

# The Journal of Undergraduate Research

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Volume 9 *Journal of Undergraduate Research*, Volume  
9: 2011


Article 1

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2011

## The Journal of Undergraduate Research: Volume 09

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### Recommended Citation

(2011) "The Journal of Undergraduate Research: Volume 09," *The Journal of Undergraduate Research*: Vol. 9 , Article 1.  
Available at: <https://openprairie.sdstate.edu/jur/vol9/iss1/1>

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South Dakota State University

**JOURNAL OF  
UNDERGRADUATE  
RESEARCH**

Volume 9 • 2011



**The South Dakota State University  
Journal of Undergraduate Research**  
is published annually by the Office of Research & Sponsored Programs  
at South Dakota State University

Editor  
Dr. George Langelett

Associate Editor  
Linda Winkler

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**Journal of Undergraduate Research**  
Office of Research & Sponsored Programs  
130 Administration Building  
Brookings, SD 57007

*South Dakota State University*

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## Table of Contents

Guidelines – SDSU Journal of Undergraduate Research . . . . .	iv
Behind the Bars of “Beauty”	
SHERI BINKLY . . . . .	1
Anxiety and Visual Discriminations in Undergraduates	
KATHERINE BOWERS . . . . .	7
Long Term, Continuous Temperature Monitoring of a Simple Anaerobic Digester and Open Manure Storage Pond in Eastern South Dakota	
J. DARRINGTON, E. CORTUS . . . . .	19
The Equitarian Initiative: International Humanitarian Aid Using Horses	
ANGELA GEBHART . . . . .	29
Engineering Our Climate: A Critical Review of the Geoengineering Response to Climate Change	
GARY HUFF . . . . .	39
How Priming of Behavioral Symptoms May Affect College Students’ Decision to Diagnose	
CAITLIN GILLEY, SARAH STERTZ . . . . .	49
Tools of Horror: Servants in Gothic Novel	
JACOB HERRMANN . . . . .	57
Deception Detection Accuracy Using Verbal or Nonverbal Cues	
CAROLINE HICKS, NICOLE ULVESTAD . . . . .	63
Re-examining “In A Different Voice” for the New Millennium	
BRITTANY MORRIS . . . . .	69
Parental Influence on Adolescent’s Academic Performance	
JESSICA SCHMUCK . . . . .	77
Comparison of Three Physical Activity Measurement Tools to Assess Physical Activity Guideline Compliance in Children	
EMILY C. HUBER, ANDREW M. LITZ . . . . .	85

Real Number Rado Numbers for the Equation $\sum_{i=1}^{m-1} x_i + c = x_m$	
MELANIE ZINTER . . . . .	93
“Born Again Hard”: Sexualized Violence in the Creation of American Warriors	
KATHERINE HIGHFILL . . . . .	103
Vibrational Analysis of Soloflex Whole Body Vibration Platform	
ZACHARY CROATT, JOSH ROBERS . . . . .	115
Biosolar Conversion of N <sub>2</sub> and H <sub>2</sub> O to Ammonia by Engineered N <sub>2</sub> -fixing Cyanobacteria	
SETH T. HARRIS . . . . .	121
Still Free, Still Alive: Images of Haitian Collective Values Portrayed Though Child Characters in Lamartine’s <i>Toussaint Louverture</i> and Agnant’s <i>Alexis d’Haïti</i>	
VANESSA C. MARCANO . . . . .	131
The Impact of a Fundamentals of Speech Course on Public Speaking Anxiety	
JESSICA J. COLBECK . . . . .	145
Residual Stress Analysis of Composite Cannon Barrel	
TYLER BROCKEL, OZAN OZDEMIR . . . . .	161
Vibrational Analysis of an Electromechanical Toothbrush	
MARK WAGER . . . . .	175
Xenakis’ Combination of Music and Mathematics	
JANELLE ANDRESON . . . . .	185

## MANUSCRIPT SUBMISSION *(Due June 1 of each calendar year.)*

This section is intended to provide you with some guidance regarding the final structure and format your research manuscript should possess to warrant publication in the *SDSU Journal of Undergraduate Research*. Student authors wishing to have their work published in the *Journal* are advised to follow these guidelines as closely as possible, as manuscripts submitted to the *Journal* that are not of high quality in content and format may be rejected by the editor. The *Journal* editor understands that research products and manuscripts from different disciplines may take on quite different forms. As such, if these guidelines do not adequately answer your questions, simply follow the format and guidelines utilized by a major scholarly journal in your field of study. Professional journal articles in your field of study are a guideline for manuscript length. (When in doubt, article conciseness is important.) Your faculty mentor should be able to advise you in this regard.

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## FINAL PRODUCT

The final form of your paper will depend greatly on the nature of your topic and certain publishing conventions that may exist within your discipline. It is expected that the faculty advisor for each project will provide substantial guidance in this matter. An excellent general resource providing details of the content, style and organization of a typical journal article is the *Publication Manual of the American Psychological Association*, which is accepted as a definitive source in many disciplines. While the emphasis there is on empirical research reports (based upon original research and data collection), other types of papers are also described (review articles, theoretical articles), and an appendix: “Material Other Than Journal Articles,” may be useful.

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Sample Article:

## Title Of Your Article

Author(s): Your Name, Your Partner's Name(s)

Faculty Sponsor: Faculty Mentor's Name

Department: Economics

### ABSTRACT

This will be a brief statement of what was done in your research, along with your principal results and conclusions. Only the most important facts should be related here, in nonindented paragraph form. Offset the abstract by using margins that are indented 0.5" on each side relative to the body of your manuscript. You may list key words to aid in online computer-search applications, if that is appropriate. For example, **Keywords:** undergraduate research, manuscript, submission, guidelines.

### INTRODUCTION

This is the first formal section of a research report. This and the sections to follow should be single-spaced and laser-printed on only one side of the paper (8.5" x 11"). Early in this section, provide a general description of the research problem or activity. Attempt to identify and define whatever terms your reader will need to understand your project. The remaining paragraphs are often used to summarize relevant findings from previously completed research. Always be sure to cite your sources. Sarbin and Coe (1969) state that "in preparing a . . . report, the student must pay careful attention to the problems of documentation." In these examples of citations, "the documentation is contained in the parentheses . . ." (Sarbin and Coe, 1969). To find the remaining information, the reader examines the reference list at the end of the paper. This citation style is sometimes called "scientific notation." Other citation styles may be more appropriate to your own disciplines. Be sure to be consistent and to discuss this with your faculty advisor. Ultimately, you should use a citation style that is commonly accepted within your discipline.

The last portion of an introduction is often used to state the specific expected outcomes of the project; sometimes this appears as one or more formal testable hypotheses.

## METHODS

The content of this subsection may vary greatly, depending upon the nature of the research project. You should refer to publication manuals or published research for information specific to your type of project. Sometimes this subsection is labeled “Materials and Method.” Figures (see below) are often used to clarify and explain important details. In general you should use this subsection to explain to your reader, in as clear a way as possible, what you did, in the order that you did it. In an empirical research report, you should try to provide enough detail that another researcher could essentially duplicate your study without referring excessively to other sources.

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This should be a clear description of any data (or other material) generated as a result of your research. It must start out as a written description, but this subsection is often supplemented with FIGURES and TABLES, or PLATES, or other types of graphic images. These are never sufficient by themselves. Figures and Tables should not appear in your paper until after they've been mentioned or referred to in the written portion of this section. They should appear as soon as is reasonable after such mention, either on the same page, or on the next page (see Figure 1, and Table 1). Notice, in particular, that in most scientific papers, the number and title of a Table appear above the data being described, but the number and title of a Figure appear below the data. Any units of measure must appear either in the title, or independently in the column or row headings. A table is useless unless the reader can understand exactly what is represented.

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The Results section is also the place to include any statistical interpretation of the data, if such exists. Be sure to point out any important features of your findings, but AVOID to the extent possible, any THEORETICAL INTERPRETATION unless you are combining this with the next section (DISCUSSION or CONCLUSIONS).

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(3) WHAT theories or explanations seem to best explain or account for the results that you are describing.

Again, be sure to cite (Sarbin and Coe, 1969) the sources for theoretical ideas and explanations provided by other writers or sources. Also, address whether there any practical applications for the results or methods used in your research.

## **LIMITATIONS**

It is often useful, particularly in undergraduate research, to provide a summary of the limitations of the research from methodological, theoretical or other points of view to provide perspective and to serve as a possible basis for improvements in future projects.

## **ACKNOWLEDGEMENTS**

Feel free to use this section to BRIEFLY acknowledge any and all who helped you bring your project through to fruition. You may also thank any funding sources if appropriate.

## **REFERENCES**

Provide a complete list of all cited materials in a format that is consistent with publications in your area of study.

## **APPENDIX**

This section is optional and generally unnecessary. In some cases, it may be included to provide a more complete description of materials used. The editor of the *SDSU Journal of Undergraduate Research* would prefer that no appendices be used. However, if absolutely necessary, the number of pages in an appendix should be kept to an absolute minimum!

The Journal of Undergraduate Research would like to thank Dr. Kevin Kephart, Vice President for Research, for his efforts to secure funding for the *Journal*.

# Behind the Bars of “Beauty”

Author: Sheri Binkly  
Faculty Sponsor: Dr. Meredith Redlin  
Department: Women’s Studies

## ABSTRACT

Using Naomi Wolf’s *The Beauty Myth: How Images of Beauty are Used Against Women*, as my starting point for analysis, I set out to find the truth about the “beauty myth,” and what affect it has on women in our society. With the help of research done by Michelle Goldberg and Marissa Audia-Raymo, I analyzed current society, and examined why women still seem to be held back. My initial prediction proved to be naive. I wasn’t giving women enough credit for their struggles both now and throughout history. What I encountered was a problem that was established very deeply in the roots of our society. Patriarchy proved to be at the heart of the “beauty myth,” and what has and continues to hold women down in society.

## INTRODUCTION

Women have been forced to come up against its fury for ages. Now, it’s back and it’s stronger than ever. The beauty myth is once again rearing its ugly head into the lives of American women, and as Wolf explains in her book, it’s unfortunately and all too often successful. *The Beauty Myth* pushed me to rethink the many aspects of myself that I tend to harshly analyze, and it made me notice that there is a deeper problem within society—one that often goes unnoticed. I ventured out to discover if there was an intense connection between patriarchy and the idea of “beauty.” I needed to know if the beauty myth still exists today, and if so, what can women do to start challenging its principles?

## THE BEAUTY MYTH: ANALYSIS

Wolf explores how women’s liberation and women’s perception of beauty are interconnected through the ideas of a liberal feminist. Although Wolf, I feel, is dangerously close to crossing the line from liberal to slightly radical at times, these ideas are seen throughout every aspect of women’s lives: work, culture, religion, sex, hunger, and violence.

To begin, Wolf explores the life of a working career woman, and how “beauty” is not intimate or even sex-related. It is political and linked very closely with the economy. On that note, Wolf describes how “beauty” has actually become a form of currency, and how the beauty myth has taken a very tight hold on women that are both qualified for and deserving of their high-ranking positions in companies. The growing focus of women’s attractiveness as they become more powerful and independent emerges as a way for men to undermine

women's progress, and ultimately remain in the more powerful position. Men have every reason to be intimidated by women's desire to obtain economic independence and to acquire positions of power. Since they are intimidated, the beauty myth is necessary because "women work hard-twice as hard as men" (Wolf, 22). This has been proven throughout history, and in places all over the world. However, now that women are obtaining full-time careers outside of homemaking, they are now expected to maintain their careers, home, family, and, on top of all that, their appearance. Since women must come home after a long day of work, only to do more work, the beauty myth just adds to their anxiety. Wolf credits the beauty myth as being the so-called "Iron Maiden" of society today. It essentially bears down on already over-worked women, sometimes causing them to lose their motivation and drive for independence. The most dangerous aspect about the beauty myth is that it is not only torturing women, but it is doing so internally—emotionally destroying women's sense of self.

