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Theory of Mind Ability in Opposite-Sex Twin Females: The TTT Hypothesis

Rakshita Kota

This study researched the Twin Testosterone Transfer hypothesis, which predicts that “Female fetuses developing between two males [in the womb] tend to show masculinized ... traits as adults ... due to the transfer of testosterone from male fetuses” (1). This study aimed to determine whether opposite-sex twin females had lower socio-cognitive ability as compared to singleton females through the “Reading the Eyes Through the Mind Test” (RMET) test, which measures a form of social cognition known as “Theory of Mind”. Thus, the study tested the question, “Does the exposure to elevated levels of prenatal testosterone for opposite-sex twin females result in lower Theory of Mind ability?” Ultimately, the results showed that opposite-sex twin females have lower RMET scores, and therefore lower socio-cognitive ability than singleton females, thus validating the Twin Testosterone Transfer hypothesis.

Keywords: Twin Testosterone Transfer hypothesis, Theory of Mind, Social cognition, Opposite-sex twins

INTRODUCTION AND BACKGROUND INFORMATION

Research regarding fraternal twins is very limited compared to the extensive amount of studies and research done on identical twins. Within fraternal twins, one recent and under-researched topic is the Twin Testosterone Transfer (TTT) theory, which is

a specific case of the Prenatal Testosterone Transfer (PTT) theory. The PTT theory is the phenomenon that hypothetically occurs when testosterone utilized by a developing fetus transfers to other embryos in the womb through either amniotic fluid or via the mother’s blood stream, therefore influencing the development of these fetuses (1). While this has been researched in various animals such as rodents and pigs (1), it has rarely been tested in twins, due to its recent discovery in the field of twin studies. The PTT theory

in regards to humans specifically is the TTT theory, which hypothesizes that females in opposite-sex (OS) twin pairs, are exposed to higher levels of testosterone than singleton, or single-birth, females due to testosterone transfer from their male co-twins (2). The TTT theory in OS twins has been tested by various studies in order to determine whether this elevated exposure of testosterone for OS twin females results in more male-typical behavior in the OS twin females.

LITERATURE REVIEW

Previous studies on the TTT Theory on OS Twin Females

There is currently limited research on the Twin Testosterone Transfer theory. Past studies have tested the effect of the TTT theory on female opposite-sex twins in regards to physical (3), socio-economic (4), behavioral (5), and cognitive (6) perspectives. The results of past studies are split, with some studies being in support of the TTT theory and some studies either rejecting it or stating that they can neither validate nor invalidate the theory.

The studies in support of the TTT theory^{3, 4, 5, 6} determine that these individuals seem to be more male-typical than singleton females. For example, in relation to the physical perspective of the TTT theory, researchers at the University of Adelaide in Australia tested the dental crown size of OS twin and singleton (S) females. Dental crown size is a reliable measure used by many researchers to test the biological difference between males and females, as it is established that females consistently have smaller dental crown sizes than males (3). Dempsey, Townsend, and Richards (1999) found that OS twin females had significantly larger dental crown sizes than the S females, therefore supporting the theory that the TTT phenomenon results in OS twin female masculinization (3). In relation to the *socio-economic* perspective of the TTT theory, a large-scale study was done using a total of 13,800 twin births. By tracking these twins over the course of 30 years, researchers found that OS twin females are less likely to graduate from high school (-15.2%) or get married (-11.7%) (4). Additionally, researchers also found that OS twin females have lower fertility rates (-5.8%) and life-cycle earn-

ings (-8.6%) (4). While the findings of their study do not necessarily show that OS twin females are more “male-like”, the findings are “consistent with the idea that passive exposure to prenatal testosterone changes women’s education, labor market, and fertility outcomes”, which proves a biological sex-difference as a result of exposure to prenatal testosterone (4).

Additionally, in respect to the *behavioral* perspective, a study conducted on 422 British twin pairs tested the Sensation Seeking Scale (SSS) score of each pair (5). Sensation seeking is defined as the tendency to take risks to pursue sensory and complex pleasures (for example, skydiving). Because males are found to consistently have higher SSS scores, this British study tested the SSS in OS twin females to determine whether OS twin females are more male-typical in this aspect. In this study, the researchers found an increase in SSS scores in OS twin females (5). In addition, several studies were conducted regarding the spatial visualization ability (*cognitive* perspective) of OS twin females via mental rotation tests. Mental rotation is the ability to rotate objects in one’s mind by merely visualizing it, and it is established that men consistently perform better in these tests than females. In a mental rotation study on OS twins published by the Association for Psychological Science, OS twin females exhibited superior spatial abilities than their S female counterparts (6).

