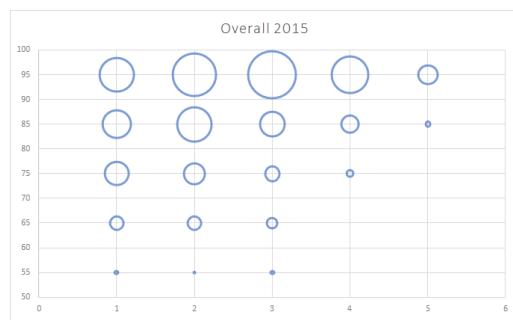


Figure 1. This graph presents an overall view of all the data collected from the year 2015. Most students obtained an A in the class, and a 3 on their exam.

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

Traditional Classes

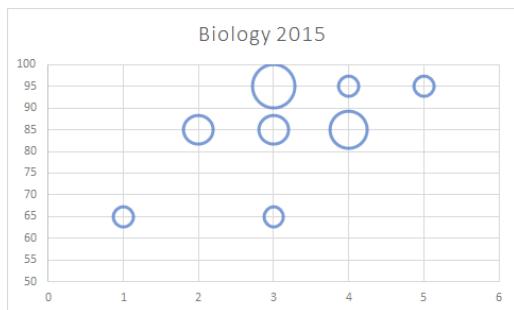


Figure 2. Biology students in 2015 mostly finished their second semester with an A or B in the class. Two outliers ended the year with D's. AP exam score varied greatly.

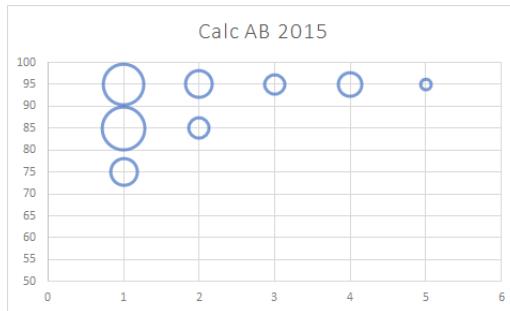


Figure 3. Students in Calculus AB had a majority of students perform poorly on the AP exam, despite earning A's and B's in the class. Only students with A's passed with a 3 or higher.

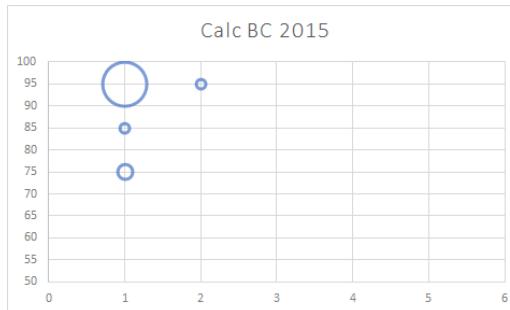


Figure 4. Students in Calculus BC performed very poorly on the AP exams in 2015. While a majority of students completed the year with an A in the class, no students passed the AP exam.

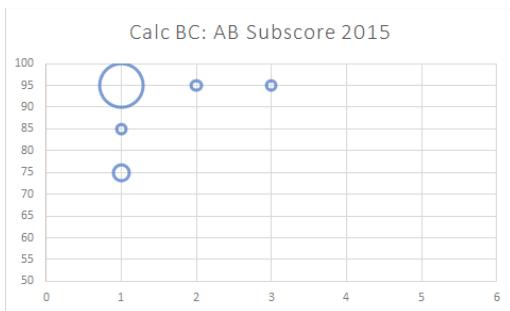


Figure 5. The Calculus BC exam is given two scores. This graph represents the AB subscore for students. Only one student passed this exam.

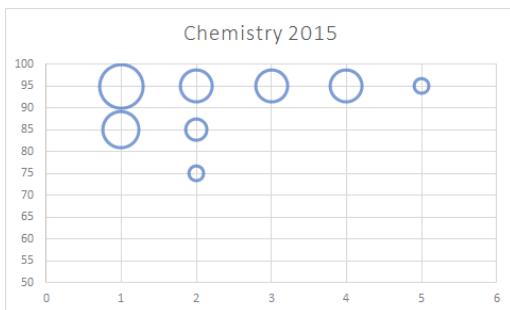


Figure 6. Chemistry students generally performed well in the class setting. Most students scored 1's on the exam, but many also scored 2's, 3's, and 4's. One student scored a 5.

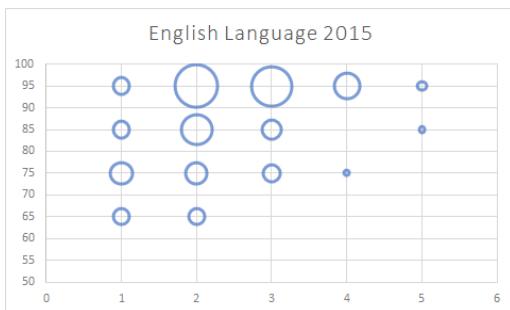


Figure 7. There was high variety between class grade and exam score in English Language in 2015. Most students earned A's in their class and scored 2's and 3's on the exam. A few students earned 5's on their exam as well.