Subsequently, Wolf takes a look at the role of the beauty myth in our culture, and how women have turned to fabricated means, such as the media, in search of role models. It may not seem entirely obvious, but once it is pointed out, it becomes quite undeniable. There have been countless men throughout history that have been preserved by way of monuments and statues, where women tend to appear only anonymously. Rarely have women been recognized and praised throughout history. This lack of sufficient female role models could be the reason that women today turn to magazines and television in pursuit of someone, anyone, to look up to. As Wolf describes, even heroines in literature and movies are picked apart by the myth. "Culture stereotypes women to fit the myth by flattening the feminine into beauty-without-intelligence or intelligence-without-beauty; women are allowed a mind or a body but not both" (Wolf, 59). From the Bible to Shakespeare to Gilligan's Island, two women are best viewed in way of one being the winner (beauty), and the other being the loser (brains). So, as patriarchal culture has sparked this segregation of qualities, women have grown up learning and knowing only that beauty is the desired trait above all the others.

Magazines and other forms of media have grown to reinforce the myth. Stick thin models with perfect hair, breasts, and complexion bombard women from all corners of the media world. In turn, everyday women feel belittled by these near-impossible standards despite the fact that, little do they know, these "perfect" women are airbrushed, photo-shopped, and technologically altered. In the documentary, *America the Beautiful*, independent filmmaker Darryl Roberts goes on a journey to find out how "beauty" has affected women today. What he found were mass amounts of women and young girls that expressed how they wanted to be skinny and "beautiful" like the models in magazines (Roberts, 2007). The myth steps in to give women the impression that they are to be this way—and this way only—even though the "perfect" is, by most, absolutely unattainable and unnatural.

Following culture, Wolf explores the beauty myth's origins from religion, and its impacts as a form of religion. Wolf (1991) claims:

The beauty myth is essentially the gospel of a new religion...women participate in re-creating a belief system as powerful as that of any of the churches whose hold on them has so rapidly loosened. The Church of Beauty is like the 'Iron Maiden,' a two-sided symbol...the social order imposes it as eagerly, to supplant religious authority as a policing force over women's lives (p. 86).

The Rites of Beauty, as Wolf calls them, contradict women's modern freedoms by implanting a medieval, mindset that beauty is not determined by people, but by a higher,

divine power. The biblical story of Adam and Eve reigns as an example. God chose to make Eve from Adam; therefore, it was seemingly implied that men possessed this inborn, God-given right to be able to judge women while remaining unevaluated. However, the church has lost a lot of clout in the past generation when it comes to dictating women's actions. Since women were being less constrained by the patriarchal powers of churches, men were going to be threatened. If women began to formulate their own moral guidelines, the guidelines could contradict the very structure of patriarchy. For example, compassion could supersede patriarchal hierarchy, and "a traditionally feminine respect for human life might severely damage an economy based on militarism, and a job market based on the use of people as expendable resources" (Wolf, 90). To combat this fear, the Rites of Beauty intervened to ingrain in women a new religious authority to keep them in order. This new religion grew quickly as it destroyed women from the inside, leaving them with a new void to fill—one that the beauty myth would soon consume.

Thereafter, Wolf tackles issues surrounding female sexuality, and how the media, religion, and other factors have suppressed the amount of pleasure a woman feels—both mentally and physically. Women have it all. From multiple orgasms to continual orgasms, the magnitude of female sexual pleasure is endless, but unfortunately that sexual experience isn't seen in women living in today's society. Not long after the sexual revolution, the beauty myth was deployed to subdue female sexuality, once again, by way of "beauty pornography" and "beauty sadomasochism," "which arose to put the guilt, shame, and pain back into women's experience of sex" (Wolf, 132). For a patriarchal society, women who felt freedom in their sexuality posed a serious threat, so "the external cues of the beauty pornography and sadomasochism reshape female sexuality into a more manageable form than it would take if truly released" (Wolf, 132). Beauty pornography gives this impression: the "flawless" woman remains lying on her back in a state of domination. Women see this not only in pornographic films and magazines, but also in ads for everyday products such as perfume, shoes, clothes, cigarettes and cars. Sadomasochism in ads has affected women in the same way. Women relate the ecstasy felt by these women to domination, pain, and perfection. This misrepresentation of female sexuality sparked the idea that women and their bodies are just objects—objects to be perfected. These ideas arose not only as a way to boost consumerism for the economy (for example, beauty products, diet supplements, cosmetic surgery, etc.), but also as a way to sustain the sexual battle between men and women. Therefore, images that objectify and seductively belittle women have appeared to negate women's self-declaration. These images became necessary because it seemed that men and women were becoming too equal in the eyes of the powerful, and something was needed to keep women in their place. This objectification, sadly, has begun to be the norm.

Wolf also investigates America's hunger crisis, or technically, lack thereof. Bulimia and anorexia are becoming increasingly more common as the beauty myth saturates more and more areas of women's lives. Wolf paints a vivid, fictional image in the reader's mind about an epidemic of anorexia and bulimia sweeping America's male population. She points out that one would expect an immediate response from both the government, and the population. America would not want to see this happen to its sons. This crisis is actually occurring right now, only with the opposite gender. Each year, "150,000 American women die of anorexia," (American Anorexia and Bulimia Association as cited in Wolf, p. 182), and the public is



almost entirely oblivious. The media coverage of women dying from these disorders is extremely rare even though the death toll exceeds many other well-publicized events. Why is America reluctant to ask why their women are starving? Why doesn't America want to promote awareness of these all-consuming, deadly diseases? Maybe it is because these women are "over-achieving" at something that they are expected to do. The beauty myth expects a woman to be thin, and these women that are dying from bulimia and anorexia are simply just too good at what they are expected to do. I believe that many people in our population, mainly men, do not take these disorders seriously.

Ultimately, Wolf wraps up the book by taking a look at the violence that the beauty myth has caused women to commit against themselves. Cosmetic surgery is a rapidly growing industry where women are mutilating not only their bodies, but also their sense of self. They are making themselves believe that they are not beautiful, perfect, or otherwise, without these surgeries.

With this, Wolf states her main point. She notes that as women make more legal and political advancements, the image of feminine "beauty" becomes more strict and more harsh. It is evident that our patriarchal society keeps women "in check" by challenging them with the extra, unnecessary preoccupation of fulfilling a certain image. The "Beauty Myth" makes women objectify themselves, which in turn, lowers their self-esteem, and keeps them at a notch below their bold, self-assured counterpart-men. So, what can be done to confront the beauty myth, and maybe even challenge patriarchy?

## CONTEMPORARY UNDERSTANDINGS OF THE BEAUTY MYTH

The Beauty Myth and the points that Naomi Wolf defends were undeniable. Equipped with statistics, Wolf made it almost impossible for readers, especially women, to brush aside the fact that inequality between genders is still very much alive in our society. Women are being held back by a notion that society has created. The beauty myth is not only tearing women apart emotionally and mentally, but it is also causing women to destroy themselves physically. There is proof of women's self-mutilation floating through the media, and even experienced more personally through women's female peers. Diet supplements, cosmetic surgery, anorexia and bulimia plague American women's thoughts on a daily basis. What can women do to help reverse the beauty myth? Is it too late to help women love themselves for who they are?

In "Feminism for Sale," Michelle Goldberg (2000) explores how consumerism plays a huge part in women being stuck in the rut known as the beauty myth. The beauty myth and patriarchy make women believe that they are to maintain a "perfect" image. They must use makeup, wear the most fashionable clothes, cling tightly to their youth, and possess and maintain a "desirable" body image. These qualities of the beauty myth promote consumerism, and thus, allow patriarchy to get the best of women. By preoccupying themselves with shopping for all the "right" products, women are performing just as patriarchy wants them to. Patriarchy wants women to feel content preoccupying their time with frivolous acts because they definitely do not want women interfering with important political, legal, and business-

related issues. They created the beauty myth to distract women from progressing in independence and power, and it has been, unfortunately, quite successful.

The current “feminist” model seems to be this trendy, “urban, liberated career chick... In the year 2000, decades after wrangling the myth of the ugly, hirsute, ball-busting women’s liber, the culture has finally seemed to reconcile beauty, power, fun, and feminism” (Goldberg, 2000:1). However, are we sure this is the feminist role model we want? Goldberg states that this “easy-to-swallow feminism,” persuades women to spoil themselves, dispose of guilt, and glide through life like Carrie in *Sex in the City*. This type of feminism doesn’t make women feel bad about wearing makeup, or buying that pair of over-priced, but oh-so-darling, red stilettos. It tries to prove to women that a consumer culture is enjoyable (2000:1). Ultimately, the message that this feminism presents is that women will find pleasure and confidence in buying products like over-priced stilettos. As one can see, the beauty myth is present, and still very active.

Why is it that we try so hard, today, to forget about the efforts of the women in the 1970’s? Consumerism was exactly what the feminists of the 70’s were fighting against. They were angry that society was trying to convince them that they should find satisfaction and meaning simply in the things they buy. “On a very deep level, to re-embrace the commercial culture is to betray the agenda of the modern women’s movement (Faludi as cited in Goldberg, 2000:2). Women today seem to think that the 70’s women’s movement was all about saying “no” to everything that was considered feminine. So, to go against that, they want to prove that feminism is about confidence and showing that women can wear makeup and dresses and still be powerful. However, this consumer-based “feminism” completely misses the point of the second wave feminists. It was never about instructing women that it was bad to wear makeup, it was about encouraging women to think for themselves rather than just buying things that society told them was necessary. Consumerism is a backlash against the very foundation of feminism, and is simply a supporter of the beauty myth. It is convincing women that they should be using their economic advancements and independence to buy thoughtless objects.

I believe that by understanding that consumerism is only nurturing the beauty myth, women can learn to overcome the ridiculous standards that society puts on us. In her article, “The Fat Friend,” Marissa Audia-Raymo (2010) shares her story about how she defeated the feelings of a reckless stereotype. Audia-Raymo had always felt that she was the “fat friend” in her group of friends—she was there to solely make all the other girls feel more attractive. She soon realized that even after periods of dieting, starvation, bulimia, and weight loss pills, she was skinnier than her friends, but she still felt fat and ugly. She finally came to the conclusion that her weight obsession stripped her of her self-esteem and personality. “Women have been made to feel like second-class citizens because of their bodies, often from a very young age, (Audia-Raymo, 2000:64). It took Audia-Raymo a very long time to realize that she wasn’t really the “fat friend,” she just thought she was, and the societal standards are what sparked that notion in the first place. She felt like she had to wear all the right clothes, use makeup, and make use of the newest, hottest diet program in order to fit in. She had to consciously choose to be happy with herself after years of doing all the “right” things and still being discontent. When she did, she realized that she needed to fill her life with people that loved her for her good qualities and accepted her bad—excluding weight as a feature.