In all four of the aforementioned studies, the results of each of the studies support the TTT theory regarding their various perspectives. However, it is important to note that there are also several studies that either reject the Twin Testosterone Transfer theory or state that they can neither validate or invalidate the theory^{7, 8, 9}. For example, in a cognitive national Danish cohort study conducted on 1812 OS twins, 4050 same-sex (SS) twins, and 13,900 singletons, by comparing ninth grade test scores of several subjects, researchers found that males performed significantly better than females in mathematics tests, and the opposite was true for Danish tests (7). However, the researchers “did not find that OS females performed better in mathematics than SS and singleton females”. Thus, they concluded that the study showed no evidence for the masculinization of OS twin females with their male co-twins, meaning that the TTT theory in regards to academic performance was invalidated with this study (7). In another study done by research-

ers from the Indiana University Department of Psychology, researchers studied the attitudes associated with femininity and the fertility of Finnish SS and OS twins. They found that “there was no evidence of differences between sisters from same- and opposite-sex twin pairs, and thus, no evidence of either androgenization or cross-sex socialization” (8). While the last two studies rejected the TTT hypothesis, there are also studies that state that it cannot be proved or disproved until further research is conducted. For example, in a study done by the School of Psychology at the University of Western Australia, researchers conducted a systematic review by consolidating and reviewing the evidence of previous studies that also focused on the TTT hypothesis. For example, they used studies on “behavioral, perceptual, cognitive, morphological and physiological traits”, sensation-seeking, perception (otoacoustic emissions), visuo-spatial ability, and physiology and morphology (specifically tooth size, 2D:4D ratio, and brain volume) and evaluated whether the culmination of this evidence can determine a clear-cut “yes” or “no” answer on whether the TTT phenomenon is apparent in humans (9). Ultimately, they concluded that although the evidence is inconsistent, “the evidence for the TTT hypothesis is sufficient to warrant further investigation” (9). Thus, given the varying conclusions regarding the TTT hypothesis, more research needs to be done to ensure that the scientific community one day reaches a consensus on this theory.

Under-researched Cognitive Perspective of the Twin Testosterone Transfer

While the TTT theory has been previously tested^{1,2,3,4,5,6,7,8,9} regarding the behavioral, physical, socioeconomic, morphological, physiological, and cognitive perspectives, one of the most important and under-researched perspectives of the TTT is the cognitive perspective, which is the perspective that studies how excess prenatal exposure to testosterone affects the cognition of OS twin females. There are three basic, major variables under the cognitive field that can be tested due to previously demonstrated biological sex differences: spatial visualization, language comprehension, and social cognition. Previous studies have attributed male advantage in spatial visualization to their higher levels of testosterone (10). On the other

hand, past studies have attributed female advantage in language comprehension and social cognition to their lower levels of testosterone, meaning that these variables can be attributed back to the Twin Testosterone Transfer theory, if tested in OS twin females (11). The TTT theory in relation to spatial visualization has already been tested in multiple studies in OS twin females, by measuring mental rotation ability, as mentioned previously. However, the other two variables, language comprehension and social cognition, have yet to be tested in opposite-sex twin females.

Theory of Mind Ability and the RMET Test

Between the two variables, language comprehension and social cognition, I chose to test social cognition because it is easier to measure quantitatively than language comprehension.

Within social cognition, I chose to test the Theory of Mind trait. Theory of Mind is the socio-cognitive ability to “explain and predict other people’s actions in terms of underlying mental states, such as beliefs, intentions, or feelings” (12). Theory of Mind is often tested using the Reading the Mind in the Eyes test (RMET).

Additionally, low Theory of Mind ability is typically associated with Autism Spectrum Disorder thus, as a result, the RMET test is generally used to test the degree of Autism Disorder in an individual. In a previous study, Mauro Adenzato and her team found that females significantly perform better than males in Theory of Mind ability (12); thus, in relation to the TTT theory, it is practical to test the Theory of Mind ability of OS twin females and S females. However, in a notable previous study conducted that researched a similar topic, the results were opposite to what was expected. In this study conducted from data from the Swedish Child and Adolescent Twin Study, researchers tested whether OS twins were more likely to reach the cutoff score for ASD than same-sex (SS) twins. Contrary to what the researchers hypothesized, the findings of the study were that SS twin females were closer to the Autism Spectrum Disorder cutoff score than OS twins. Furthermore, the researchers were at a loss as to explain why, as according to the TTT theory, OS females should be closer to the Autism Disorder spectrum (13).

RESEARCH GAP

My research addresses an apparent gap in current literature because as mentioned previously, the TTT theory is a recent topic in the twin studies field and thus needs to be more extensively studied. Additionally, the cognitive perspective of the TTT theory is an important aspect of the TTT; however, it is currently under-researched. Furthermore, the confusion and inconsistent results regarding ASD and the TTT theory further validates my choice of research. Thus, I have chosen to conduct a study similar to the ASD study mentioned previously. However, instead of measuring ASD prevalence in general, I am measuring the prevalence of a specific trait of ASD: Theory of Mind.

PURPOSE AND HYPOTHESIS

The purpose of my study is to determine whether OS twin females have lower RMET scores, and therefore lower social cognition ability due to the TTT theory as compared to females. Since it is assumed that OS twin females have higher testosterone levels than S females, there is a chance that this will result in lower Theory of Mind scores. With this arises the research question: “Does the exposure to elevated levels of prenatal testosterone for opposite-sex twin females result in lower Theory of Mind ability?” Given my review of literature, I am predicting that opposite-sex twin females have a lower Theory of Mind ability (RMET scores) than their singleton female counterparts due to their exposure to excess prenatal testosterone in the womb.