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

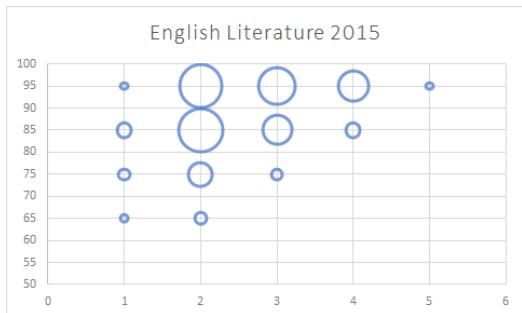


Figure 8. English Literature had very few students who scored 1's and 5's. Most students earned 2's and 3's.

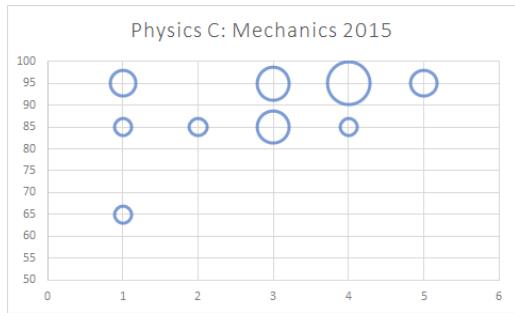


Figure 11. Almost all Physics C: Mechanics students finished the year with an A or B in the class. Most students earned 4's on their exams as well.

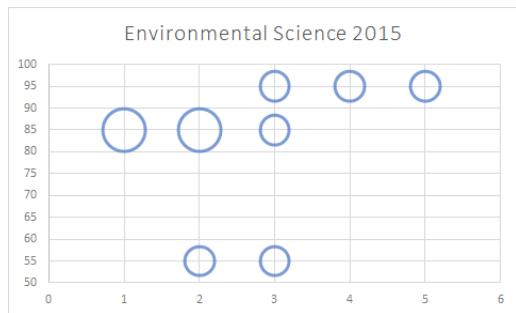


Figure 9. Students in Environmental Science either did well in the class, with A's and B's, or failed. It can be seen however that the only students with 1's on the exam finished the class with a B.

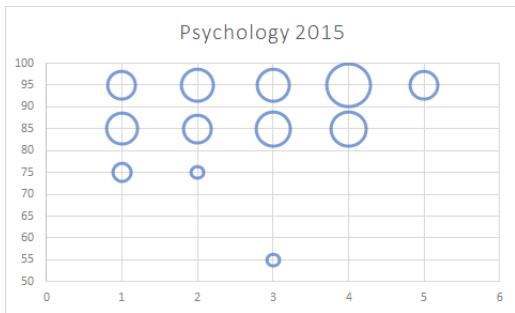


Figure 12. All students in Psychology, except for one outlier, ended 2015 with at least a C in the class. AP exam scores were much more dispersed.

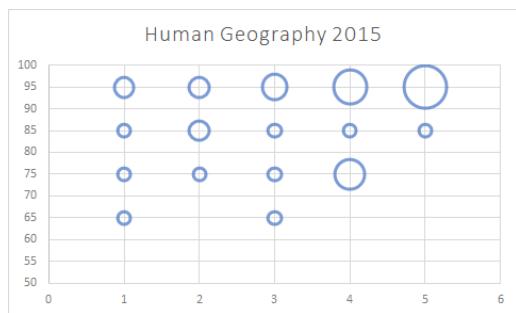


Figure 10. Exam score and class grade were extremely dispersed for Human Geography students. A majority did end up earning 5's on the exam and an A in the class.

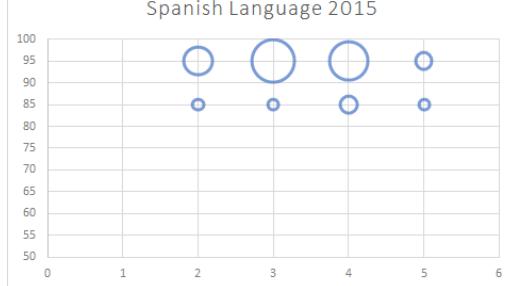


Figure 13. All students earned B's and A's in their Spanish Language class in 2015. Almost all passed the AP exam too, but a few students did receive 2's.

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

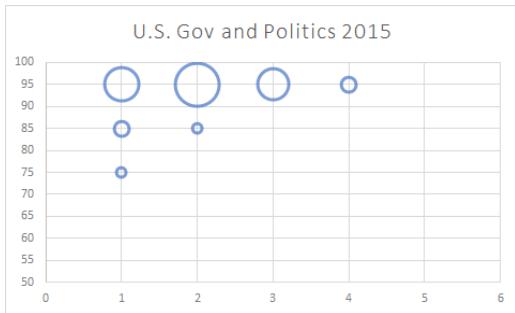


Figure 14. Students taking Government performed well in class, but not as well on the AP exam. Most students earned 2's, or a 1 or 3.

Portfolio Classes

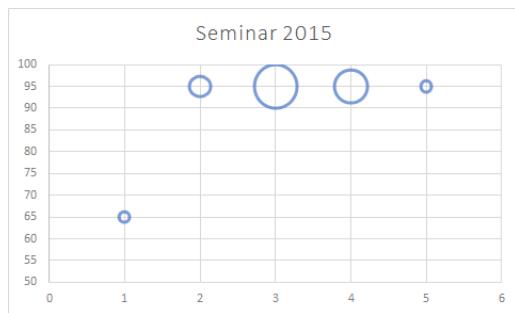


Figure 17. Almost all Seminar students finished the year with an A in the class. Most students earned 3's on their exam, while several achieved a 4.

