THE INFLUENCE OF EMOTIONAL CUES ON MENTAL ROTATION ABILITY

A Senior Scholars Thesis

by

FARAH AMLANI

Submitted to Honors and Undergraduate Research
Texas A&M University
in partial fulfillment of the requirements for the designation as

UNDERGRADUATE RESEARCH SCHOLAR

May 2012

Major: Biology

THE INFLUENCE OF EMOTIONAL CUES ON MENTAL ROTATION ABILITY

A Senior Scholars Thesis

by

Farah Amlani

Submitted to Honors and Undergraduate Research
Texas A&M University
in partial fulfillment of the requirements for the designation as

UNDERGRADUATE RESEARCH SCHOLAR

Approved by:

Research Advisor: Gerianne Alexander
Associate Director, Honors and Undergraduate Research: Duncan MacKenzie

May 2012

Major: Biology

ABSTRACT

The Influence of Emotional Cues on Mental Rotation Ability. (May 2012)

Farah Amlani
Department of Biology
Texas A&M University

Research Advisor: Dr. Gerianne Alexander
Department of Psychology

Men compared to women perform significantly better on mental rotation tasks for argued biological and environmental reasons. Threat has been previously found to influence the magnitude and direction of sex differences in cognitive abilities. This study examined the influence of threat on spatial ability and evaluated the gender difference of this influence through a facial stimulus and performance on a mental rotation task. Participants included 30 women and 30 men randomly assigned to a neutral or threat condition. All participants completed a WASI IQ test for a standard measure of general intelligence and a mental rotation task that was presented on a computer monitor. For participants in the neutral condition, a neutral male face preceded each test question. For the threat condition, an angry male face preceded each item. We hypothesized that women in the threat condition would score lower than women in the neutral condition. In contrast, we hypothesized that threat would have no negative effects on men's performance. The results were consistent with previous findings of a robust sex difference in MRT with men outperforming women in both conditions. There were two

statistically significant results: Women fixated more often in the eyes look zone and men who fixated more often in the friendly condition performed better. The results can be explained by biological and social theories. One biological explanation is that from previous studies it has been found that women are far better than men at recognizing non-verbal cues from a very early point in life, which can be a response to sex-linked hormonal surges. Another explanation is the social constructivist theory that argues the behavior is a result of imitating adults. The finding that men who fixated more in the friendly condition performed better can be explained by the friendly stimulus offering encouragement and boosting confidence.

DEDICATION

I dedicate this to women around the world. Fight for what you believe in and don't settle for anything less. Oprah Winfrey said it best, "It doesn't matter who you are, where you come from. The ability to triumph begins with you. Always."

ACKNOWLEDGMENTS

I would like to thank my research advisor, Dr. Gerianne Alexander, and graduate student co-advisor, Janet Saenz. They have served as role models and mentors to me through my first independent research project and have ignited a spark for curiosity and thirst for answers through the process. I would also like to thank my lab partners, Jessica Diaz de Tuesta, Matthew Sanchez, Doreena Lopez, Lauren Walker, and Christine Pohl for their relentless efforts in helping me through this project. This project would not have been possible without them.

Also, I would like to thank my family for their continuous support, love, and encouragement. They served as my motivation to succeed through this endeavor.

Finally, I would like to thank all my friends, colleagues, and the Texas A&M institution for providing me with wonderful memories, experiences, and a strong educational foundation that has prepared me well for my continuing education.

NOMENCLATURE

IQ	Intelligence Quotient
WASI	Wechsler Abbreviated Scale of Intelligence
MRT	Mental Rotation Task

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

There are differences in the performance of males and females in a subset of behaviors evident among various species, including humans (Collaer 2005). The debate around explaining these differences has been coined nature versus nurture. To explain these differences from a biological perspective, many have studied the effect of hormones on sexual differentiation. Once the chromosomes of the mammals have merged to produce XY or XX sex-linked genes, then multiple sex differentiation events occur, including the development of behavioral characteristics.

There is little to no gender difference in overall intelligence (Collaer 2005). IQ tests are purposefully created to eliminate any gender discrimination. The Wechsler Abbreviated Scale of Intelligence (WASI) IQ test is used to measure cognition and on average shows no sex difference. However, prior research indicates that there are consistent and robust gender differences in spatial ability (Levine, 2005). One measure of spatial ability is measured through mental rotation task, which is the ability to transform a multidimensional object. Significance is given to this gender difference, because of its presumed influence on performance in academic areas such as math and science courses (Delgado & Prieto, 2004) and the SAT (Casey, 1996). Explanations for the gender

---

This thesis follows the style of *Evolution and Human Behavior*.

difference involve biological and environmental determinants. The mental rotation task that produces the sex difference was developed by Vandenberg and Kuse (1978).