METHODOLOGY

RMET and Data Collected

For this study, I tested two groups: OS twin females and S females. For these two groups of females, I assessed their Theory of Mind ability, which is a form of social intelligence that determines how well one can read facial expressions and interpret social cues. I assessed their Theory of Mind ability using the RMET (Reading the Mind in the Eyes Test) developed by professor Simon Baron-Cohen at the University of

Cambridge in order to test social intelligence.

It has been adapted by the Autism Research Center (ARC) and is sometimes used to test for certain autism traits. The RMET test is publicly available for research purposes on the ARC website (14). The RMET test is an assessment in which the participant is given 36 questions.

Each question consists of a picture of a set of eyes, and the participant is asked to choose the emotion that the person in the picture is feeling by merely looking at the set of eyes. Because the test is a multiple-choice exam, it was feasible and convenient for me to conduct the study and quantify the results. The only data or information I needed to collect from my study participants was their RMET score.

Participants

For this study, participants include one group of singleton females (41) and one group (7) of opposite-sex twin females. This was because in order to determine whether OS twins had higher average RMET scores than S females, both groups of data had to be analyzed. In order to get opposite-sex twin participants, I sent out a survey (Appendix A) to English teachers of all high schools in a large and racially diverse Texas school district. The teachers distributed the survey to their students via a QR code that I had given them ahead of time. I also sent the survey to other AP Research teachers in the United States, who forwarded my survey to their students.

In the survey, I asked the students whether they were an opposite-sex twin female and if so, I asked them to provide their email address in order to contact them. I kept the survey open for approximately three weeks to allot adequate time to gather interested participants. After the three weeks, I sent out an email (Appendix F) to the OS twin females regarding the details and purpose of my study in order to provide them with context regarding my research. In this email, I also sent out a link to the online RMET test (Appendix C) and requested the opposite-sex twin females to take the test. I instructed them to take a maximum of 10 minutes for the test so that each participant takes roughly the same amount of time in order to complete the test. This way, no one person is at an advantage for having more time to take the test than another. They were also allowed to use

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a supplementary vocabulary document (Appendix E) to aid them. The document consisted of the words and definitions of all of the words on the RMET test: most words were above-average in vocabulary level. Because of the supplementary document provided, no one person was at an advantage for having a higher vocabulary than another.

In order to attain participants for my singleton female group, I sent a survey (Appendix B) to all English teachers of one high school in the aforementioned school district as well as the same AP Research teachers around the US. The rest of this process was the same as the process described in the previous paragraph (Appendix D, E, and G). The survey participants were high school students mostly from the same large, racially and economically diverse, urban Texas school district so that the Theory of Mind ability of students from varying backgrounds could be analyzed and interpreted.

Data Analysis

After getting back RMET scores from both the singleton females and the opposite-sex twin females, I then compared the averages for both groups using the t-test to determine whether or not RMET scores (and therefore Theory of Mind ability) of OS twin females are significantly lower - and also not due to random chance - than singleton females, thus validating or disproving the TTT hypothesis.

Materials

For this study, necessary materials included a computer with internet access. This was necessary for procedures such as emailing participants and teachers (Gmail), attaining participants (Google Forms), and analyzing data (Google Sheets). There was no need for any additional special equipment or resources to collect data or information, because all parts of my study was done via online surveys and an online RMET test. The RMET test that I had used for my study was provided by the Autism Research Center. Their tests are public for researchers to use. The paper version of the test can be found at the Autism Research Center website in the "Tests" tab under the "Eyes Test (Adult)" drop-down menu (14).

Limitations of Methodology

The biggest limitation to this methodology is that if the S or OS twin females become frustrated with the RMET assessment midway, they may not give their best attempt on some -or all- of the questions, which would impact the data. While this may be true for any adolescent that takes the RMET test, it especially applies to this study because this study is not professionally administered. Due to the lower stakes and low pressure nature of my study compared to the professional administration of the test (which is used to screen for autism), this concern is especially apparent in my study.

RESULTS AND DISCUSSION

Survey Data

In total, the survey (online RMET test) for OS twin females gained 7 responses from students. The RMET test for singleton females gained 41 responses overall. As shown by Figure 1, OS twin females had an average RMET score of 29.43 and the singleton females had an average RMET score of 32.19 meaning that the singleton females had a higher average score of RMET.

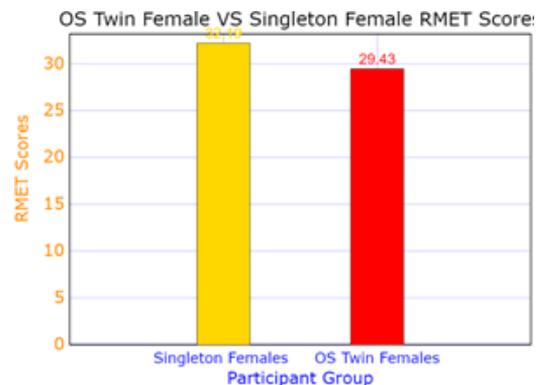


Figure 1 compares the average RMET scores of opposite sex twin females and singleton females

While these two numbers may be different, in order to be sure that my RMET averages were statistically different (meaning that the discrepancy is

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not a result of natural fluctuation), I conducted a two-sample t-test. After inputting information such as the sample means of the groups, the sample standard deviations, and the sample sizes into an online calculator, the final p-value turned out to be 0.033. Because this value of 0.033 is less than the standard significance level of 0.05, I reject the null hypothesis that the two RMET averages are not statistically different. This means that the data support the alternate hypothesis that the average RMET score of opposite sex twin females is statistically different from the average RMET score of singleton female. This means that the discrepancy of average RMET scores between singleton and opposite-sex twin females is not due to random chance. Instead, we attribute it to a biological reason: the twin testosterone transfer hypothesis. The study's results support the TTT hypothesis that opposite sex twin females display more male-typical characteristics due to their exposure to higher levels of testosterone. Ultimately, despite the possible shortcomings listed in the previous limitations section, the methodology still proved successful in answering my research question

and fulfilled my purpose of determining whether OS twin females had lower social cognition ability due to the TTT theory.