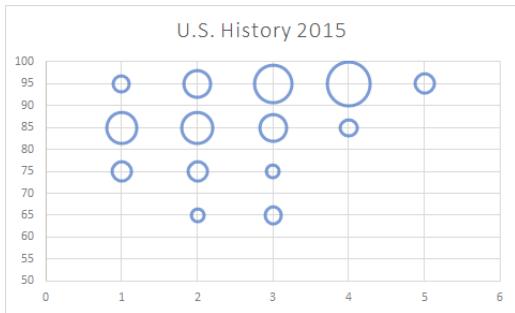


Figure 15. Grades and exam scores were varied greatly in U.S. History. A majority of students did earn both an A and 4. Several students were also able to obtain 5's on their exam as well.

Studio Art: 2D 2015

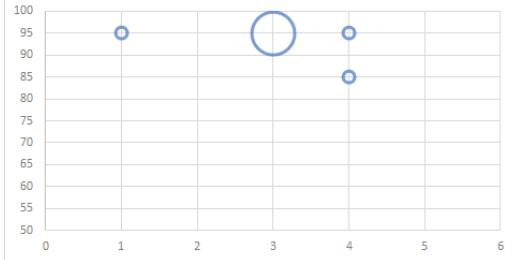


Figure 18. All students earned an A in the class and 3 on the Studio Art: 2D exam except for 3 outliers.

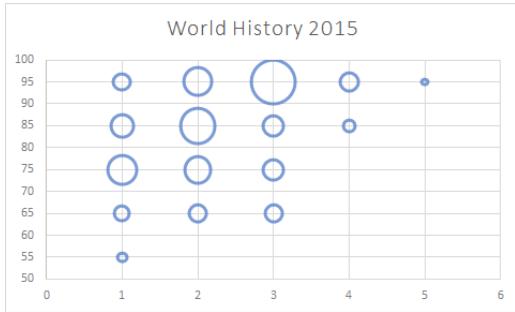


Figure 16. World History students generally did not pass their AP exam, or passed with a 3. Few students earned 4's, and only one earned a 5.

Studio Art: 3D 2015

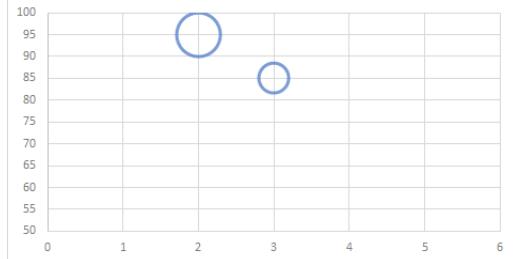


Figure 19. Students in Studio Art: 3D either had an A in the class and 2 on the exam, or a B in the class and 3 on the exam.

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

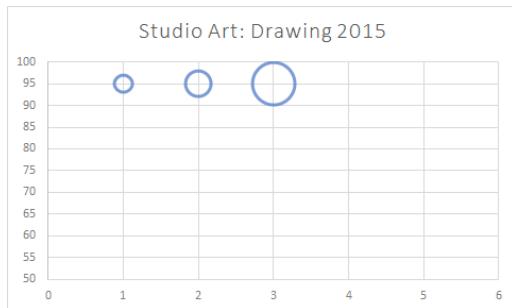


Figure 20. All Studio Art: Drawing students earned A's in their class. On the AP exam, students only scored 3's or lower.

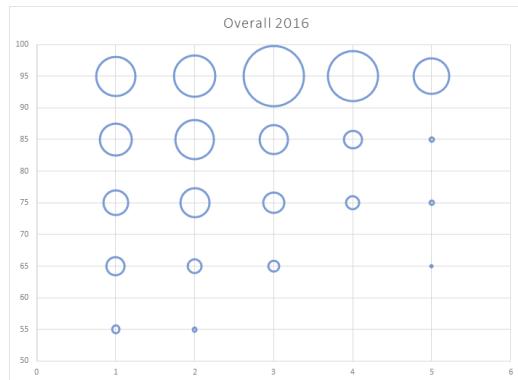


Figure 1. This graph presents an overall view of all the data collected from the year 2016. Most students obtained an A in the class, and a 3 on their exam.

Appendix B

There was a mix of numerical and categorical variables involved in the collection of data. AP Exam Grade refers to the score that a student received on their AP exam, ranging from 1 to 5. Semester Grade refers to the final grade that a student received in their AP class, ranging from 55 to 95. There were a total of 20 different AP exams, within 17 AP classes. AP Government is a yearlong class at NHS, but there are two separate exams, Comparative Government and U.S. Government. AP Studio Art is also offered to students at NHS for a year, but within the class students choose to take the 2D, 3D, or Drawing AP exam. The AP BC Calculus exam provides students with two scores; their BC score and AB subscore. This data was presented in two separate graphs. These 20 AP exams were also split up by type, either traditional or portfolio. Data is represented from 2016.