The distinctive gender difference is explained through biology as an evolutionary difference from ancestral hunting and gathering needs. The male responsibility of hunting led to a greater advantage in mental rotation, while the gathering duty of females increased attention to detail and memory to ease the repetitive locating of the same types of plant for food (Alexander, 2005). It is likely that both hunters and gatherers dealt with threat situations while searching for food. However, the gender differences in mental rotation and cognition after a threat situation have yet to be measured. The sex difference can also be explained biologically with association of hormone levels. On the other hand, environmental factors can also be attributed to for a male advantage in spatial abilities. For example, male boys are often encouraged to play with toys such as blocks, which require mental rotation (Scali 2000). The lack of practice leads, encouragement, and motivation leads to reduced future instances of spatial manipulation. Furthermore, men are encouraged to take classes that support a male-dominant profession, which often employs spatial abilities. Women are often not encouraged to enroll in these math and science courses.

Objective/ Hypothesis

The objective is to examine the influence of threat on the sex differences for a mental rotation task. We hypothesize that emotional cues will differentially affect mental

rotation ability and IQ scores for males and females. More specifically, we hypothesize that viewing a stimulus of an angry face will simulate a threat situation and cause a negative effect for women.

CHAPTER II

METHODS

Participants

Participants were undergraduate psychology students enrolled in an introductory psychology course. Participants receive partial fulfillment of course requirements. A total of 29 women and 28 men volunteered for the study.

Materials

The stimuli were two black and white images of a male with neutral race distinction. One image of this male presented happy facial characteristics (Fig 1A), while the other displayed angry facial characteristics (Fig 1B). The emotional cues were developed using software called FACES.

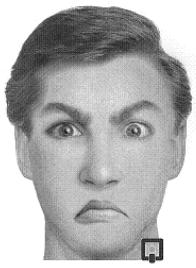
A  B 

Fig. 1. Examples of the emotional cues. A is the happy or friendly stimulus and B is the threat stimulus. Faces A and B differ in the essential features for characteristics (eyebrows and mouth), but maintain consistency in nonessential features such as the nose, hair, and shape of face.

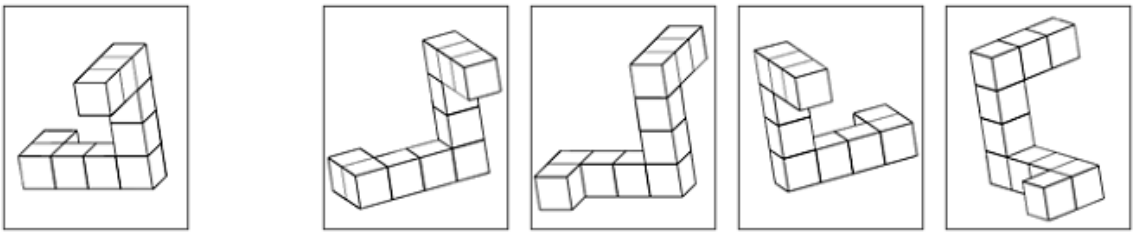


Fig. 2. Example of an MRT Problem. The left is the shape that is the object of question and the 4 figures on the right are answer choices, 2 of which are correct.

The mental rotation task slideshow was composed of 4 practice problems and 12 test problems. Each problem slide had an image of a shape on the left and 4 answer choices to the right (Fig 2). The answer choices showed the same shape just turned around, so the participant saw a different side. Every problem had 2 correct choices and the participant was scored on each individual response. The slideshow was designed to flash the stimulus face displaying the randomly assigned emotional condition (angry or happy) for 1 second in between each mental rotation question. The dependent variable is the total number correct.

A WASI IQ test including subtests of vocabulary, matrix reasoning, and block design was administered. The WASI includes: WASI manual, stimulus booklet, WASI form, and 9 blocks for the block design section. The vocabulary subtest asked participants to give their best definitions of some words. The WASI manual contained detailed descriptions describing how to score the participants' response for each vocabulary word. The scale ranged from zero points for incorrect answers, to two points for the most accurate responses. For the matrix reasoning subtest, participants were asked to look at

an incomplete matrix and to choose from five options the one that best completes the matrix. Participants received one point for correct responses and zero points for incorrect responses. The vocabulary and matrix reasoning scores are used to calculate the Full 2-IQ.