Limitations of Results

A major possible limitation to my findings is the small sample size of singleton and OS twins. According to the Central Limit Theorem, a statistics concept that states "if you take sufficiently large random samples from the population with replacement, then the distribution of the sample means will be approximately normally distributed", a sample size of 30 is sufficient to represent a population (16). Although the results of the singleton females may be relatively reliable because their sample size of 41 was greater than 30, the reliability of the OS twin results is admittedly questionable, as their sample size of 7 was significantly lower than 30: this small sample size allows for high variability in the OS twin group's data. Furthermore, another possible limitation of my findings is that because most (about 75%) of the singleton females were from the same school, a highly competitive school with students of comparatively high socio-economic status, their Theory of Mind ability may in some way

be skewed compared to the general population. Additionally, the same goes with the OS twin females, although to a lesser extent. This is because although all of the OS twin females are from the same district, the district is comprised of high schools with various backgrounds and socioeconomic statuses.

Thus, this limitation may not drastically change the data.

CONCLUSION

The study's results confirmed the initial hypothesis that opposite-sex twin females have a lower Theory of Mind ability (RMET scores) than their singleton female counterparts. The findings that I have presented support previous studies, because similar to the work done by the University of Adelaide on dental tooth crowns (3), the work done by Northwestern University on the socio-economic aspect (4), and the work done by the Association for Psychological Science on mental rotation (6), the results of my study confirm the twin testosterone transfer theory.

Specifically in this case, they show that the decreased RMET scores, or Theory of Mind ability for opposite sex twin females can be attributed to the increased exposure to testosterone for opposite sex twin females in comparison to singleton females.

Implications and Reflection

My findings have implications in the twin community. For one, it shows the extent to which the mother's womb and an individuals' prenatal environment can have on an individual throughout their life. This is important because it can lead to further exploration of differing maternal environments that may also affect individuals later on in their lives. Second, it shows that opposite sex twin females differ in thinking from singleton females. This is important because it may lead to future research on how and which types of cognitive function differ between singleton and opposite-sex twin females: my study only looked specifically into social cognition. Most importantly, my results bring the scientific community one step closer to one day reaching a consensus regarding the twin testosterone theory.

Future Research

Most research conducted on the Twin Testosterone Transfer Theory examines the effect of prenatal testosterone transfer between male and female co-twins in the womb on behavioral and physical perspectives 2, 4, 6, 7; however, few studies have examined the effect of this testosterone transfer phenomenon in regards to the cognitive perspective, specifically, social cognition. Consequently, future research for determining the validity of the Twin Testosterone Transfer Theory should further and expand on my study by comparing RMET scores of four groups: singleton males, singleton females, opposite-sex twin males, and opposite-sex twin females. This avenue for future research is significant since it allows one to determine whether the difference in social cognition of opposite-sex twin females aligns more with males than females, vice-versa, and by how much. Additionally, by adding an opposite-sex twin male group as well in the study, one can observe the effects, if any, of the females hormone transfer in the womb on their male co-twin.

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Appendix A:

Survey to district High Schools to attain opposite-sex twin female participants

Research Study Participation Survey - OS Twin Females

This survey is meant to get the contact information of opposite-sex twin females for a research study being conducted.

Are you an opposite-sex twin female? (In other words, are you a female that has a twin brother?) *

Yes

No

If you answered yes to the previous question, please provide your email address so that you can be contacted regarding a research study. The research study will just be a quick, 10 minute online assessment. Results will not negatively affect you in any way. Your participation would greatly help!

Short answer text

Appendix B:

Survey to English teachers at High School to attain singleton female participants

Research Study Participation Survey - Singleton Females

This survey is meant to get the contact information of singleton females for a research study being conducted.

*** Required**

Are you a female? Because this survey is focused on females, if you are not a female, the survey will end for you. *

Yes

No

Do you have a twin or triplet? *

Yes

No

If you answered "yes" to the first question and "no" to the second question, please provide your email address below in order to participate in a research study. The research study is just a quick, 10 minute online assessment. Results will not negatively affect you in any way. Your participation would greatly help! *

Your answer _____

Appendix C:

Online RMET test images for opposite-sex twin females

Section 1 of 37

Research Study RMET Test - OS Twin Females

Thank you so much for participating!

Please fill out the following form and answer the following 36 questions to the best of your ability. DO NOT TAKE MORE THAN 10 MINUTES. If you do not know what a word means, you may search it up in the supplementary definitions handout provided.