Traditional Classes

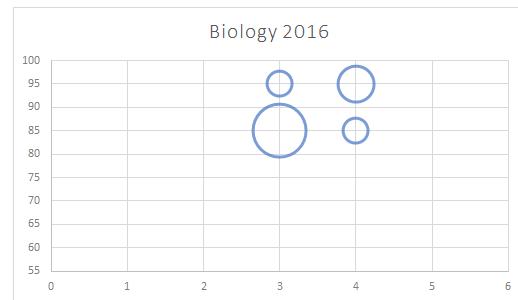


Figure 2. No Biology students earned less than an A or B in 2016. All students also scored a 3 or 4 on their exam.

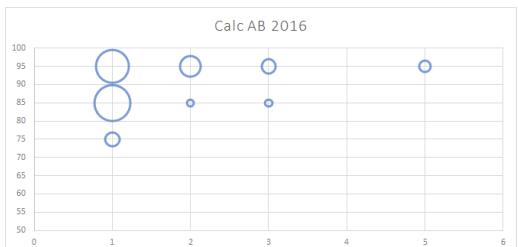


Figure 3. A few outliers were able to obtain 5's on the Calculus AB test, but most students scored a 3 or lower. All students passed the class though with a C or higher.

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

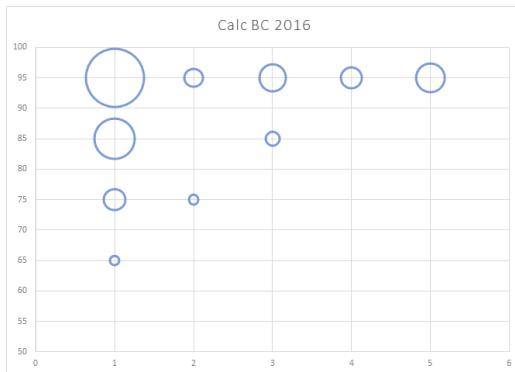


Figure 4. Calculus BC students had varying degrees of performance on the AP test. A majority did not pass, and ended up receiving 1's. Students who did pass almost equally earned 3's, 4's, and 5's.

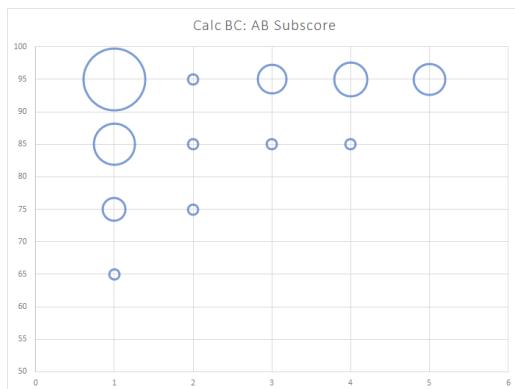


Figure 5. The Calculus BC exam is given two scores. This graph represents the AB subscore for students. Most students also received 1's on this portion of their AP test as well.

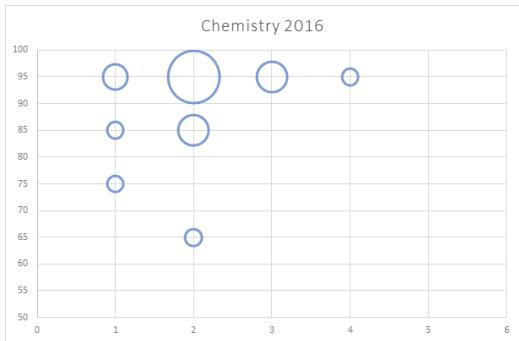


Figure 6. Most Chemistry students scored 2's on their AP exam, but many finished the class with an A.

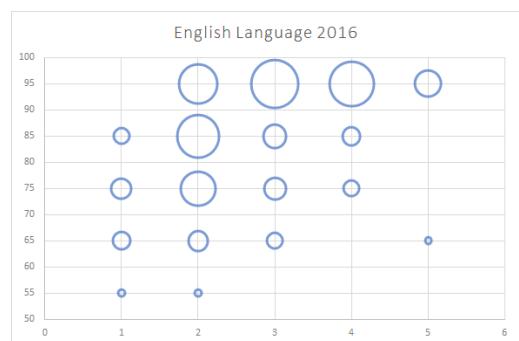


Figure 7. Students performed very differently on the English Language exam. Many students did earn A's in their class and a 3 on the exam. One outlier earned a 5 and had a D in the class.

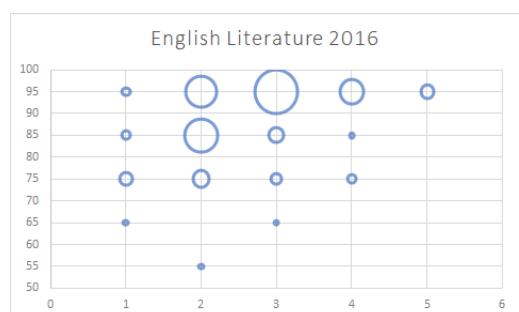


Figure 8. Several students earned 1's on the English Literature exam, despite their class grade. Most students had A's in the class and scored 3's on their exam. A few were able to earn 5's.

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

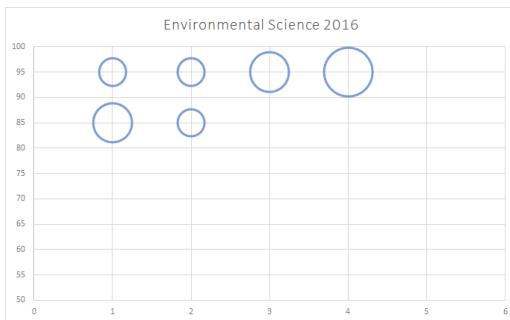


Figure 9. All students in Environmental Science finished the year with at least a B in the class. Half of the class failed the exam while the other half passed.