It does seem that women are becoming slightly more aware of the danger and demeaning essence of the beauty myth, and the “Iron Maiden” that it has produced. Ads like Dove’s Campaign for Beauty, are taking some steps forward in helping women and society accept all kinds of beautiful. The campaign promotes Dove’s Movement for Self-Esteem, whose overall goal is to instill in girls and women that “beautiful” includes women of all shapes, sizes, races, and statures. This impression is what could positively change society for both women and men.

## CONCLUSION

In the final analysis, I came to realize that the beauty myth poses a bigger burden on women than most tend to realize. Much to my surprise, I discovered that not only does patriarchy impact the idea of the beauty myth, but it is also the culprit behind its creation. What society sees as simply the “norm” is a notion that is devastating the daughters of America. I feel that society can change, and Campaigns like Dove’s Movement for Self-Esteem is a great way to begin in our current media-saturated society. Such campaigns will hopefully spark confidence in women throughout the Western world. Women with this newfound certainty can then stand up and support the rest of society’s emotionally damaged women. In turn, we can create positive feminists role models that can oppose materialism, and attest that there is more to life than an expensive pair of shoes. With women being raised in this mindset, we can then block out the beauty myth and the consumerism it promotes which occupy both women’s time and money. Without the anxiety of the beauty myth bearing down on women, we can steer away from that pair of \$400 stilettos, and use our financial independence to change the world. Think of the contributions that we, as women, can make to the world with the “\$12.4 billion that is spent on cosmetic surgery yearly” (Roberts, 2007). I do believe that there is hope for the women in our society. The beauty myth can be defeated. It takes just one strong role model, and from there we can finish what first and second wave feminists began—the fight for the equality of women everywhere.

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# Anxiety and Visual Discriminations in Undergraduates

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## ABSTRACT

Mathematics tests were used to create anxiety in undergraduates. Heart rates were recorded as a measure of anxiety. Following each mathematics test, participants completed a different visual discrimination tasks, Stroop Colored Word Tests, Where's Waldo Puzzles, and IQ Matching Tests. Reaction times and accuracy were measured for each task. The hypothesis was that those with more difficult mathematics tests would have longer reaction times and be less accurate. The results of the study suggest that mathematics anxiety did not have a significant effect on reaction times for any task, and was only significant for the accuracy of the IQ matching tests.

*Keywords:* visual discriminations, anxiety, stroop, IQ, where's Waldo, mathematics

## ANXIETY AND VISUAL DISCRIMINATION IN UNDERGRADUATES

Visual discrimination is the ability to recognize and identify visual shapes, objects, and patterns in various forms. Many visual discrimination tasks are considered of average difficulty level under normal conditions. However, with the introduction of anxiety, visual discriminations become more difficult (Knights, 1965). Anxiety is the increase of heart rate due to a difficult, stressful situation. Anxiety is considered to consistently alter the result of visual discrimination tasks (Bai et al., 2009).

Research has shown that mathematics is thought to consistently induce anxiety (Bai et al., 2009). Geist (2010) found that mathematics anxiety is also very predictable when paired with strict time constraints. Alansari (2004) conducted Stroop colored-word tests on individuals who scored high on anxiety tests. They found that those with high levels of anxiety scored lower on Stroop tests than those with normal levels of anxiety. Head and Engley (1991), as well as Avram et al., (2010), found that anxiety increased reaction time (RT) for high and low level difficulty tasks. Britton et al., (2009) found that participant reaction times (RTs) increased when participants were under stress and had an increased heart rate. Bradley et al., (2010) researched the relationship between heart rate and anxiety. They found that heart rate increased with anxiety and that participants with lower heart rates (control group) were more accurate on a variety of tasks, including visual discrimination tasks. Hopko et al., (2002) found that self-reporting the increase of heart rate was accurate when using mathematics to induce anxiety.

In the current study, anxiety is induced by having the participants complete timed mathematics tests. The experimental group will only view each problem for 2,000 milliseconds then be presented with the multiple-choice answers. Answering incorrectly will result in the problem being repeated. The control group will have 10,000 milliseconds to view each problem and will then be presented with the multiple-choice answers. Answering incorrectly will not result in the problem being repeated for the control group (Appendix B). The hypothesis of the current study is that those who complete mathematics tests with strict time limits (experimental group) will be less accurate and have longer reaction times than those in the control group. Accuracy and reaction time will be measured across three different stimulus types, Stroop colored word tests, IQ matching tests, and Where's Waldo tests. The independent variables for this study are anxiety and type of visual discrimination tasks. This study is a 2 (Group Type [Control, Experimental]) x 3 (Visual Discrimination Task [Stroop, Where's Waldo, IQ]) Mixed Factorial design. Counter-balancing was used to ensure that the results were not due to the order of the visual discrimination tasks. Both groups will receive mathematics tests, however the control group will have more time to complete the task than those in the experimental group, those in the control group will also not have to repeat problems that are answered incorrectly. Accuracy and reaction time will be measured and compared for both groups to see if the independent variables had an effect.

## METHOD

### *Participants*

The Institutional Review Board (IRB) approved this experiment (IRB approval number 1103006-EXP). The recruitment for participants took place in five history classes and one psychology class. The participants were 18-24 years old and were current students of South Dakota State University. The experimenters visited the classes and asked for volunteers. Twenty-four participants completed the study and consented for their data to be included in the final analysis, 14 men and 10 women. The data from one man and one woman were thrown out due to errors with the stimulus presentation software. Students who met the following criteria were not allowed to participate: students with a current diagnosis of any form of psychiatric or behavioral disorder, students who at the time of testing were under the influence of alcohol, illegal substances, any form of antidepressant or anti-anxiety medication, antihistamines or any form of cold medication, students with a history of epilepsy or seizures, students taking medication for any form of Attention Deficit Disorder, students under 18 years of age and students who were colorblind. One professor offered compensation for participation in the form of extra credit. An alternate form of extra credit, worth the same amount of points, was offered for those that chose not to participate in the study. The possible benefits for participation included the opportunity to participate in and learn more about a psychological study. Possible risks of participation included minor anxiety or frustration. All participants were provided with the contact information for both experimenters, the project supervisor, the IRB, and the SDSU Counseling Center.

### *Materials*

Heart rate recording sheets were used for participants to keep track of their heart rates, an experimenter made these. SuperLab (Versions 4.0 and 4.5) was the software used to conduct the study. Three types of visual discrimination stimuli were used. The Stroop colored word stimuli were experimenter made, the Where's Waldo puzzles were from *Where's Waldo? The Great Picture Hunt* (Handford, 2009) and *Where's Waldo? The Fantastic Journey* (Handford, 2006). The IQ matching questions were from *IQ Tests to Keep You Sharp* (Philip & Kenneth, 2002). The Stroop colored word stimuli were the following words: black, blue, green, brown, white, orange, yellow, purple, and pink. All of the words were in a color not matching the word (Appendix A). The Where's Waldo pictures were complex pictures of various scenes in which Waldo or Odlaw was hiding. The IQ matching questions were multiple-choice questions, and the participants were presented with the question and the answers on the same screen (Appendix A). All mathematics problems were addition and multiplication. The problems and answers were made in a drawing program by the experimenters. The red "WRONG" screen was also experimenter made (Appendix B).

### *Procedures*

All sessions took place on campus and the experimenter completed the study with up to four participants in each session. The researcher read the consent form to the participants and asked that if anyone did not meet the requirements they should leave, and they would still be awarded extra credit. Participants were then instructed how to take a measure of their pulse using the carotid artery.

Before participants arrived they were placed in groups to determine which group they would be in (control or experimental) and which order they would complete the tasks (Version 1: Stroop, Waldo, IQ; Version 2: Waldo, IQ, Stroop; or Version 3: IQ, Waldo, Stroop). Each trial consisted of completing a mathematics test, a heart rate recording, and a visual discrimination task. All components were presented for each of the three visual discrimination tasks. For the math tests, the experimental group had 2 seconds to select a multiple-choice answer, and answering incorrectly resulted in a red screen being presented with the words "WRONG!!! Try Again," and the problem repeated. The control group had 10 seconds to select a multiple-choice answer and answering incorrectly did not result in the problem being repeated. There were twelve addition and multiplication mathematics problems (Appendix B).

For the Stroop task, the word "black" was displayed on the computer screen; the color of the word was purple. Participants were instructed to press the key that corresponded to the first letter of the color. For this example, the correct response was "P" because the word was colored purple. Participants only had 5 seconds to make a response. There were fifteen different stimuli in the Stroop colored word section. The Where's Waldo task started with a picture of Waldo and Odlaw. For each picture shown, participants were to press W if the picture contained Waldo, or O if the picture contained Odlaw. They had 10 seconds for each stimulus. There were twenty different stimuli in the Where's Waldo section. For the IQ section, participants were shown a series of symbols and asked to find which one did not fit in with the rest, and press the key A, B, C, D, or E, that corresponded to the correct answer. Participants were informed that for each problem, they were to determine either which shape

did not fit, or which shape should come next in a series. They had 10 seconds to complete each stimulus. There were ten IQ questions. The experimenter debriefed the participants and told them what the experiment was measuring and the hypothesis. All participants were given the contact information of both experimenters, the project supervisor, the IRB and the SDSU counseling center.

### *Results*

The control group was more accurate on all math tests than the experimental group. The average accuracy on the three math tests for the control and experimental groups is compared in Table 1. The most accurate group is the control group for math test 1. A mixed ANOVA shows there is a significant difference in accuracy on the different math tests,  $F(2,40)=12.318$ ,  $p=.0003$ . The control group is more accurate than the experimental group. There is a significant difference in accuracy of the control and experimental groups,  $F(1,20)=15.086$ ,  $p=.01$ . There is not a significant interaction between the accuracy on the math tests and group type,  $F(2,40)=.591$ ,  $p=.673$ .

The average change in heart rate (HR) for the control and experimental groups are compared for HR 2, HR 3, and HR 4 in Figure 1. A mixed ANOVA shows there is not a significant difference in the HR change for the four HR recordings,  $F(2,40)=.894$ ,  $p=.417$ . There is not a significant difference in HR change for the control and experimental groups,  $F(1,20)=2.151$ ,  $p=.158$ . There is a significant interaction between HR change for group type and the four HR recordings,  $F(2,40)=3.746$ ,  $p=.03$ . A post-hoc within  $t$ -test was conducted to see if there is a significant change in HR toward the end of the study. There is not a significant difference between the baseline HR and HR 3 and baseline HR and HR 4,  $t(21)=1.48$ ,  $p=.155$ , two-tailed.

Accuracy on the visual discrimination tasks is shown in Figure 2. Participants are most accurate on the Stroop task. There is a significant difference in accuracy on the three visual discrimination tasks,  $F(2,40)=193.94$ ,  $p=2.87E-21$ . Neither the control nor the experimental group is more accurate for all three tasks. There is not a significant difference in the accuracy of the control and experimental groups,  $F(1,20)=1.749$ ,  $p=.201$ . There is not a significant interaction between the control and experimental groups and accuracy on the different tasks,  $F(2,40)=1.589$ ,  $p=.217$ . The IQ task had the greatest difference in accuracy for the control and experimental groups. A post-hoc between  $t$ -test was conducted to compare the accuracy on the IQ task for the control and experimental groups. There is a significant difference between the accuracy on the IQ task and the control and experimental groups,  $t(20)=1.93$ ,  $p=.03$ , one-tailed.