1. What emotion do you believe the eyes below are showing? *

- Playful
- Comforting
- Irritated
- Bored

Picture 1



Section 2 of 37

Question 2

Description (optional)

2. What emotion do you believe the eyes below are showing? *

- Terrified
- Upset
- Arrogant
- Annoyed

Picture 2



Section 3 of 37

Question 3

Description (optional)

3. What emotion do you believe the eyes below are showing? *

- Joking
- Flustered
- Desire
- Convinced

Picture 3



Section 4 of 37

Question 4

Description (optional)

4. What emotion do you believe the eyes below are showing? *

- Joking
- Insisting
- Amused
- Relaxed

Picture 4



Section 5 of 37

Question 5

Description (optional)

5. What emotion do you believe the eyes below are showing? *

- Irritated
- Sarcastic
- Worried
- Friendly

Picture 5



Section 6 of 37

Question 6

Description (optional)

6. What emotion do you believe the eyes below are showing? *

- Aghast
- Fantasizing
- Impatient
- Alarmed

Picture 6



Section 7 of 37

Question 7

Description (optional)

7. What emotion do you believe the eyes below are showing? *

- Apologetic
- Friendly
- Uneasy
- Dispirited

Picture 7



Section 8 of 37

Question 8

Description (optional)

8. What emotion do you believe the eyes below are showing? *

- Despondent
- Relieved
- Shy
- Excited

Picture 8



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Section 9 of 37

Question 9

Description (optional)

9. What emotion do you believe the eyes below are showing? *

- Annoyed
- Hostile
- Horrified
- Preoccupied

Picture 9



Section 10 of 37

Question 10

Description (optional)

10. What emotion do you believe the eyes below are showing? *

- Cautious
- Curious
- Bored
- Aghast

Picture 10



Section 11 of 37

Question 11

Description (optional)

11. What emotion do you believe the eyes below are showing? *

- Terrified
- Amused
- Regretful
- Flirtatious

Picture 11



Section 12 of 37

Question 12

Description (optional)

12. What emotion do you believe the eyes below are showing? *

- Indifferent
- Embarrassed
- Skeptical
- Dispirited

Picture 12



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 13 of 37

Question 13

Description (optional)

13. What emotion do you believe the eyes below are showing? *

- Decisive
- Anticipating
- Threatening
- Shy

Picture 13



Section 14 of 37

Question 14

Description (optional)

14. What emotion do you believe the eyes below are showing? *

- Irritated
- Disappointed
- Depressed
- Accusing

Picture 14



Section 15 of 37

Question 15

Description (optional)

15. What emotion do you believe the eyes below are showing? *

- Contemplative
- Flustered
- Encouraging
- Amused

Picture 15



Section 16 of 37

Question 16

Description (optional)

16. What emotion do you believe the eyes below are showing? *

- Irritated
- Thoughtful
- Encouraging
- Sympathetic

Picture 16



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 17 of 37

Question 17

Description (optional)

17. What emotion do you believe the eyes below are showing? *

- Doubtful
- Affectionate
- Playful
- Aghast

Picture 17



Section 18 of 37

Question 18

Description (optional)

18. What emotion do you believe the eyes below are showing? *

- Decisive
- Amused
- Aghast
- Bored

Picture 18



Section 19 of 37

Question 19

Description (optional)

19. What emotion do you believe the eyes below are showing? *

- Arrogant
- Grateful
- Sarcastic
- Tentative

Picture 19



Section 20 of 37

Question 20

Description (optional)

20. What emotion do you believe the eyes below are showing? *

- Dominant
- Friendly
- Guilty
- Horrified

Picture 20



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 21 of 37

Question 21

Description (optional)

21. What emotion do you believe the eyes below are showing? *

- Embarrassed
- Fantasizing
- Confused
- Panicked

Picture 21



Section 22 of 37

Question 22

Description (optional)

22. What emotion do you believe the eyes below are showing? *

- Preoccupied
- Grateful
- Inaistig
- Implying

Picture 22



Section 23 of 37

Question 23

Description (optional)

23. What emotion do you believe the eyes below are showing? *

- Contented
- Apologetic
- Defiant
- Curious

Picture 23



Section 24 of 37

Question 24

Description (optional)

24. What emotion do you believe the eyes below are showing? *

- Pensive
- Irritated
- Excited
- Hostile

Picture 24



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 25 of 37

Question 25

Description (optional)

25. What emotion do you believe the eyes below are showing? *

- Panicked
- Incredulous
- Despondent
- Interested

Picture 25



Section 26 of 37

Question 26

Description (optional)

26. What emotion do you believe the eyes below are showing? *

- Alarmed
- Shy
- Hostile
- Anxious

Picture 26



Section 27 of 37

Question 27

Description (optional)

27. What emotion do you believe the eyes below are showing? *

- Joking
- Cautious
- Arrogant
- Reassuring

Picture 27



Section 28 of 37

Question 28

Description (optional)

28. What emotion do you believe the eyes below are showing? *

- Interested
- Joking
- Affectionate
- Contented

Picture 29



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 29 of 37

Question 29

Description (optional)

29. What emotion do you believe the eyes below are showing? *

- Impatient
- Aghast
- Irritated
- Reflective

Picture 29



Section 30 of 37

Question 30

Description (optional)