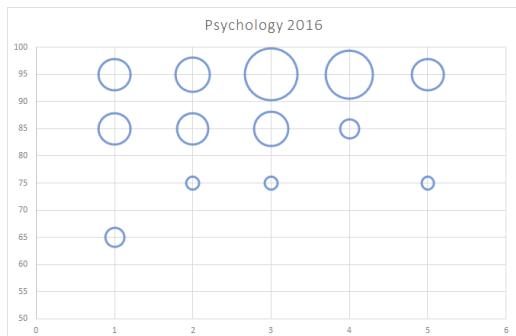


Figure 12. A majority of Psychology students earned A's in the classroom. Several students obtained 5's on the exam, with one outlier who had a C in the class.

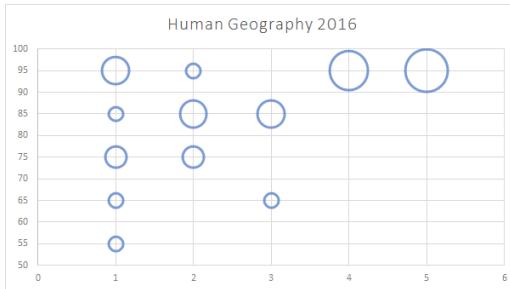


Figure 10. Students scored 1's on the Human Geography exam while also finishing the class with every type of final grade. Several students did earn 4's and 5's, with A's in the class.



Figure 13. All students earned B's and A's in their Spanish Language class in 2016. Most students got a 3 on their exam but several received 5's. An outlier had a B and a 5.

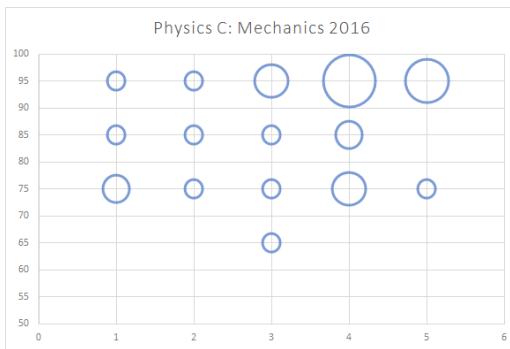


Figure 11. Almost all Physics C: Mechanics students finished the year with an A or B in the class. Most students earned 4's on their exams as well.

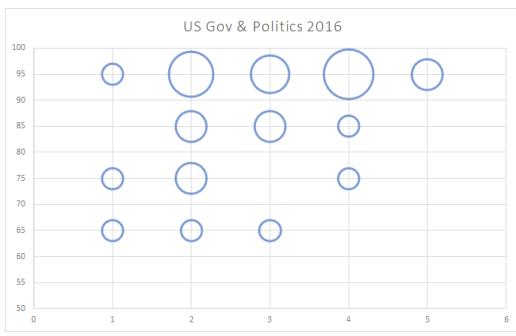


Figure 14. There was great variance between all combinations of class grade and exam score. Most students either had an A and a 4, or an A and a 2.

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

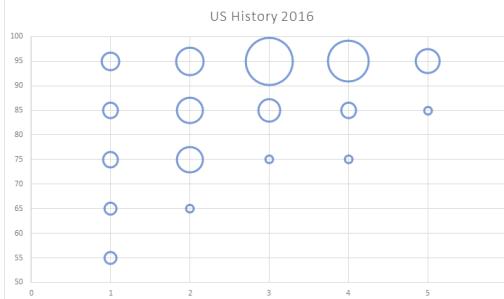


Figure 15. Grades and exam scores were varied greatly in U.S. History. A majority of students did earn both an A and 3 or a 4. Several students were also able to obtain 5's on their exam as well.

Portfolio Classes

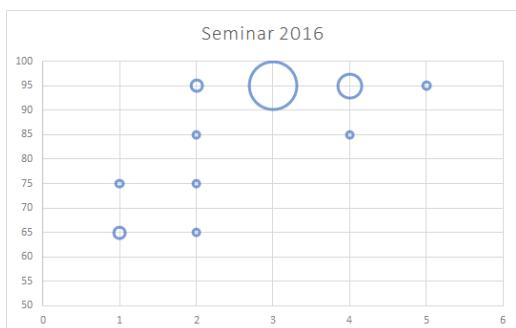


Figure 17. 2016 Seminar students had many outliers. A majority of students earned 3's and A's, and several 4's also occurred. The other combinations were almost all individual.

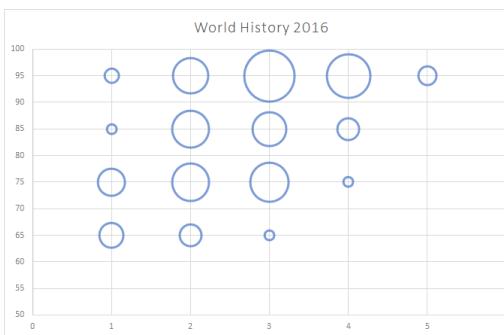


Figure 16. World History students generally did not pass their AP exam, or passed with a 3. Few students earned 4's, and several earned a 5.