In the block design section of the WASI, the participants had blocks that are all the same. The blocks were all red on some sides, all white on some sides, and half red and half white on the other sides. The goal was to make a design with the blocks that was the same as the one presented in the stimulus booklet within the allotted timeframe. The scoring for this section depended on accuracy of the design and speed. The block design subtest began with four blocks, used to make 2 by 2 square designs, and increased to nine blocks, used to make 3 by 3 square designs.

Procedure

Participants signed a consent form and filled out a demographic form asking for their date of birth, ethnicity, and race. They were randomly assigned to threat (14 men, 15 women) and friendly (14 men, 15 women) conditions. The study began with the vocabulary and matrix reasoning subtests of the WASI IQ test. Then, participants were seated in front of a computer in a room adjacent to where the WASI was administered. A desktop ASL Eye Tracker measured the allocation of attention during the mental rotation task. This remote eye tracker used the reflection of the retina and cornea to determine eye gaze (Alexander & Son, 2007). The optics system was placed beneath the monitor of

the testing computer. Participants were seated approximately 24 inches away from the eye tracker. A 9-point calibration was performed on each subject that covers 80% of the viewing area. The calibration served to improve the accuracy of the data collected by the ASL Eye Tracker. Once calibrated, the Mental Rotation Task (MRT) began. The buffer slide with the emotional stimulus was flashed for 1 second between each problem slide. The participants were able to press the space bar to advance to the next slide once they had given their answers to the mental rotation problem.

After completion of the MRT, the participant returned to the desk in the main room to take the Block Design section of the WASI IQ test. The same emotional stimulus presented through the MRT was placed at the top left corner of the desk, while the subject worked through the block design section.

The participants' demographic information, WASI IQ results, and responses to the mental rotation task were recorded. Two look zones were created around the eyes and around the mouth on each buffer slide. Eye tracking data was extracted from GazeTracker and compiled into SPSS to be analyzed. The eye tracking data included time spent on each mental rotation problem, percent time tracked for buffer slides, and percent time in zone, fixation count, and percent time fixated for each look zone (eyes and mouth).

CHAPTER III

RESULTS

Participant demographics

Table 1 describes the characteristics of the study participants. Women and men were similar in age, ranging from 17-21 years for women and 18-23 years for men and the majority self-identified as White and non-Hispanic. Scores on the general measure of intelligence were slightly above average (i.e., 100) in both sexes. As expected, men scored significantly higher than women on the measure of mental rotation ability (MRT).

Table 1 Participant Demographics

	Women	**Men**
Count	29	28
Age [Average (SD)]	19.103 (1.291)	19.929 (1.609)
Condition:		
Angry	15	14
Friendly	14	14
Race:		
American Indian/ Alaska Native	1	0
Asian	2	0
Black or African American	3	1
White	23	27
Ethnicity:		
Hispanic	8	4
Non-Hispanic	21	24
Full 2 IQ [Average (SD)]	108.48 (11.891)	109 (11.421)
MRT [Average (SD)]	67.098 (16.112)	77.932 (12.383)

Note: Data is presented as frequencies for Count, Condition, Race, and Ethnicity and presented as averages with standard deviations for Age, IQ, and MRT. Full 2 IQ is based on the participants' performance on the Vocabulary and Matrix Reasoning sections of the WASI IQ test with no stimulus presented. The participants give 2 answers for each mental rotation problem slide. The MRT averages are based on the accuracy of each individual response.

Results

1. Effects of Condition (Angry, Friendly) on Task Performance

Analysis of variance using time to complete the task as a dependent measure and condition (angry, friendly)and sex (male, female) as grouping factors showed no effect of condition on time to complete the mental rotation task (M = 32.48, SD = 14.30 minutes for the Angry condition vs. M = 32.64, SD = 13.00 minutes for the Friendly Condition), F (1, 50) < .001. There was no overall sex difference in time to complete the task, F (1, 50) = .23, P = .72. However, the interaction between sex and condition approached significant, F (1, 50) = 3.71, P = .06. As shown in Figure 1 below, women in the friendly condition required more time to complete the task than did women in the angry condition. In contrast, men in the friendly condition took less time to complete the task than did men in the angry condition.