30. What emotion do you believe the eyes below are showing? *

- Grateful
- Flirtatious
- Hostile
- Disappointed

Picture 30



Section 31 of 37

Question 31

Description (optional)

31. What emotion do you believe the eyes below are showing? *

- Ashamed
- Confident
- Joking
- Dispirited

Picture 31



Section 32 of 37

Question 32

Description (optional)

32. What emotion do you believe the eyes below are showing? *

- Serious
- Ashamed
- Bewildered
- Alarmed

Picture 32



THEORY OF MIND ABILITY IN OS TWIN FEMALES: THE TTT HYPOTHESIS

Section 33 of 37

Question 33

Description (optional)

33. What emotion do you believe the eyes below are showing? *

- Embarrassed
- Guilty
- Fantasizing
- Concerned

Picture 33



Section 34 of 37

Question 34

Description (optional)

34. What emotion do you believe the eyes below are showing? *

- Aghast
- Baffled
- Distrustful
- Terrified

Picture 34



Section 35 of 37

Question 35

Description (optional)

35. What emotion do you believe the eyes below are showing? *

- Puzzled
- Nervous
- Insisting
- Contemplative

Picture 35



Section 36 of 37

Question 36

Description (optional)

36. What emotion do you believe the eyes below are showing? *

- Ashamed
- Nervous
- Suspicious
- Indecisive

Picture 36



After section 36 Continue to next section

Section 37 of 37

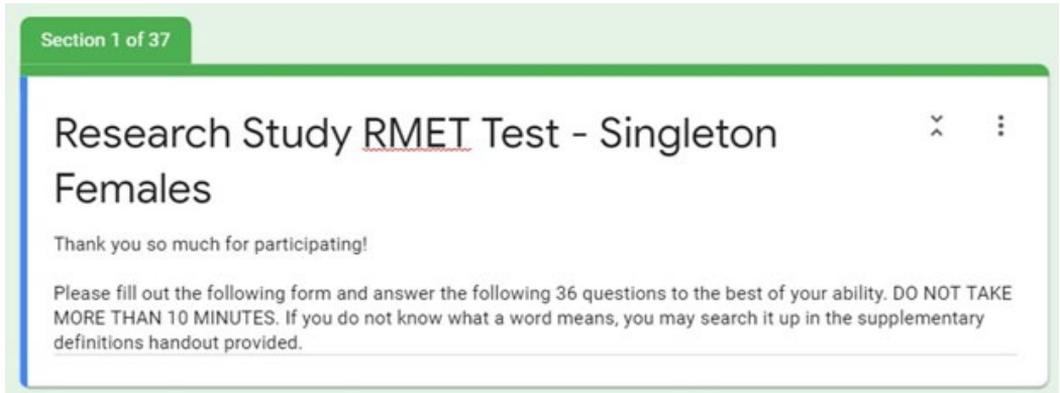
That is it! Thank you for participating in the survey!

Description (optional)

Appendix D:

Online RMET test images for singleton females

It is the same as Appendix C, with only one difference, the starting description:



The image shows a screenshot of a web-based test interface. At the top left, there is a green tab labeled "Section 1 of 37". The main title of the test is "Research Study RMET Test - Singleton Females", with "RMET" underlined in red. To the right of the title are two small icons: a close button (an 'x') and a menu button (three vertical dots). Below the title, the text reads: "Thank you so much for participating!". This is followed by instructions: "Please fill out the following form and answer the following 36 questions to the best of your ability. DO NOT TAKE MORE THAN 10 MINUTES. If you do not know what a word means, you may search it up in the supplementary definitions handout provided." The text is enclosed in a light blue border.

Appendix E:

RMET test supplementary document with definitions

RMET Test Instructions

For each set of eyes, choose and circle which word best describes what the person in the picture is thinking or feeling. You may feel that more than one word is applicable but please choose just one word, the word which you consider to be most suitable. Before making your choice, make sure that you have read all 4 words. If you really do not know what a word means, you can look it up in the following definition handout.

WORD DEFINITIONS

ACCUSING: blaming

The policeman was accusing the man of stealing a wallet.

AFFECTIONATE: showing fondness towards someone

Most mothers are affectionate to their babies by giving them lots of kisses and cuddles.

AGHAST: horrified, astonished, alarmed

Jane was aghast when she discovered her house had been burgled.

ALARMED: fearful, worried, filled with anxiety

Claire was alarmed when she thought she was being followed home.

AMUSED: finding something funny

I was amused by a funny joke someone told me.

ANNOYED: irritated, displeased

Jack was annoyed when he found out he had missed the last bus home.

ANTICIPATING: expecting

At the start of the football match, the fans were anticipating a quick goal.

ANXIOUS: worried, tense, uneasy

The student was feeling anxious before taking her final exams.

APOLOGETIC: feeling sorry

The waiter was very apologetic when he spilt soup all over the customer.

ARROGANT: conceited, self-important, having a big opinion of oneself

The arrogant man thought he knew more about politics than everyone else in the room.

ASHAMED: overcome with shame or guilt

The boy felt ashamed when his mother discovered him stealing money from her purse.

ASSERTIVE: confident, dominant, sure of oneself

The assertive woman demanded that the shop give her a refund.