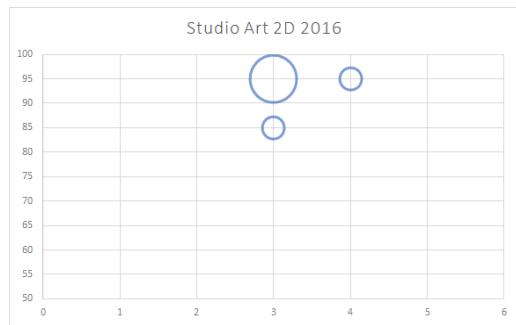


Figure 18. A majority of students earned an A in the class, as well as a 3 on the exam. Two students experienced other combinations of scores.

COMPARING TRADITIONAL AP CLASSES TO PORTFOLIO AP CLASSES

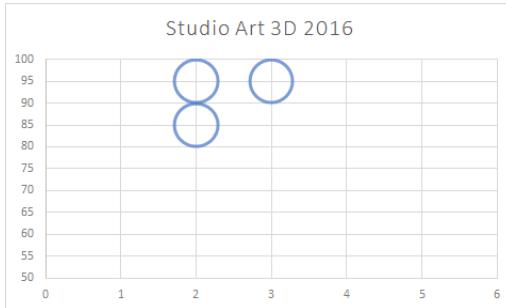


Figure 19. Students in Studio Art: 3D either had an A in the class and 2 or 3 on the exam, or a B in the class and 2 on the exam.

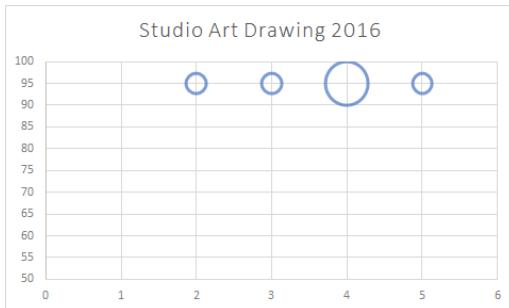


Figure 20. All Studio Art: Drawing students earned A's in their class. On the AP exam, students mostly scored 4's.

Contributors

Pranshu Adhikari was born in Nepal and moved to the United States when she was 10 years old. Since then, she has been attending school in Norman, Oklahoma, where she is actively involved in many organizations, such as Global Awareness Club, Student Congress, National Honor Society, College Board Youth Advisory Council, AEGIS Math, AEGIS English, and AP Capstone. She enjoys learning Physics, studying languages, tutoring math and science, and sleeping.

Annie Cao is a student at Freedom High School in Florida. She has cultivated a lifelong passion for science and hopes to devote her career to scientific research and discovery to improve the lives of people all around the world.

Owen Clute attends Royal St. George's College in Toronto, Canada. He is passionate for the Arts and Humanities subjects. Outside of school he invests a lot of time in photography and sports.

William Deo is a grade 12 student from St. Andrew's College in Aurora, Ontario. Born in Toronto, he has always had an interest in energy and improving the efficiency of systems. This passion has led him to participate in numerous programs such as the SHAD Program, Yale Young Global Scholars (ASE) and the Harvard Science Research Conference. William is an AP Scholar, Captain of his Varsity Swimming Team. He serves as a band leader and trumpet section leader in his school's wind ensemble and participates in district honour bands (CISMF). Looking forward, William looks to pursue studies and a career in Engineering where he sees his purpose as being a change agent in today's and tomorrow's society.

Elizabeth Grace Dickens is a senior at Mabank High School. Her interests are primarily centered around environmental sustainability, governmental policy, and writing. She plans to attend the University of Texas at Austin to study journalism, and hopes to pursue a career in digital journalism focusing on international environmental policy.

Jensen Ghidella is a junior at Gig Harbor High School in Gig Harbor, Washington. She wrote this paper over the course of seven months and whilst in the process discovered a passion for research. Ghidella hopes to become a professional biological researcher when she is older, preferably in a field under neuroscience.

As a researcher at Norman High, **Margaret Goodin** joined the AP Capstone program because she loved to research new topics. She really enjoyed the atmosphere and skills that AP Research provided her for her future. The class has given her valuable skills that she plans to use in college next year and the workforce. She is very proud of the work she has done and was very interested in the topic she chose to pursue.

Ethan Kelly is a Grade 12 AP Research student at Royal St. George's College in Toronto, Ontario.

Sergio Lozano is a High School senior at Colegio Nueva Granada, an American school in Bogota, Colombia. He was born and raised in Colombia, although he lived in Colorado for two years. He has always been passionate about topics within the humanities and the social sciences, such as the relationship between the United States and Latin America. He is also a big fan of film and television, even though enjoys reading novels and plays, going to concerts, and exploring pieces of art.

Lia Martin is a senior at Norman High School in Oklahoma. She will be attending Rice University in the fall. Lia is an accomplished singer and a member of her local Young Democrats club. Her interests include music, social policy, and women's rights.

Leanne Olona is a senior at Norman High School, located in Norman, OK. She will be attending the University of Michigan in Fall of 2017 but is undecided on what she will be studying. She hopes to continue conducting research in the future. Leanne also is a founder of the first recorder club at Norman High School. She plans on growing the club across various high schools as well as universities.