The average reaction times (ms) for the different visual discrimination tasks are compared in Figure 3. Participants are fastest on the Stroop task. There is a significant difference in the reaction times on the different tasks,  $F(2,40)=133.142$ ,  $p=2.52E-18$ . Participants in experimental group are faster than the control group on all three tasks. There is not a significant difference in the reaction times on the control and experimental groups,  $F(1,20)=.476$ ,  $p=.498$ . There is not a significant interaction in the reaction times of group type and the reaction times on the different tasks,  $F(2,40)=.017$ ,  $p=.984$ .



### *Discussion*

The hypothesis of the current study was that with the presence of anxiety, accuracy on visual discrimination tasks would decrease and reaction time (RT) would increase. Anxiety was induced by using timed mathematics tests and measured by self-report heart rate. Heart rate was only a measure of anxiety, not a variable. The mathematics tests were more difficult for the experimental group than the control group. There was not a significant difference in accuracy on the three math tests. However, the third math test had the lowest accuracy for both the control and experimental groups. This may be due to the third math test containing more multiplication problems than the other two tests. A Latin square design was used to rule out the order effect in the mathematics tests.

The increase in heart rate was not significant when comparing the average HR change of the control and experimental groups. However, there was an interaction between the control and experimental groups and the different HR changes. For the experimental group, HR 4 produced the greatest change from the baseline, which was taken after the final math test. This slight increase in HR was most likely due to the participants in the experimental group getting frustrated and tired due to task completion.

There was not a significant difference in the accuracy of the control and experimental groups on the Stroop colored word test or the Where's Waldo tests. However, the control group was significantly more accurate on the IQ task. According to Richards and French (1992), anxiety reduces the accuracy on visual discrimination tasks. The IQ questions were the most difficult out of the tasks. This is due to the questions being more complex and difficult to answer correctly in the given time compared to the other tasks. This suggests that perhaps the actual IQ questions, not the math tests, raised the anxiety of the participants. The Stroop colored word questions were the least difficult of the tasks. This is evident in the very high accuracy on this task and minimal difference in accuracy for the control and experimental groups. According to this same concept, that difficult tasks produced more anxiety than math, the Stroop task produced the least anxiety during the actual task because it was the easiest task. According to Alansari (2004), those with increased anxiety were less accurate on Stroop colored word tasks than those who were not anxious. If the Stroop task was more difficult (more anxiety provoking), the differences in accuracy between the control and experimental group would most likely be greater. This is also true for the Where's Waldo task. If the actual task was more difficult, it might have produced more anxiety during the task than was produced during the math tests, which would have reduced accuracy for the experimental group. If all the visual discrimination tasks were as difficult as the IQ task, significance might have been found for accuracy on the different visual discrimination tasks.

There was not a significant difference in the RTs for the control and experimental groups with regard to the different tasks. Increased HR has been correlated with increased reaction times (Head & Engley 2002). Britton et al., (2009) also found that as HR increased, RT increased. However, the difference in HR for the control and experimental groups, in the current study, did not achieve statistical significance. This suggests that the anxiety was not sufficient in altering the average reaction times of the control and experimental group on any of the tasks.

In the current study, this lack of difference in both reaction time and accuracy between the groups is most likely due to low anxiety. The participants also may not have been



anxious for the duration of task completion. In sessions where multiple participants were completing the experiment, some participants had to wait after completing the math tests for all other participants to finish the math test. This may have resulted in a decrease in anxiety. The decrease in anxiety may not have been evident in the results because anxiety may have decreased faster than actual HR decreased.

Possible confounding variables are the warm temperature of the experimental room, task timing, and instruction errors. Temperature of the room would affect the results because if the room was very warm at the time of the study, the participants would be distracted and may not pay attention to the actual tasks. Temperature may also have caused participants to hurry through the tasks in an attempt to complete the study as soon as possible.

The timing of the tasks also may contribute to the lack of significance in the results. If participants selected an answer at the end of the time limit, they would often accidentally select an answer at the start of the next question, resulting in very fast RT. However, this was not examined in the current study. Instruction errors may have also affected the results. There were errors in the script that were not discovered until participant sessions had already begun. These errors were minor and included incorrect instructions, such as “Press P” when the correct key was “X.” These errors could have contributed to the insignificance of the results because if participants received incorrect instructions, they were more likely to not pay attention to the rest of the study. Inaccurate instructions would result in the participants devaluing the study and not paying attention to the actual tasks.

The current study did not use the same recruitment measures as those of Bradley et al., (2010) who required participation as part of a class. Requiring participation would increase participant motivation. In addition, Geist (2010) used money as compensation for participants. This would also increase motivation. Because the current study did not require participation and did not offer money as compensation, this most likely caused participants to have lack of motivation about completing the experiment resulting in overall low anxiety.

## ACKNOWLEDGEMENTS

Special thanks to Dr. Debra Spear, for guidance, leadership, helping this project become a reality and editing this article. Thanks to Kasandra Johnson, my research partner, for not only being a researcher, but also for being a friend. Thanks to Professor Christopher Hummel and Dr. Andrew Woster, for allowing me and Kasandra to recruit participants in their classes. Thanks to the Psychology department for giving me this opportunity.

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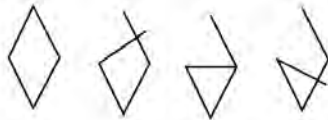
APPENDIX A

# Black



(Hanford, 2006)

What comes next in the sequence?



(Phillip and Kenneth, 2002)

$$\begin{array}{r} 88 \\ +15 \\ \hline \end{array}$$

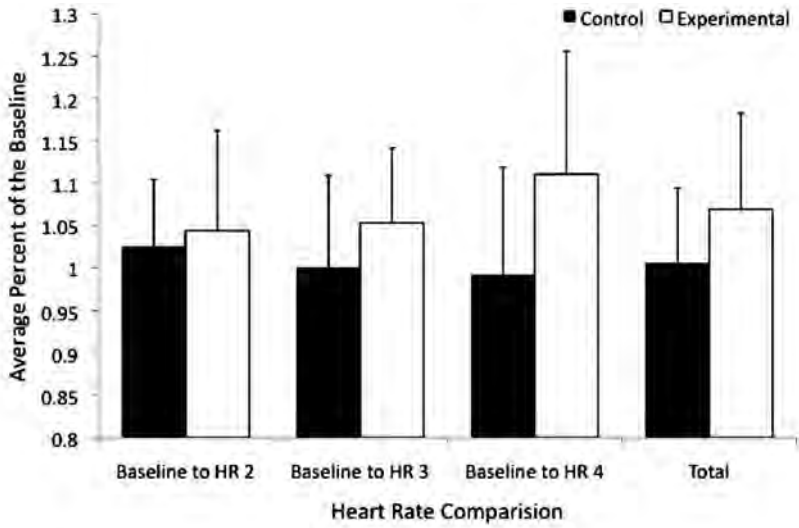
- a. 103
- b. 93
- c. 105
- d. 113

**WRONG!!!**  
Try Again

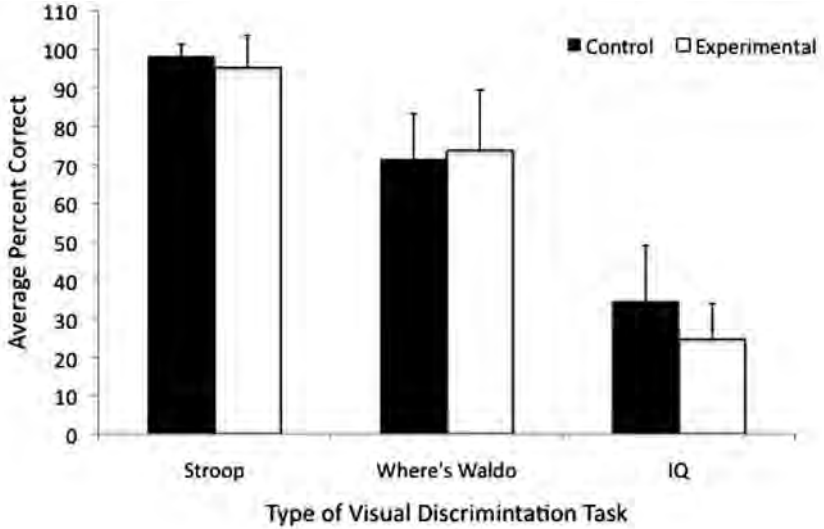
**APPENDIX B**

**Table 1.** Means and Standard Deviations of Math Tests 1, 2, 3 and Total

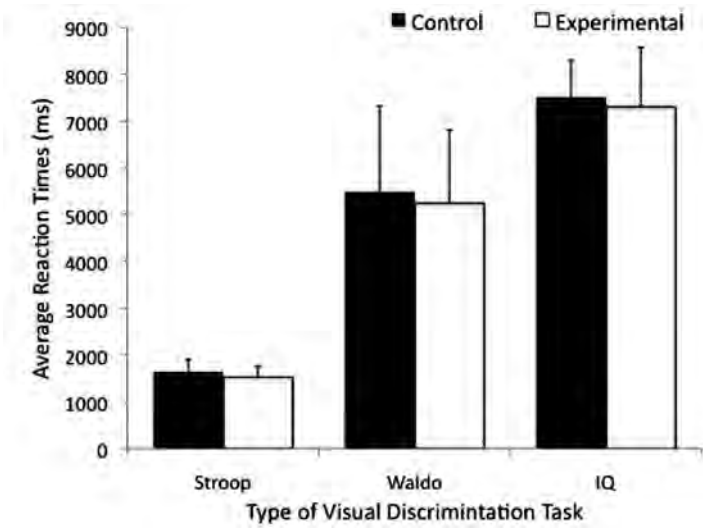
	Test 1	Test 2	Test 3	Total
Control	<i>M</i> =96.97	<i>M</i> =91.67	<i>M</i> =82.58	<i>M</i> =90.40
	<i>SD</i> =4.20	<i>SD</i> =10.54	<i>SD</i> =14.17	<i>SD</i> =7.59
Experimental	<i>M</i> =81.82	<i>M</i> =71.21	<i>M</i> =65.91	<i>M</i> =72.98
	<i>SD</i> =13.34	<i>SD</i> =16.82	<i>SD</i> =16.86	<i>SD</i> =12.80



**Figure 1.** The average change in heart rate from the baseline for the control and experimental groups. Error bars denote standard deviations.



**Figure 2.** The average percent correct for the different visual discrimination tasks are illustrated for the control and experimental groups. Error bars denote standard deviations.



**Figure 3.** The average reaction times (ms) for the different visual discrimination tasks are illustrated for the control and experimental groups. Error bars denote standard deviations.



# Long Term, Continuous Temperature Monitoring of a Simple Anaerobic Digester and Open Manure Storage Pond in Eastern South Dakota

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## ABSTRACT

A two-cell manure storage system with a cover on the first cell was constructed in the late summer of 2009 in Eastern South Dakota. The covered cell acts as a simple anaerobic digester. Continuous temperature monitoring for 8 months shows the winter effluent temperature equilibrated to around 6°C, and that the effluent temperature trend lagged the ambient temperature trend by a month. Manure composition was also analyzed and was found to be relatively steady throughout the system. Volatile solids were the only component that dropped appreciably across the treatment cell, with an observed maximum of 50% reduction.