BAFFLED: confused, puzzled, dumbfounded

The detectives were completely baffled by the murder case.

BEWILDERED: utterly confused, puzzled, dazed

The child was bewildered when visiting the big city for the first time.

CAUTIOUS: careful, wary

Sarah was always a bit cautious when talking to someone she did not know.

COMFORTING: consoling, compassionate

The nurse was comforting the wounded soldier.

CONCERNED: worried, troubled

The doctor was concerned when his patient took a turn for the worse.

CONFIDENT: self-assured, believing in oneself

The tennis player was feeling very confident about winning his match.

CONFUSED: puzzled, perplexed

Lizzie was so confused by the directions given to her, she got lost.

CONTEMPLATIVE: reflective, thoughtful, considering

John was in a contemplative mood on the eve of his 60th birthday.

CONTENTED: satisfied

After a nice walk and a good meal, David felt very contented.

CONVINCED: certain, absolutely positive

Richard was convinced he had come to the right decision.

CURIOUS: inquisitive, inquiring, prying

Louise was curious about the strange shaped parcel.

DECIDING: making your mind up

The man was deciding whom to vote for in the election.

DECISIVE: already made your mind up

Jane looked very decisive as she walked into the polling station.

DEFIANT: insolent, bold, don't care what anyone else thinks

The animal protesters remained defiant even after being sent to prison.

DEPRESSED: miserable

George was depressed when he didn't receive any birthday cards.

DESIRE: passion, lust, longing for

Kate had a strong desire for chocolate.

DESPONDENT: gloomy, despairing, without hope

Gary was despondent when he did not get the job he wanted.

DISAPPOINTED: displeased, disgruntled

Manchester United fans were disappointed not to win the Championship.

DISPIRITED: glum, miserable, low

Adam was dispirited when he failed his exams.

DISTRUSTFUL: suspicious, doubtful, wary

The old woman was distrustful of the stranger at her door.

DOMINANT: commanding, bossy

The sergeant major looked dominant as he inspected the new recruits.

DOUBTFUL: dubious, suspicious, not really believing

Mary was doubtful that her son was telling the truth.

DUBIOUS: doubtful, suspicious

Peter was dubious when offered a surprisingly cheap television in a pub.

EAGER: keen

On Christmas morning, the children were eager to open their presents.

EARNEST: having a serious intention

Harry was very earnest about his religious beliefs.

EMBARRASSED: ashamed

After forgetting a colleague's name, Jenny felt very embarrassed.

ENCOURAGING: hopeful, heartening, supporting

All the parents were encouraging their children in the school sports day.

ENTERTAINED: absorbed and amused or pleased by something

I was very entertained by the magician.

ENTHUSIASTIC: very eager, keen

Susan felt very enthusiastic about her new fitness plan.

FANTASIZING: daydreaming

Emma was fantasizing about being a film star.

FASCINATED: captivated, really interested

At the seaside, the children were fascinated by the creatures in the rock pools.

FEARFUL: terrified, worried

In the dark streets, the women felt fearful.

FLIRTATIOUS: brazen, saucy, teasing, playful

Connie was accused of being flirtatious when she winked at a stranger at a party.

FLUSTERED: confused, nervous and upset

Sarah felt a bit flustered when she realised how late she was for the meeting and that she had forgotten an important document.

FRIENDLY: sociable, amiable

The friendly girl showed the tourists the way to the town centre.

GRATEFUL: thankful

Kelly was very grateful for the kindness shown by the stranger.

GUILTY: feeling sorry for doing something wrong

Charlie felt guilty about having an affair.

HATEFUL: showing intense dislike

The two sisters were hateful to each other and always fighting.

HOPEFUL: optimistic

Larry was hopeful that the post would bring good news.

HORRIFIED: terrified, appalled

The man was horrified to discover that his new wife was already married.

HOSTILE: unfriendly

The two neighbours were hostile towards each other because of an argument about loud music.

IMPATIENT: restless, wanting something to happen soon

Jane grew increasingly impatient as she waited for her friend who was already 20 minutes late.

IMPLORING: begging, pleading

Nicola looked imploring as she tried to persuade her dad to lend her the car.

INCREDULOUS: not believing

Simon was incredulous when he heard that he had won the lottery.

INDECISIVE: unsure, hesitant, unable to make your mind up

Tammy was so indecisive that she couldn't even decide what to have for lunch.

INDIFFERENT: disinterested, unresponsive, don't care

Terry was completely indifferent as to whether they went to the cinema or the pub.

INSISTING: demanding, persisting, maintaining

After a work outing, Frank was insisting he paid the bill for everyone.

INSULTING: rude, offensive

The football crowd was insulting the referee after he gave a penalty.

INTERESTED: inquiring, curious

After seeing Jurassic Park, Hugh grew very interested in dinosaurs.

INTRIGUED: very curious, very interested

A mystery phone call intrigued Zoe.

IRRITATED: exasperated, annoyed

Frances was irritated by all the junk mail she received.

JEALOUS: envious

Tony was jealous of all the taller, better-looking boys in his class.

JOKING: being funny, playful

Gary was always joking with his friends.

NERVOUS: apprehensive, tense, worried

Just before her job interview, Alice felt very nervous.

OFFENDED: insulted, wounded, having hurt feelings

When someone made a joke about her weight, Martha felt very offended.