Elizabeth Phillips is a senior at Norman High School, she will be attending the University of Oklahoma in the fall of 2017. While attending this university she plans to major in biomedical engineering, with a pre-med track. Elizabeth spends most of her time on the tennis courts, and hanging out with friends.

Calla Reed is a rising senior at duPont Manual Magnet High School in Louisville, Kentucky. She enjoys writing papers examining various social injustices, such as welfare discrimination, the lack of indigenous rights, aspects of racism and racial discrimination, and educational inequality. This summer she also plans to conduct a research project within the National Institute of Health. She plans to attend a 4-year university as a pre-med and biochemistry major, in high hopes of attending medical school and becoming a trauma surgeon, who will work with the United Nations in order to assist in the pursuit to a higher standard of global health. In her free time, she enjoys playing varsity tennis, tutoring middle school students, volunteering at various hospitals, and being co-president of her school's mental health awareness club and feminism club.

Hollyn Saliga is a rising Senior at Lake Howell High School in Winter Park, Florida who takes interest in Psychology and History.

Greg Schwartz is a junior in duPont Manual High School's MST magnet. He stays busy competing in debate, robotics, and tennis. In his free time Greg enjoys programming, discussing philosophy, and rock climbing.

Brooke Shapiro is a junior in high school. She is the founder and editor-in-chief of a female empowerment collaborative blog called The F-Word. She is interested in film, journalism, and feminism.

Palmer Short is a high school student with an interest in science. He hopes to begin his academic portfolio by publishing a paper this summer.

Faculty and Advisors to Contributors

Sarah DeWitt is a teacher at Norman High School in Norman, Oklahoma where she leads the school's AP Capstone program and also teaches world history. She currently is pursuing a Master of Education degree at the University of Oklahoma in Instructional Leadership and Academic Curriculum. Her academic research interests include inquiry-based learning and culturally-responsive practices. She has presented at the Oklahoma Council for Social Studies State Conference and received the Spriesterbach Award from the Oklahoma Library Association. Sarah builds her teaching practice around her students' innate curiosities and the development of student agency in the learning process.

Jessica Hupper teaches at Gig Harbor High School in Gig Harbour, Washington.

Megan Lewandowski teaches at Freedom High School in Tampa, FL

Stacey Marten teaches at Gig Harbor High School in Gig Harbour, Washington.

Lauren Oliva is a Social Studies and AP Capstone teacher at Lake Howell High School and their 2017 Teacher of the Year. She has taught at Lake Howell for six years and was instrumental in the development and implementation of the AP Capstone program. She has also grown the AP Art History program and inspires young people to travel the world and explore different cultures. She is proud to be a Silver Hawk alumna and to continue the tradition of Lake Howell excellence. Recently, she participated in a scholarship program to study History and Politics at the University of Oxford's Exeter College in the summer of 2016 and is a consultant for College Board's AP Seminar summer institutes. A dedicated educator, she is always seeking new opportunities to better education either with her own students or through mentoring new teachers.

Samantha Scheepers is an Upper School English and AP Research teacher at St. Andrew's College. She is also the chair of school's Standing Committee for Excellence in Teaching and Learning. She holds a Master's of Teaching, specializing in metacognition and reading comprehension, as well as a BA (Hons.) with high distinction in English and Renaissance Studies from the University of Toronto. She has recently completed a teaching fellowship focused on leadership in independent schools at Columbia University and has presented her research on cooperative learning through the International Boys' School Coalition.

Dr. Sal Severe has been a school psychologist for over thirty years. He was formerly the Director of Flor del Sol alternative school in the Cartwright School District in Phoenix, where he was also the Chairman of the Psychological Services Department. He has provided field supervision for school psychology internships for Arizona State University and Northern Arizona University. He has taught graduate courses in research methods. He has provided consultation for the University of Arizona, the Arizona Department of Education and the Arizona Department of Corrections. The Executive Board of the Arizona Association of School Psychologists named Dr. Severe the Arizona School Psychologist of the Year 2001. Dr. Severe served on the Board of Advisors for *Parents* magazine for ten years. His *New York Times* best-selling book, *How To Behave So Your Children Will, Too!* has sold over 800,000 copies and has been translated into twenty-one languages. He is currently semi-retired in Gig Harbor, WA. where he provides consultation to the Peninsula School District.

Lindsay Tait is a teacher at H. B. Plant High School in Tampa, Florida.

Bryan E. Wilk holds both a bachelors and masters of science from the University at Buffalo in the field of exercise science with a concentration in biomechanics. He is a former bioengineer who worked at the Texas Scottish Rite Hospital for Children. He currently teaches chemistry and research design at Lake Howell High School.

Aaron M. Williams is the Dean of Academics at Mabank High School in Mabank, Texas. He coordinates academic activities on the High School campus in addition to working with students in AP Research. Mr. Williams is from Rio Vista, Texas and attended Northwestern State University of Louisiana, graduating with a degree in Music Education in 2009. He began work as a band director in Mabank, Texas in 2009, and upon completing his Master's degree in Educational Leadership from Stephen F. Austin State University, launched the Mabank Scholars' Institute in 2013 to meet the needs of advanced and G/T students at the high school level. AP Capstone was an integral part of that effort. In addition to his duties at Mabank High School, he also serves as the Vice President of Development for the Mabank Independent School District Education Foundation. He is currently working towards a doctoral degree in Entrepreneurial Leadership in Education through Johns Hopkins University in Baltimore, MD. Mr. Williams is passionate about his profession, dedicated to his students, and obsessed with learning..