## INTRODUCTION

Anaerobic digestion is a well-known method of utilizing chemical energy from organic wastes, both agricultural and municipal. Anaerobic microbes break down organic material as a part of their metabolism, and certain species produce methane as a waste product. Methane is a greenhouse gas of high regulatory concern with over 20 times the heat capturing capacity as carbon dioxide (EPA, 2011). In a managed anaerobic system, the methane produced can be collected and then burned as a fuel, reducing the total greenhouse gas production of a system. Since digestion is dependent on microbial activity, the environment where the digestion occurs is an important factor in the system's effectiveness. Microbial life occurs in three distinct temperature ranges: thermophilic (50-60°C), mesophilic (25-40°C), and psychrophilic (<20°C). Commonly, anaerobic digesters operate in the mesophilic range. The pH and manure nutrient composition also impact the microbial activity and digestion process.

An unheated manure storage system can be converted to an ambient temperature anaerobic digester (AD) with the addition of a cover and gas collection system (NRCS, 2003). While this type of AD is relatively low-cost and less technical than other types of ADs, gas production is affected by uncontrolled effluent temperature variation. The stored manure moves to an equilibrium temperature based on ambient and soil temperatures, radiation gains and losses, and heat generated during the digestion process.

There have been some studies that have investigated the digestion process under cool conditions. An early study from the Netherlands found no biogas production in dairy effluent



or swine slurry below a temperature of 20°C in any of the studied digesters without addition of previously treated effluent or an inoculum of temperature adapted bacteria (Zeeman et al. 1988). A Russian study in the late 1990's focused on the use of anaerobic digestion in the temperature range of 3 to 9°C. The purpose for their investigation was to determine if psychrophilic anaerobic digestion was a viable alternative for industrial wastewater treatment. They used a two-stage lab-scale system and loaded it with a constant mixture of volatile fatty acids. Under the low temperature conditions they observed a removal rate of over 90% of volatile material after an initial break in period, even when the temperature dropped to a minimum of 3°C for a period of 8 days. In addition to reducing the operational temperature they attempted to decrease the hydraulic retention time to a minimum while maintaining effective removal of volatile matter (Lettinga et al. 1999). This shows that degradation of volatile matter to methane can occur at low temperatures, and can attain high conversion efficiencies. Martin (2008) monitored the performance of a covered lagoon utilizing separated dairy effluent in California. They found no variation in the amount of gas produced by the system during the year of monitoring. The temperature of the effluent varied from 12.4°C (54.4°F) to 28.6°C (83.6°F) and differed from ambient temperature by 9.1°C (15.3°F) in January. As the gas production remained unchanged the temperature of the lagoon never left the optimal range for microbe growth even though the lagoon fell below 20°C. The literature suggests psychrophilic anaerobic digestion has the potential to be effective down to 3°C in an intensely controlled system. Furthermore, effective digestion was shown to continue through a 16.2°C reduction while maintaining gas output. Also, it was found that addition of adapted bacteria to the effluent acted to jump start digestion in cold systems that would otherwise have not produced biogas. The monitored system is not controlled and will not be as effective as a tightly regulated system. However, the simplicity of the construction and maintenance could balance out the loss of performance.

This paper shows preliminary results from a long term, continuous monitoring project of a simple AD system in South Dakota. This temperature data provides baseline measurements for more specific investigations into the overall effectiveness and heat transfer basics of simple AD systems in cooler climates.

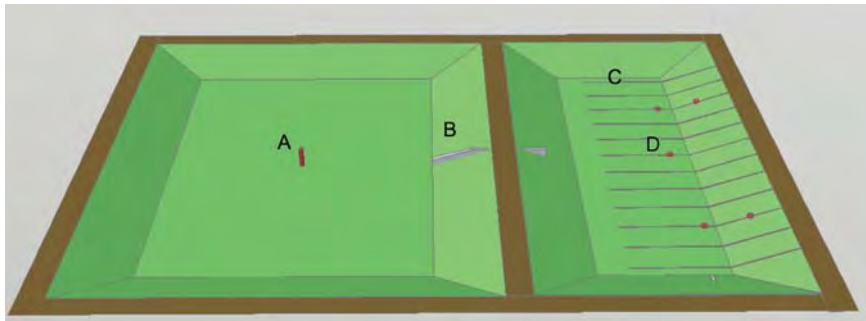
## MATERIALS AND METHOD

The monitored site was a 1,100-head dairy operation in eastern South Dakota with a flush manure removal system and a two-cell waste storage system. The flushed manure first encountered a solid separation system. The liquid fraction flowed out into the covered cell and the solid portion was used for bedding. The covered cell was connected in series with an open cell that stores the treated liquid that flows from the covered cell. Some of the liquid in the second cell was recycled back through the barn in the flush system.

The cover was a synthetic material, weighted down with concrete tubes to push gas through a gas collection system around the perimeter of the covered cell. The gases produced in the anaerobic conditions of the covered cell were flared off in order to reduce the total greenhouse gas emissions of the system. A total of 12 polyvinyl chloride(PVC) sludgelines were built into the covered cell, parallel to the east wall and along the bottom, approximately

20 cm from the covered cell floor. The purpose of the sludgeline was to allow for agitation and then removal of any sludge accumulation in the covered cell. The sludgelines offered a practical access point to inside the covered cell.

Temperature data for the covered cell was collected by threading five temperature loggers (Model UA-001-08, Onset Computer Corp., Bourne, MA) into the sludgelines with cross-linked polyethylene (PEX) tubing. Three loggers were placed at the full depth of the covered cell in sludgelines 3, 7, and 10. Two loggers were placed at approximately half the depth of the covered cell in sludgelines 3 and 10 (Figure 1). The tube and loggers were left in the sludgelines continuously except during monthly data retrieval, from 9/24/2010 to 5/17/2011. Temperature measurements were recorded every 15 minutes.



**Figure 1.** Location of the float (A) and weir (B) in the open cell (left), and the sludgelines (C) and temperature loggers (red circles, D) in the covered cell (right).

Temperature data for the open cell was collected by placing a float in the center of the cell. The float was made of capped PVC pipe and wood. The dataloggers were fastened to a 3-m chain at depths 0.6, 1.8, and 3.0 m from the surface. The float was anchored on the edges of the open cell. The open cell froze over in the winter so the sample rate was set to 1 hour to allow for deployment without retrieval from 11/19/2010 to 4/19/2011.

The ambient temperature 1 m above the south berm of the covered cell was recorded with a logger in a solar shield from 11/19/2010 to 5/17/2011. Prior to 11/19/2010 hourly mean temperature data from Brookings, SD, was used (weatherunderground.com).

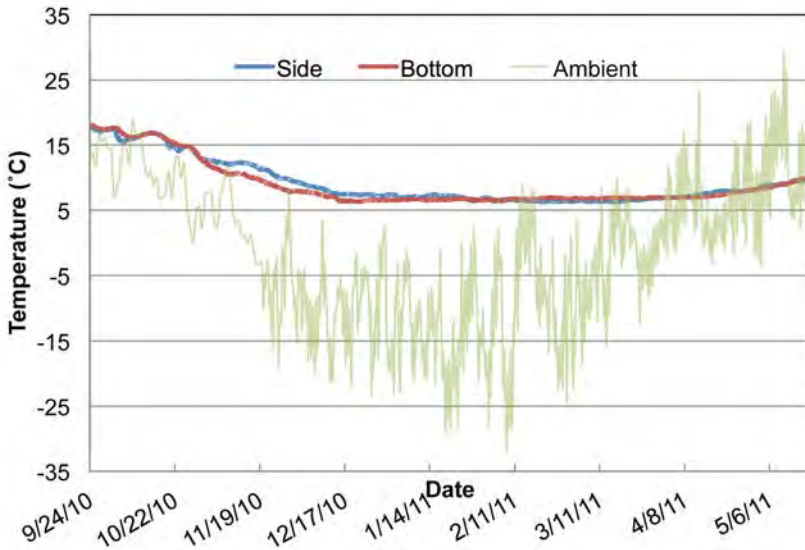
The temperature accuracy of the dataloggers was assessed in ice water upon each deployment. The observed logger accuracy was within  $\pm 0.5^{\circ}\text{C}$ .

Manure samples were taken every two months starting in December to measure manure composition before and after treatment in the covered cell, as well as on recirculation into the barn (after the open cell). The sample dates were 12/15/2010, 2/8/2011, and 4/19/2011. Effluent was collected prior to treatment just after the solid separation process. Effluent was collected after treatment at the weir that controls flow from the covered to the open cell. Recirculation liquid was collected at the point where it re-entered the barn. Analyses (density, total nitrogen, phosphorus, potassium, ammonium nitrogen, pH, and moisture) were completed by Olson Agricultural Analytical Services Laboratory using standard practices.

The volatile solids were determined by the Water and Environment Engineering Research Center using standard methods.

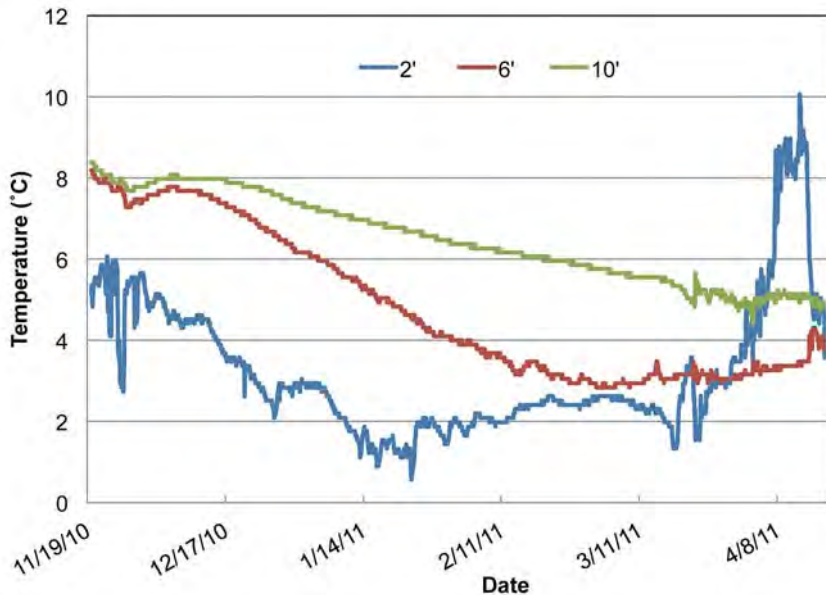
## RESULTS AND DISCUSSION

Temperature in the covered cell in September was around 18°C, with the warmest temperature being 18.6°C on the bottom of sludgeline 10 and the coolest being 17.8°C on the side of sludgeline 10. The temperature steadily declined to a minimum of between 5.5 and 6.5°C throughout the covered cell. The early fall manure temperature of 18°C was cooler than expected and appeared to already be on the decline. The effluent temperature trend in the covered cell lagged the ambient temperature trend by approximately 4 weeks. The temperature trends were defined as periods when the temperature increased, decreased, or stayed the same over a period of time. Figure 2 shows the data collected from both dataloggers in sludgeline 3 as well as the recorded ambient temperature. The temperature in sludgeline 3 stayed essentially constant from 12/17/2010 to 3/25/2011. After 3/25/2011, the manure temperature rose at a gradual rate to a local maximum of 9.9°C for the bottom and 9.6°C for the side loggers. The observed equilibrium temperature reached during the winter was 6-7°C which constitutes psychrophilic conditions.