PANICKED: distraught, feeling of terror or anxiety

On waking to find the house on fire, the whole family was panicked.

PENSIVE: thinking about something slightly worrying

Susie looked pensive on the way to meeting her boyfriend's parents for the first time.

PERPLEXED: bewildered, puzzled, confused

Frank was perplexed by the disappearance of his garden gnomes.

PLAYFUL: full of high spirits and fun

Neil was feeling playful at his birthday party.

PREOCCUPIED: absorbed, engrossed in one's own thoughts

Worrying about her mother's illness made Debbie preoccupied at work

PUZZLED: perplexed, bewildered, confused

After doing the crossword for an hour, June was still puzzled by one clue.

REASSURING: supporting, encouraging, giving someone confidence

Andy tried to look reassuring as he told his wife that her new dress did suit her.

REFLECTIVE: contemplative, thoughtful

George was in a reflective mood as he thought about what he'd done with his life.

REGRETFUL: sorry

Lee was always regretful that he had never travelled when he was younger.

RELAXED: taking it easy, calm, carefree

On holiday, Pam felt happy and relaxed.

RELIEVED: freed from worry or anxiety

At the restaurant, Ray was relieved to find that he had not forgotten his wallet.

RESENTFUL: bitter, hostile

The businessman felt very resentful towards his younger colleague who had been promoted above him.

SARCASTIC: cynical, mocking, scornful

The comedian made a sarcastic comment when someone came into the theatre late.

SATISFIED: content, fulfilled

Steve felt very satisfied after he had got his new flat just how he wanted it.

SCEPTICAL: doubtful, suspicious, mistrusting

Patrick looked sceptical as someone read out his horoscope to him.

SERIOUS: solemn, grave

The bank manager looked serious as he refused Nigel an overdraft.

STERN: severe, strict, firm

The teacher looked very stern as he told the class off.

SUSPICIOUS: disbelieving, suspecting, doubting

After Sam had lost his wallet for the second time at work, he grew suspicious of one of his colleagues.

SYMPATHETIC: kind, compassionate

The nurse looked sympathetic as she told the patient the bad news.

TENTATIVE: hesitant, uncertain, cautious

Andrew felt a bit tentative as he went into the room full of strangers.

TERRIFIED: alarmed, fearful

The boy was terrified when he thought he saw a ghost.

THOUGHTFUL: thinking about something

Phil looked thoughtful as he sat waiting for the girlfriend he was about to finish with.

THREATENING: menacing, intimidating

The large, drunken man was acting in a very threatening way.

UNEASY: unsettled, apprehensive, troubled

Karen felt slightly uneasy about accepting a lift from the man she had only met that day.

UPSET: agitated, worried, uneasy

The man was very upset when his mother died.

WORRIED: anxious, fretful, troubled

When her cat went missing, the girl was very worried.

Appendix F:

Instruction email to opposite-sex twin female participants

Dear opposite-sex twin females,

Thank you all for providing me your email addresses and showing interest in this research study!

Please read this email in its entirety. You are of great value to this research study and this entire process will only take a maximum of 15 minutes.

My name is ----- and I am a junior at ----- . This school year, I was given an amazing opportunity to take the College Board AP Research class at my school and to conduct research myself on a topic of my interest.

For my research study, I chose to test social cognition ability in opposite-sex twin females in comparison to singleton females. I am testing this using the Reading the Mind in the Eyes test (RMET).

The link below is a link to the online RMET test. The RMET test is an assessment in which the participant is given 36 questions. Each question consists of a picture of a set of eyes, and you are asked to choose the emotion that best fits the set of eyes.

LINK TO RMET TEST: <https://forms.gle/xYV1AWNbLJ8o9ekAA>

Please fill out the above form and answer the 36 questions to the best of your ability. DO NOT TAKE MORE THAN 10 MINUTES. If you do not know what a word means, you may search it up in the supplementary definitions handout provided below. Your assessment score will not negatively affect you in any way nor will your name be exposed.

Thank you so much for taking the time to participate in this study! Your effort is greatly appreciated. Feel free to ask any questions you may have.

Thank you once again!

Appendix G:

Instruction email to singleton female participants

Dear singleton females (females who are not twins, triplets, or other multiple-birth individuals),
Thank you all for providing me your email addresses and showing interest in this research study!
Please read this email in its entirety. You are of great value to this research study and this entire process will only take a maximum of 15 minutes.

My name is ----- and I am a junior at --. This school year, I was given an amazing opportunity to take the College Board AP Research class at my school and to conduct research myself on a topic of my interest.

For my research study, I chose to test social cognition ability in opposite-sex twin females in comparison to singleton females. I am testing this using the Reading the Mind in the Eyes test (RMET).

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LINK TO RMET TEST: <https://forms.gle/DrsdXpmzz5MzvfUPA>

Please fill out the above form and answer the 36 questions to the best of your ability. DO NOT TAKE MORE THAN 10 MINUTES. If you do not know what a word means, you may search it up in the supplementary definitions handout provided below. Your assessment score will not negatively affect you in any way nor will your name be exposed.

Thank you so much for taking the time to participate in this study! Your effort is greatly appreciated. Feel free to ask any questions you may have.

Thank you once again!