Alesia Williams has a background in the humanities. She has a BA in art history from Berea College and has completed coursework for a MA from the University of Cincinnati. She has a MAT with a focus on English from Spalding University. She has been teaching in the public school system in Louisville, KY for sixteen years. Thirteen of those years have been at duPont Manual High School which has five magnets and is typically ranked as the best high school in Kentucky. She has been teaching AP English Language and Composition for ten years and AP Research for one year. She is focused on helping her students achieve at the highest levels especially in regards to academic writing. She encourages her students to think of themselves as writers and to pursue writing competitions and publication. Her students have been recognized with top honors from the NCTE and KCTE writing competitions, the Scholastic Art and Writing competition, and the MIT INSPIRE research competition.

Glenn Zwanzig teaches at duPont Manual High School in Louisville, Kentucky.

Editors of the Journal

Barrie Bennett
BPE, MEd, PhD

Barrie Bennett is professor emeritus at the Ontario Institute for Studies in Education at the University of Toronto (OISE/UT). His research work focuses primarily on the design of powerful learning environments for students and teachers through the process of systemic change. He is currently working in districts in three countries on long-term projects related to instructional intelligence and systemic change (Australia, Ireland and Canada). Instructional intelligence involves intersecting the current research on curriculum, assessment, and instruction guided by what is known about how students and teachers learn. That intersection being driven by what is known about change and systemic change. He also assists teachers, schools, and districts with issues related to classroom management and school wide-discipline. Barrie has taught at the elementary and secondary levels, as well as, having worked in group homes, prisons, and security units for juvenile offenders. He has written six books: *Cooperative Learning: Where Heart Meet Mind*; *Classroom Management: A Thinking and Caring Approach*; *Beyond Monet: The Artful Science of Instructional Integration*; *Graphic Intelligence: Playing With Possibilities* and most recently *Power Plays*. Currently he is just finishing a text titled, *Effective Group Work: Beyond Cooperative Learning*.

Anthony Campbell
BA, MA, PhD

Anthony Campbell established Grow for Good Urban Teaching Farm in 2013 as a business model innovation laboratory and learning centre for young entrepreneurs. He spent time working throughout North America, Europe, Australia, Asia and now resides in his hometown of Toronto. Examples of Anthony's work are documented in *The Innovator's Field Guide* (2014), co-authored by David Crosswhite and Peter Skarzynski, as well as multiple Harvard Business School and Corporate Executive Board case studies chronicling the innovation and capability-building efforts of companies such as Samsung, Whirlpool, Best Buy and McDonald's. Previously, Anthony taught Film Studies, Writing and English Literature at The University of Western Ontario.

Jeremy B. Caplan
ScB, PhD

Jeremy Caplan is an Associate Professor in Psychology Department at the University of Alberta, where he is also the Principal Investigator at the University of Alberta Computational Memory Lab. The lab is focused on human verbal memory behaviour and its basis in cognitive and neural processes. The team takes several approaches towards research, including mathematical modeling, measures of behaviour in the cognitive psychology tradition, and measures of brain activity using electroencephalography (event-related potentials and oscillations) and functional magnetic resonance imaging. He has been a referee for 38 academic journals.

Hance Clarke
BSc, MSc, MD,
PhD, FRCPC

Dr. Clarke is the director of Pain Services and the medical director of the Pain Research Unit at the Toronto General Hospital. He is appointed to the Institute of Medical Sciences at the University of Toronto and is a graduate of the Royal College Clinician Scientist Program. His research interests include identifying novel acute pain treatments following major surgery, identifying the factors involved in the transition of acute postsurgical pain to chronic pain, studying the genetics of acute and chronic pain after surgery, and identifying risk factors associated with continued opioid use and poor health related quality of life after major surgery as well as the efficacy of hyperbaric medicine. Over the past five years he has authored 47 peer reviewed manuscripts.

Will Fripp
BA, MA

Will Fripp is a public affairs and political risk analyst for Canadian and international clients and a historian specializing in intelligence and espionage. 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, Will was the historian for the high school history curriculum www.Spiesintheshadows.com, reviewing Canada's intelligence history with its influences on Canada's national development. An occasional lecturer, Will's writings and review articles have appeared in the peer-reviewed academic journal *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 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.
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.
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 <i>Leadership and Policy in Schools</i> , <i>The Dalhousie Review</i> , and <i>The Nashwaak Review</i> .
Lori Loeb BA, MMSt, 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 <i>Consuming Angels: Advertising and Victorian Women</i> . 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.
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.

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.

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

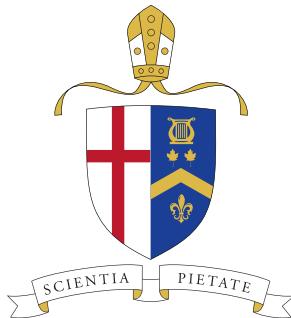
- All studies involving human participants must have been approved by a Research Ethics Board

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