**Figure 2.** Measured temperature at the side and bottom of sludgeline 3 and ambient temperature.

Temperature in the open cell in November was around 5°C at the 0.6-m (2') depth and around 8°C at the bottom. The 1.8-m (6 ft) and 3-m (10 ft) dataloggers both started on the bottom of the cell as it was recently pumped out in November. As the depth increased the loggers separated and a temperature profile developed as can be seen in figure 3. The response to ambient temperature change was negatively correlated to depth, or the deeper the logger the slower the response to the temperature change. That is most noticeable in mid April when the measured temperature of the 0.6-m (2 ft) datalogger spikes upward in response to higher ambient temperature. The open cell was pumped out again starting on 4/18/2011.



**Figure 3.** Manure temperatures in the open cell at 0.6 m (2'), 1.8 m (6') and 3 m (10') depths from the surface.

The data for three month-long periods were averaged by hour (Figures 4, 5, and 6). During October of 2010, there is an increase in effluent temperature between noon and 16:00. The average change is small, around 0.15°C, which is less than the accuracy of the sensors, but it is unlikely that the observed increase in temperature at these hours would be due to a consistent error in all of the sensors for the duration of deployment. Figure 5 shows the average temperature over the January 2011 period. The temperature remained constant through this period. Figure 6 shows the data from April-May of 2011. Emerging temperature changes are evident in the morning from 8:00 to noon in all locations. Interestingly, the changes in the spring month (Figure 6) are opposite to what was observed in the fall (Figure 4), and the logger locations of the maximum and minimum temperatures are exactly opposite between fall and spring.

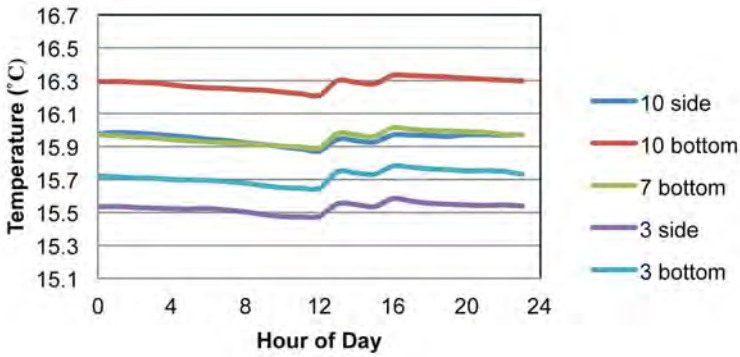


Figure 4. Hourly averages over the 9-24 to 11-4 deployment period.

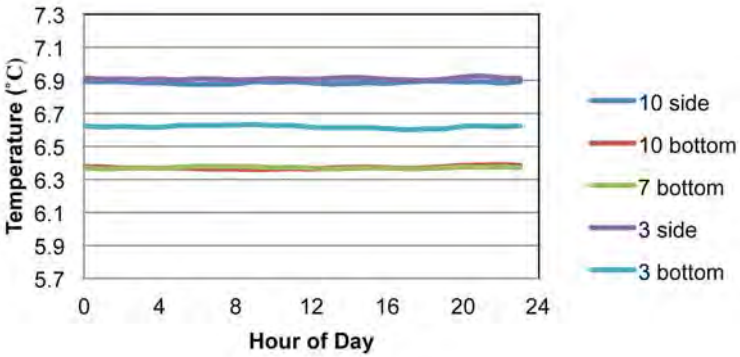


Figure 5. Hourly averages over the 1-12 to 2-8 deployment period.

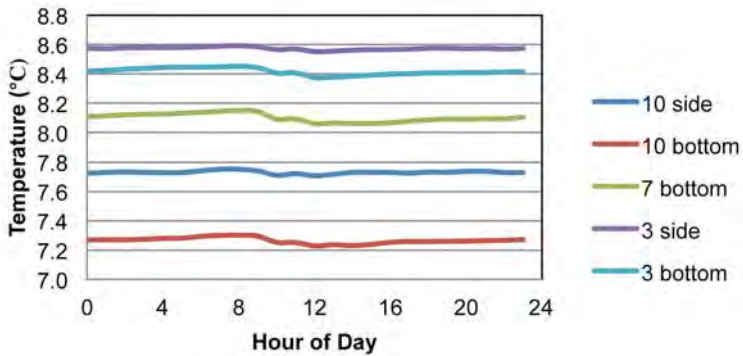


Figure 6. Hourly averages over the 4-19 to 5-17 deployment period.

Based on these measurements, we recommend a temperature sampling frequency of 1 hour to allow for longer deployment durations as the dataloggers are robust enough to handle the environment, as was seen in the open cell. Also, hourly sampling still allows for daily trends to be examined. The recommended location of sampling is multiple depth profiles in the covered manure if possible. If the emergency vents through the cover are located in the full depth of the covered cell, this provides an ideal sampling location for measuring the temperature profile. If temperature profiles through the cover are not an option, sampling in the sludgelines works well. It is recommended for future projects to add another sampling location in the sludgeline at a shallower depth so that more of a profile could be seen. Also, it would be interesting to monitor the temperature of the effluent flowing from the closed to the open cell at the weir.

Manure composition results are shown in Table 1. The composition of the effluent at each stage is variable, but does not change appreciably. The solids composition decreases the further through the system the effluent goes, and likewise the density increases towards 1 g/mL, the density of water. The pH of the effluent in all stages was observed highest from the February sampling; this corresponds to a higher ammonia concentration. Ammonia is a base and is less volatile under cool conditions so higher concentrations will lead to higher pH measurements. The manure samples take a snapshot of the effluent compositions at each of the locations. The design hydraulic retention time of the covered cell was 60 days; the total time it took for effluent to be recycled back to the barn in the flush system is not known. Also, only a fraction of the effluent was used as flush water, but it is assumed that the recirculation effluent is representative of the open cell composition.

Table 1 shows that volatile solid composition changed through treatment in the covered cell. Volatile solids are the feed material for the microbial population, and are converted to methane. Thus, volatile solid destruction correlates to the amount of methane produced and is a common method of determining digestion efficiency. On 12/15/2010 the volatile solids were reduced by 50% through the covered cell. The overflow volatile solid composition increased markedly on the following two sample dates. There was an observed 33.5% reduction on 2/8/2011 and an observed 5.6% increase in volatile solids on 4/19/2011. The volatile solids in the separated effluent on 4/19/2011 were much lower than the previous samples. The sample was taken at a different time of day and likely corresponded with the flushing of washwater used to clean the parlor after the morning milking. Washwater would dilute the effluent which would lower the concentration of observed volatile solids. It is assumed that the volatile solid loading into the covered cell would be relatively constant in the 0.019 to 0.020 g/ml (0.16 to 0.17 lbs/gal) range based on constant diet nutrient composition, homogeneous cattle genetics, and the first two measurements.

**Table 1.** Manure composition for each sample point and each date.

Sample Location Quality Parameter	12/15/2010	2/8/2011	4/19/2011
<b>After separator, flowing into the closed cell</b>			
Density (g/mL)	0.989	0.9802	0.9684
Total Nitrogen (%)	0.278	0.2366	0.2199
Phosphorus (%)	0.0240	0.0270	0.0220
Potassium (%)	0.152	0.142	0.129
Ammonium (%)	0.112	0.1248	0.1071
pH	7.45	8.14	7.89
Moisture (%)	97.2	97.0	97.8
Total Solids (%)	2.82	3.04	2.20
Volatile Solids (g/mL)	0.019	0.020	0.013
<b>After the closed cell, at the weir, flowing into the open cell</b>			
Density (g/mL)	0.992	0.9967	0.9909
Total Nitrogen (%)	0.184	0.2459	0.2371
Phosphorus (%)	0.0230	0.0210	0.0210
Potassium (%)	0.136	0.135	0.126
Ammonium (%)	0.108	0.1192	0.1131
pH	7.45	8.02	7.69
Moisture (%)	97.8	97.8	97.9
Total Solids (%)	2.25	2.24	2.11
Volatile Solids (g/mL)	0.0096	0.013	0.013
<b>After the open cell, used as recirculation water to flush the barn</b>			
Density (g/mL)	1.01	0.9808	1.001
Total Nitrogen (%)	0.169	0.2233	0.2369
Phosphorus (%)	0.0170	0.0240	0.270
Potassium (%)	0.139	0.138	0.126
Ammonium (%)	0.107	0.1203	0.1131
pH	7.53	7.85	7.72
Moisture (%)	98.1	97.7	97.6
Total Solids (%)	1.87	2.31	2.37

## SUMMARY

Data gathered from the monitored site represents baseline data on the seasonal temperature characteristics of a simple anaerobic digester in a climate with harsh winter conditions and extended cold periods. The data show that winter equilibrium temperatures in the covered cell are adequate for digestion processes to occur, although at a reduced rate from the warmer months. An important finding was that the manure temperature stabilized for almost 16 weeks at around 6°C over the winter. Additionally, the hourly averages of manure temperature shows that heat addition in the covered cell follows a cycle that appears to reverse from fall to spring. Future work could include investigation into the effect of the temperature lag of the manure storage system with changes in ambient conditions and ways to reduce or lengthen it.

## ACKNOWLEDGEMENTS

The authors acknowledge the help and assistance of the dairy owner; Environmental Capitol Management, LLC; the Griffith Undergraduate Research Program and Scholarship; Scott Cortus; Corey Lanoue; and the Ag Engineering Department.



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# The Equitarian Initiative: International Humanitarian Aid Using Horses

(Winner of a 2011 SDSU Schultz-Werth Award)

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*“If I die, my family...well, they’ll survive. If my mule dies, we’ll all die.”*

This harrowing comment from a Mexican laborer echoes the worldwide importance of working horses, mules, and donkeys. For many in the United States, a horse is a source of recreation, a sport vehicle of sorts, a decoration, or a pet. For most other parts of the world, a working equid (horse, donkey, or mule) is a family’s sole vehicle, a day laborer, and the only



A donkey awaiting chores in Veracruz.

constant source of income available. Many of these communities lack a steady food source for the animals, much less a competent veterinarian; thus, the world’s veterinarians treat only about 10% of the world’s total equid population [1]. Such a staggering statistic is only part of the problem: working horses, donkeys, and mules not only lack direct care, but their owners often resort to harmful traditional medicines (or no treatment at all) when the animals need help. The vicious cycle then continues as

owners fall deeper into economic hardship when the health of their work animals does not improve. “Equitarian” work, defined as serving equids with compassion to improve their health and welfare, has a two-fold purpose: benefiting the animals, but in doing so changing the lives of their families for the better (thus the word’s derivation from “humanitarian”) [2]. Many initiatives already exist to change the state of four-legged laborers, proving that equitarian work is valuable, logical, and fills a deep need in the world.

Approximately 100 million working equids can be found in the developing world, in fields or farms, on roads and tracks, in factories, garbage dumps, tourist attractions, urban settings, or remotely rural areas [3]. This is approximately 95% of the world’s donkeys and 60% of all horses [3]. China includes the highest population of equids, at just below 20 million. Mexico has approximately 13 million, followed by Brazil and Ethiopia, with approximately eight million and six million, respectively. Pakistan and Argentina similarly have five million and four million equids, respectively [3]. It is also interesting to note that

working equids populously inhabit countries covering the full spectrum of the 2010 Human Development Index – from countries of high human development, such as Argentina and Mexico, to countries of low human development, such as Kenya, Afghanistan, and Ethiopia [4]. Donkey populations tend to be stable even in rapidly industrializing countries (like China or Brazil) because these countries most often experience the painful divide between the rich and the poor [3]. As the rich become richer and the poor become poorer, the more rural areas often experience incredible poverty, with little access to technology or education, meaning a continuing need for working horses.