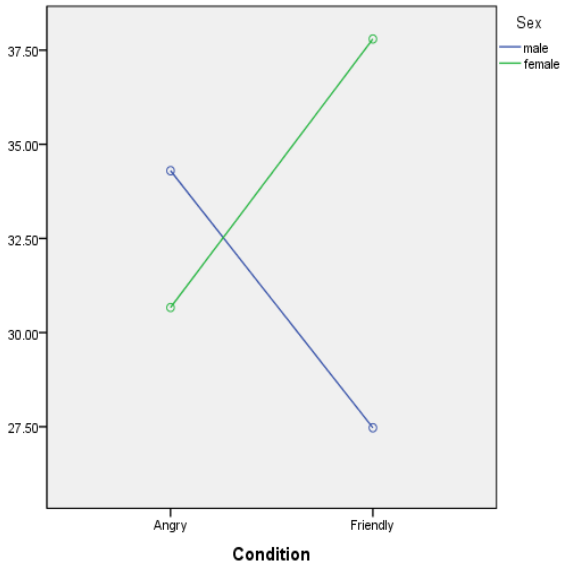


Fig. 3. Effects of Condition and Sex on Time to Complete.

Pearson's Correlation Test, a measure of the association between variables, showed no relationship between time to complete the task and accuracy scores for men, r(27)= .12, p> .05, or women, r(27)= .17, p>.05.

2. Effects of Condition (Angry, Friendly) on Visual Attention

An analysis of variance for repeated measures with sex and condition as grouping factors and look zones (eyes and mouth) as repeated factors was performed. Compared to men, women showed greater visual attention to faces, F (1, 50) = 5.48, P < .05. However, there was no significant effect of condition on visual attention, F (1, 50) = 2.10, P = .15 and no interaction between sex and condition on visual attention, F(1, 50) < .001. Figure 2 below showed the pattern of visual interest in women and men in the two conditions showing the greater amounts of attention in women compared to men.

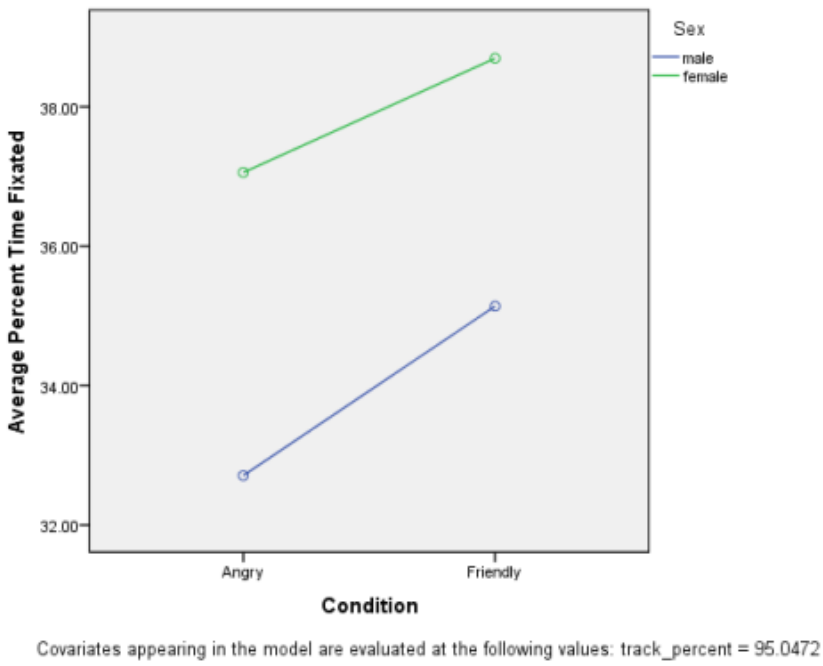


Fig. 4. Visual Attention in Women and Men Viewing the Faces in the Two Conditions

There was a trend for an interaction between sex (male, female) and zone (eyes, mouth), $F(1, 50) = 2.93$, $P = .09$. Compared to men, women spent more time looking at the eyes. In contrast, both sexes spent similar amounts of time looking at the mouth. Figure 3 showed this interaction.

Finally, the relationship between attention and performance was examined using Pearson Product Moment correlations. In the angry condition, correlations between accuracy and attention were unrelated in men. In women, greater attention to angry eyes was associated with worse performance, but the correlation was not significant, $r = -.48$, $P < .07$. In the friendly condition, men showing greater attention to friendly eyes showed better accuracy on the task, $r(13) = .55$, $P = .05$. In women the correlations were negative and not significant, $r(12) = -.39$, $P = .20$.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The results were consistent with previous findings of a robust sex difference in the MRT (Levine, 2005). Men outperformed the women in both conditions (threat and happy) in the MRT. However, the hypothesis that women in the threat condition would perform less accurately than men was not supported. There were two statistically significant results: Women fixated more often in the eyes look zone and men who fixated more often in the friendly performed better on the MRT.