Not only are working horse populations stabilizing, but uses for them in many countries are in fact growing. Increased fuel prices in countries such as Pakistan and India require more rural and urban residents alike to switch from motorized vehicles to the old-fashioned kind of horsepower [5]. Over the last 30 years, the donkey population has increased in sub-Saharan Africa, northern India, and Latin America's tropical highlands [3]. Mule populations have increased to as high as 15 million in 2008, as many owners are discovering their unique hardiness, static personalities, and easy maintenance [3]. For some very remote areas, equine transportation is the only way to get from point A to point B, as travel is too dangerous, expensive, or impossible with motorized vehicles; equine populations will remain in these countries as long as the roads need to be traveled.

As mentioned, working horses are used extensively for transportation in developing countries. Countries such as Honduras, Afghanistan, Pakistan, and Kenya battle rough terrain by choosing donkeys and carts versus larger, bulkier motorized vehicles. Donkeys, mules, and horses can also be found deep within urban areas, serving as garbage collectors in Cairo, Egypt, or Soweto, South Africa, working the brick kilns in India, laboring on coffee or livestock farms in Veracruz, Mexico, rural Ethiopia, or Lesotho, and taking children to school in Veracruz, Mexico or the Dominican Republic [3][6]. For instance, equine assistance can reduce a workweek by 25 hours in terms of fetching water alone [3]. Working equids literally help in international development—from carrying building materials in floodravaged Pakistan via a “donkey train” [7] to carrying ballots and supplies to the polls in Afghanistan's 2010 elections [8]. These animals have rightfully been dubbed the “Cinderellas” of international development [3].



Equids are an invaluable part of world transportation.



Donkeys carried the ballots in Afghanistan's 2010 elections (upi.com).

These “Cinderellas” are also extremely prevalent, but somehow devastatingly overlooked, in the worldwide tourism industry. Tourism would be impossible without the help of these gentle giants. “The animals themselves will never realise the significance of their work, but their owners do” [9]. For instance, Egypt, Morocco, Jordan, and India are hosts to a large population of equids used for tourism; many of them suffer from thirst, heat stress, lameness, hoof deterioration, overgrown hooves, lesions along their withers, spine, shoulders, base of the tail, and other areas of contact for the harness or tack, secondary injuries, lip and mouth wounds, and depressed behavior resulting from abuse, fear, exhaustion, or pain [9]. Excited tourists may not thoroughly inspect the animals prior to selecting a burro to ride or a horse to pull them in a cart;



Tourism in Petra, Jordan (thebrooke.org).

overweight tourists can be seen riding up steep mountainsides on incredibly small burros, families may overload a cart, hurried travelers and demands of the industry do not allow for sufficient rest time for the animals, and working equids face extreme climates in the world’s most tourist-laden areas, such as in Petra, Jordan or the Havasu Falls in Arizona [9][10].

“Domestic work animals...assist in eliminating poverty, reducing drudgery and creating wealth. Working animals can be sustainable, affordable and appropriate, requiring little external input especially amongst resource-poor people in developing countries,” according to Dr. Caleb A. Kudi of the Department of Agriculture and Food Studies at the University of Plymouth [3]. In more fortunate developing countries, every family has at least one donkey, mule, or horse. If a family is considered on average to be 6 people, 100 million working equids ultimately affect the lives of about 600 million people [3]. In most agriculturally-based societies, a donkey, or an even more prestigious horse, is a status symbol, a sign of wealth and prosperity for the family. Women



Children are often the sole caretakers of animals.

also rely on and appreciate their working counterparts: “For us women a donkey should be our first friend, for it takes away the loads that used to crush our backs,” says Mary Waceke, a housewife in Lari, Kenya [3]. Women welcome equines’ help with time-consuming household chores and farming tasks, and they also serve as a companion while the men are outside of the home for many hours a day. Children also utilize donkeys in as many ways as adults. Donkeys help get them to school or do the dirty work when kids are forced to work outside the home for supplemental income, such as in the markets or rubble dumps in big cities.

Children in poor areas are often the sole caretakers of animals, so they often develop deeper bonds with their burros or horses in ways people in more privileged areas may not understand. Working equids affect more than just companies or tourist agents — “For the whole world it might be only a donkey, mule or horse, but for the poor owner it is the whole world” [3].

Horses, donkeys, and mules are lauded and appreciated in many developing countries, but they can also be severely overworked, underfed, or overlooked. Neglect is often a matter of a lack of education, but sometimes it results from shortcuts taken out of economic or emotional desperation. Approximately 80% of ailments treated by The Brooke are a result of owners’ poverty or a lack of knowledge about how best to care for animals [11]. The most common areas of concern that equitarian veterinarians have faced include malnutrition and



Malnourished and extremely emaciated animals are heartbreaking to see.

parasite burdens, dental problems (orthodontic disease, malocclusions, discomfort), skin wounds, especially from improper harness, saddle, or bridle fit, musculoskeletal problems and lameness, hoof and shoe irregularities (correcting foot balance, severe growth, or improperly fitted, homemade shoes), surgery and field anesthesia needs (castrations, removing tumors, and other treatments), and internal medicine (pregnancy checks, internal diseases, other deep-seated problems) [1].

Direct care and education are the two emphasized modes of welfare improvement among many working equine welfare organizations. Primarily, animals must first be treated using the best means available, under direct care. Most often, animals presented are in need of basic deworming, assessment and changes to the tack fit, and dental and farrier work. A somewhat debatable subject is the use of modern veterinary equipment and technology. How many “toys,” gadgets, machines, and tools should we use in the field? Some may prefer to use the best technology to better “show” the owner the problems inside his horse, such as expensive radiographs, ultrasounds or Fecal Egg Counts (FEC). Other advocates say that a key to maintaining the sustainability of such ventures lies in only providing the services that could later be adopted by local veterinarians or the owners themselves. Some crafty techniques that are already being utilized by veterinarians in the field include using a modified battery-powered drill handle outfitted with a clamp on the end for easy and clean castrations; attention to easily-obtained drugs in the host country for anesthesia (depending on the availability of

Direct care and education are the two emphasized modes of welfare improvement among many working

improvement among many working



A severe saddle wound.





Radiographs: should we use first-world technology?

ketamine, xilazine, etc.); using locally-sourced foam for tweaking saddle fit; handmaking cinches, nylon headstalls, and other pieces of tack; attaching ropes and pulleys to soccer field goalposts to sustain the head during dental examinations; applying disinfectant made of orange seed to foot infections; carefully using available farm tools, such as an easily accessible blade, to trim hooves; and using nearby trees to raise I.V. fluid drips [1].

Perhaps just as vital as direct care is the educational aspect of equitarian work. Since veterinarians often have a one-time treatment opportunity with each given case (the horse, donkey, or mule is brought to a one-day clinic, to go home after treatment), generating a change in the animal’s welfare is difficult without a change in the owner’s practices. Sometimes owners are simply not aware of the harm they are causing their animals. In other circumstances, outright neglect and ignorance is at fault, just as in many places in the United States. And in still other cases, traditional remedies may have been used with the hope of treating the animal without veterinary intervention, thus creating additional issues for the animal. As Dr. Tom Juergens of the Fast Horse Project in Mongolia puts it, “They don’t (practice traditional medicine) because they don’t care about their horses – they do it because they care about their horses and they don’t have any alternatives” [12]. Our job is not to blame the well-meaning efforts of centuries-old healing techniques or homemade remedies, rather to emphasize the negative effects some of these practices may have on equines in order to foster positive change. In Mexico, euthanasia is virtually a foreign concept, even to some veterinarians: why use limited financial resources to put the animal down when it can easily remain in its pasture until natural death [1]? Also, some farm laborers believe it is detrimental to give horses water during the working day, a potentially fatal mistake. Some populations in areas such as Egypt or Multan, Pakistan will actually slit their donkeys’ nostrils in the hope that this will help them to breathe better [3]. To alleviate infection, incisions are sometimes made in a new wound, a rag or piece of cloth is inserted, then the incision is closed with thread. The abscess drains as

Perhaps just as vital as direct care is the



Tools for castration.



Traditional remedy of sewing cloth into a wound (thebrooke.org).

pus; however, some mistakenly claim this to be the “infection” leaving the wound [3]. These are just some examples of attempts owners may make to increase daily productivity; it is up to us to share the knowledge we have about better practices!

Some groups are doing just this. The first-ever Equitarian workshop was held during October 2010 to discuss and apply proper equitarian veterinary care abroad. This workshop marked an unprecedented collaboration between several equine welfare groups, which are discussed below.

The American Association of Equine Practitioners (AAEP) serves as the umbrella organization of the relatively new equitarian initiative. Equitarian work was a special topic at the 2009 AAEP National Convention, from which a workshop was forged between several groups. Many veterinarians have small projects occurring in various regions of the world, and the goal of the AAEP Equitarian initiative is to increase dialogue and join forces among many of the different existing projects and organizations. The 2010 Equitarian workshop in Mexico joined together the AAEP, the Donkey Sanctuary, World Horse Welfare, the



The 2010 Equitarian Workshop in Veracruz, Mexico.

Universidad Autónoma de México (UNAM), the Humane Society Veterinary Medical Association (HSVMA), the Asociación Mexicana de Médicos Veterinarios Especialistas en Equinos (AMMVEE), and the Asociación Mexicana de Médicos Veterinarios Dentistas de Equinos (AMMVDE). The Donkey Sanctuary is a charity founded in England with international burro outreach in many countries, including Mexico. World Horse Welfare is similarly devoted to international improvement of the welfare of horses, with notable efforts in

veterinary care abroad and campaigning, educating, and training owners and professionals in countries of interest. Although the best efforts seem to be those initiated by single teams of veterinarians in high-need areas, collaborations among influential forces such as this are key to making a global impact and realizing our shared, common goals [1].

Although this charity was not a participant of the 2010 Equitarian workshop, a notable source of information and experience is the Brooke. Perhaps the world’s expert on the state of working equids, this organization based out of the United Kingdom has an ambitious dedication to reaching 2 million working animals by the year 2016 [5]. Their mission is to provide direct care and training to prevent the unnecessary



Veracruz has the highest number of Mexico’s working equids. These burros deliver milk!

suffering of animals, but they also perform research and promote the spread of this information to all parts of the world. It is only appropriate, then, that The Brooke sponsored the Sixth International Colloquium on Working Equids in Delhi, India last year, which facilitated dialogue and planned for outreach to many more worldwide equid populations [13].

Especially prevalent in last year's program was a focus on not only veterinarians, but also a conglomeration of experts from many

different disciplines, including international development, social science, human health, and education, to better assess the economic, sociocultural, psychological, and practical effects of alleviating human and animal suffering through veterinary work [13].

Other non-veterinarians can also find a place in equitarian work – especially veterinary students and veterinary technician students. The R-VETS organization (formerly the HSVMA's Rural Area Veterinary Services, or RAVS) and the Christian Veterinary Mission (CVM) offer opportunities for veterinarians and students alike to spread their services in high-need areas stretching across the U.S. and the globe [14][15]. Short- and long-term trips are available, from the Pine Ridge Indian Reservation in South Dakota to Bolivia and Mongolia [15]. Both of these groups are well-advertised in veterinary colleges throughout the country.