In other research, The "Reading the Mind in the Eyes" Test displayed the area of the face around the eyes and asked participants to describe the thoughts and feelings of the person in the photograph (Barron-Cohen 1997). Similar to the present findings, women scored higher than men with statistical significance in understanding the mental state and matching them to the eyes. Women's tendency to fixate more in the eyes can be explained by biological and environmental reasons. One biological explanation is that from previous studies it has been found that women are far better than men at recognizing non-verbal cues even from a very early point in life (McClure 2000). The gender difference is present even through infancy, which can be a response to sex-linked hormonal surges. On the other hand, the sex difference for recognizing non-verbal cues in infancy can be explained by the social constructivist theory, which argues the behavior as a result of imitating adults (McClure 2000). The gender difference in

emotion recognition in adults can be attributed to the socialization of recognizing emotion because the emotion of their partner is a reflection of the women's well-being.

In this research, men fixated more in the friendly condition performed better on the MRT. One explanation may be that the friendly, male face offers men encouragement and boosts their confidence. Prior research has examined the correlation between a self-reporting confidence rating and performance on MRT (Cooke-Simpson 2007). The results of that research showed a positive correlation between men's presumed confidence and their accuracy on a test, such that higher confidence was related to reduced guessing. An increase in men's confidence in this study may be attributed to men in this research, a variable that in research on stereotype threat is known to enhance performance (Steele 1995). In addition, the happy stimuli (smiling, male face) could have increased the confidence of the male participants further and, thus, improved their performance on the MRT.

Future Directions

A factor that may have influenced the results is stereotype threat, a mechanism whereby the belief that one sex is not capable of good performance on a task results in poor performance (Steele 1995). Therefore, it may be useful to evaluate stereotype threat by observing the visual attention on the MRT problem slides. The measures of visual attention may provide support for speculation that stereotype threat decreases performances by distraction or not giving the problems undivided attention. In this

research, only male faces were used. It is possible that using female emotional stimuli instead of male might enhance performance in the manner observed in men in this study. It would be interesting in future research to see if a video clip could better simulate the threat situation and provide a better test of the effects of threat on performance. Finally, the effect of sex and condition on time to complete approached significance (P=0.06), which might result in significance with a larger sample size. A study with more participants would provide more power to test the hypothesis.

REFERENCES

Alexander, G. (2005). Memory for face locations: emotional processing alters spatial abilities. *Evolution and Human Behavior* 26.4: 352-62.

Alexander, G., & Son, T. (2007). Androgens and eye movements in women and men during a test of mental rotation ability. *Hormones and Behavior* 52.2: 197-204.

Baron-Cohen, S., Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another advanced test of theory of mind: evidence from very high functioning adults with autism or asperger syndrome. *Journal of Child Psychology and Psychiatry* 38.7: 813-22.

Casey, M.B. (1996). Understanding individual differences in spatial ability within females: A nature/nurture interactionist framework. *Developmental Review*, 16, 241–260.

Collaer, M., & Hines, M. (1995). Human behavioral sex differences: a role for gonadal hormones during early development? *Psychological Bulletin* 118.1: 55-107. American Psychological Association.

Cooke-Simpson, A., & Voyer, D. (2007). Confidence and gender differences on the mental rotations test. *Learning and Individual Differences* 17.2: 181-86.

Delgado, A.R., & Prieto, G. (2004). Cognitive mediators and sex-related differences in mathematics. *Intelligence*, 32, 25–32.

Hausmann, M., Schoofs, D., Rosenthal, H., & Jordan, K. (2009) Interactive effects of sex hormones and gender stereotypes on cognitive sex differences—A psychobiosocial approach. *Psychoneuroendocrinology*, 34. 3: 389-401.

Levine, S., Vasilyeva, M., Lourenco, S., Newcombe, N., & Huttenlocher, J. (2005). Socioeconomic status modifies the sex difference in spatial skill. *Psychological Science,* 16.11: 841-45.

McClure, E. B. (2000). A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents. *Psychological Bulletin*, 126(3), 424-453.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personalityand Social Psychology*, 69, 797–811.

Scali, R. Brownlow, S., & Hicks, J. (2000). Gender differences in spatial task performance as a function of speed or accuracy orientation. *Sex Roles,* 43.5/6: 359-76.

Vandenberg, S. G., & Kuse, A. R. (1978). Mental rotation, a group test of three-dimensional spatial visualization. *Perceptual and Motor Skills*, 47, 599−604.

CONTACT INFORMATION

Name:	Farah Amlani
Professional Address:	c/o Dr. Gerianne Alexander Department of Psychology 206 Psychology Building Texas A&M University College Station, TX 77843
Email Address:	famlani23@gmail.com
Education:	B.S., Biology, Texas A&M University, May 2012 Cum Laude Undergraduate Research Scholar Sigma Alpha Lambda