Not only veterinary students can participate in equitarian work, as non-veterinarians also play vital roles in spreading equitarian knowledge and resources. From helping with on-site educational activities at equitarian field locations, to providing language translating services, to offering assistance with holding or restraining horses, non-veterinary professionals can help equitarian workshops develop into cross-disciplinary initiatives. The author, as an undergraduate student that attended the 2010 Equitarian Workshop, has initiated several research projects to bring the benefits of equitarian work to horse populations within the state of South Dakota. As the R-VETS Program already performs veterinary outreach projects on South Dakota reservations such as the Cheyenne River Sioux Tribe Reservation, the "2011 South Dakota Equitarian Survey" was initiated to more exactly identify the care and health of some of these tribal horse populations, with sensitivity and cultural awareness. As part of this survey, a parallel paper survey was sent to South Dakota equine veterinarians. The veterinarian survey poses questions to South Dakota veterinarians about the resources or services they may be willing to provide for in-need tribal horse populations. The results of the 2011 South Dakota Equitarian Survey have the potential to ignite a high-powered grassroots movement that unites tribal horse owners with state-wide veterinary resources to promote the more equal distribution of animal health services. The presence of the equitarian initiative in South Dakota will only continue to solidify after completion of this survey, with a comparison of the diverse uses of reservation equines, identification of the most at-need horse populations within the state, and the facilitation of direct care for these animals with the help of veterinarians within the state. Equitarian work is an international project, but its implications within our own country are perhaps just as vital.



The Brooke hosted the Sixth International Colloquium on Working Equids (thebrooke.org).





Educating children can make an incredible difference in animal welfare.

workers and educators. Knowing the language, culture, and practices of the owners makes for fluid communication and sustainable contact. Other techniques to involve many aspects of communities include giving presentations, activities, or even coloring books to area children, since they are often the primary animal caretakers. Some organizations utilize community leaders, such as The Brooke's community animal health workers, who work within their home population to disseminate the information from outside agencies to their peers, automatically making the information more credible and applicable. Striving for sustainability, autonomy, and self-responsibility among animal caretakers at the workshops will be a continuing but worthwhile struggle in the future. Besides questions of technology, medicine, and material availability, the question also arises of whether to charge for equitarian services. On the one hand, this practice would just "feel" awkward, as well as adding an administrative burden and the fear of turning away needy cases [16]. Conversely, this practice may encourage the notion that animals have value and promote sustainability by preparing small populations to someday be receptive to supporting a local, paid veterinarian. Overall, equitarians embody the creed "To Do No Harm" by faithfully treating whatever case arises; however, sustainable practices should logically be considered to empower an improved future.

Equitarian work is fueled by individuals who love animals and understand the irreplaceable role of working equids in family life, international development, economics, and tourism, in both urban and rural settings. However, this is not just a humanitarian initiative. Equitarian work fulfills our responsibility to safeguard the welfare of working animals and to spread the knowledge that only a portion of the world has access to, working

Given the added—we might even say life-giving—importance working equids have for humanity, we cannot expect to improve animal welfare if it does not improve human welfare. Logically, no amount of volunteer work or education will change a society's practices if the new ideas do not benefit the lives of the struggling humans. Many challenges still exist despite the impressive existing efforts. As mentioned earlier, the interdisciplinary nature of equitarian work warrants teamwork between many professional fields, especially social



Utilizing local resources, especially locals and community leaders, is key.

from the ground up to positively influence the lives of our own species. Challenges exist, especially in striving to develop the most sustainable projects possible, merging the world's most effective and influential charity and action groups, cross-utilizing other disciplines to understand the global implications, and perhaps most demanding, offering suggestions to adjust the worldviews of those whose practices may limit their own productivity and the welfare of their equids.

With increased industrialization and globalization, the world seems to be growing closer, though the rift between the wealthy and poor is increasing almost uncontrollably. We can rely on a common thread between countries, however, which is the “Cinderellas” of society, beloved beasts of burden. They have much to tell us about our own human race. This is an idea echoed around the globe, from the old English saying, “Show me your horse and I will tell you who you are” to the Kenyan Vice-President’s warning: “We as a nation cannot claim to respect human rights if we can’t show respect to our animals” [3]. Who we are rests upon how we act toward those that have no say. For some horses, donkeys, and mules around the world, equitarian work may be their only voice.

## ACKNOWLEDGEMENTS

The author would like to heartily thank Dr. Jay Merriam for his guidance in the world of equitarian work, Dr. Rebecca Bott for her mentorship and desire to bring equitarian work to South Dakota, Dr. Timothy Nichols for helping to make this academic pursuit a service to surrounding communities, Jayme Murray and the Cheyenne River Tribal Council for welcoming the equitarian study to the Cheyenne River Sioux Tribe, Kathy Koch for her assistance with surveying the Cheyenne River Sioux Tribe, and Cheryl Beste and Rozanne McGrath for editorial assistance.

All photos were taken by the primary author at the 2010 AAEP Equitarian Workshop, Veracruz, Mexico, unless otherwise indicated.



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# Engineering Our Climate: A Critical Review of the Geoengineering Response to Climate Change

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## ABSTRACT

Various responses to greenhouse gas induced climate change have been proposed within the literature. While the most desirable response is to dramatically reduce greenhouse gas emissions, technological and financial obstacles make it difficult to realize the reductions necessary to solve the climate change problem. Several geoengineering schemes have been proposed that would compensate for increased greenhouse gas concentrations by reducing the solar energy absorbed by Earth. The most notable of these shortwave climate engineering schemes involves injection of sulfur aerosols into the stratosphere in order to disperse incoming radiation. This paper examines the geoengineering responses to climate change and demonstrates that, while the research necessary for their use should be pursued, the proposed schemes present a serious risk to the global community and their use should not be taken lightly.

## INTRODUCTION

### *Climate Change and CO<sub>2</sub>*

It has been well documented that the earth's climate is becoming warmer. There is currently a high level of agreement among climate scientists that the warming is due to anthropogenic contributions of greenhouse gases (GHGs), with increased carbon dioxide (CO<sub>2</sub>) concentration as the primary contributor. The atmospheric concentration of CO<sub>2</sub> has risen from pre-industrial levels of 280ppm to over 380ppm and is expected to continue to increase during the next century even if dramatic reductions in CO<sub>2</sub> emissions are enacted (Solomon et al., 2007). It is generally accepted that CO<sub>2</sub> emissions need to be reduced in the long-term to prevent catastrophic climate changes; however, numerous technological and social hurdles must be overcome before meaningful reductions in the global CO<sub>2</sub> emission rate are realized. In the short term, atmospheric CO<sub>2</sub> concentration will continue to rise, and the global average temperature is expected to continue climbing. The possibility of serious disruption of our climate system due to rising temperature has spurred discussion of potential actions that could be undertaken in order to stave off an imminent climate emergency.

CO<sub>2</sub> is a greenhouse gas because of its contribution to the so-called "greenhouse effect." Other common greenhouse gases include H<sub>2</sub>O, N<sub>2</sub>O (nitrous oxide), chlorofluorocarbons,

CH<sub>4</sub> (methane) and other molecules with a dipole moment that changes with bond length. The greenhouse effect refers to absorption by gases in the atmosphere of the outgoing, longwave (infrared) radiation; it is similar in principle to the way that the glass of a greenhouse prevents heat from escaping while allowing the energy of sunlight to enter. Greenhouse gases such as H<sub>2</sub>O are an important component of our unpolluted atmosphere, because they prevent some of the infrared radiation emitted by the earth from escaping to space, thereby allowing the average temperature at the earth's surface to maintain a reasonably warm 15°C rather than the predicted -19°C (59°F and -2°F respectively) (Girard, 2010).

To understand the difference between the expected and actual temperature of the earth, it is necessary to examine earth's heat balance. The sun provides energy to the earth at a rate of 342 W/m<sup>2</sup> (watts per square meter) as measured at the top of our atmosphere. Approximately 30% of this radiation is reflected back to space by either the earth's surface or by particulates in the atmosphere; either the earth or the atmosphere absorbs the remainder. In order to maintain a constant temperature, it is necessary for the earth to emit an equivalent amount of radiation in the infrared region of the spectrum. The absorption of infrared radiation by greenhouse gases in our atmosphere upsets the balance between incoming and outgoing energy resulting in a steady state where the earth's surface temperature is elevated above the expected temperature. This is termed the greenhouse forcing because it "forces" our climate away from its expected position (-19°C).

Radiative forcings also occur when incoming solar radiation is reflected or scattered before it can be absorbed by the earth's surface or the atmosphere. The phenomena responsible for reflecting solar input are termed albedo. Atmospheric albedo is a measure of the reflection of incoming radiation by clouds or particulates in the atmosphere; surface albedo results from the reflectivity of the earth's surface and is high for bright surfaces such as snow and ice and low for liquid water and most land surfaces. The average albedo of the earth, including both atmospheric and surface components, is around 30%. A stable climate is a steady state of energy or radiation flow, in which energy inputs are equal to energy outputs and temperature is relatively constant. This energy steady state is mathematically described by the simple relationship:

$$R_{in} = R_{out}$$

where  $R_{in}$  is incoming radiation (solar flux, essentially constant) and  $R_{out}$  is outgoing radiation (longwave, a function of surface temperature) emitted by the earth and each term represents the energy flow in W/m<sup>2</sup>. Thus, if the value of any one of the terms changes, there must be a concomitant and opposite change of another term in order to maintain a constant temperature (in reality many different atmospheric, terrestrial and oceanic factors contribute to the albedo and greenhouse effect terms, but this simple model shows that the overall forcings must balance in order to maintain a given temperature). In the current climate change, because the greenhouse effect is becoming stronger or larger, the earth must increase its temperature until the outgoing radiation ( $R_{out}$ ) is such that the right side of the equation is again equal in magnitude to the left side, thus restoring the energy steady state.

### *Proposed Solutions to Climate Change*

The best long term solution for GHG-induced climate change is to dramatically reduce anthropogenic greenhouse gas emissions. Because the most important anthropogenic greenhouse gas is CO<sub>2</sub>, the debate about the appropriate response to climate change tends to focus on reduction of CO<sub>2</sub> emissions by either utilizing renewable fuels that do not contribute to a net increase in atmospheric CO<sub>2</sub> concentration, sequestering CO<sub>2</sub> prior to emission, or increasing the efficiency with which we generate and utilize energy from fossil fuels. The technologies necessary to effect a significant change in global CO<sub>2</sub> emissions are currently in a development stage and, while capabilities are continually improving, annual CO<sub>2</sub> emissions are likely to continue to increase in the near future. The inertia of the upward global CO<sub>2</sub> emission trend has led to discussion of methods to compensate for the high levels of atmospheric greenhouse gases.

The large-scale responses to climate change fall under the category of geoengineering. These methods aim to affect the earth's climate by manipulating natural processes on a global scale. Geoengineering schemes can be categorized in two groups: those aimed at reducing the greenhouse effect, and those aimed at reducing the net solar input ( $R_{in} - \text{Albedo}$ ). The first category would do so by removing CO<sub>2</sub> from the atmosphere; the most notable proposal under this category is fertilization of the open oceans in order to stimulate rapid growth of phytoplankton that soon die and drift to the bottom of the ocean, taking with them atmospheric carbon dioxide that is taken up by phytoplankton production (Barker, 2007). This idea continues to be researched with limited success. However, such removal of CO<sub>2</sub> from the atmosphere usually involves slow processes. Therefore, reducing the greenhouse effect via CO<sub>2</sub> removal should bring about long term cooling of the earth, but is not expected to produce immediate results. Since most of the discussion of geoengineering revolves around the solar input reducing methods, CO<sub>2</sub> reduction methods will not be further considered in the paper.

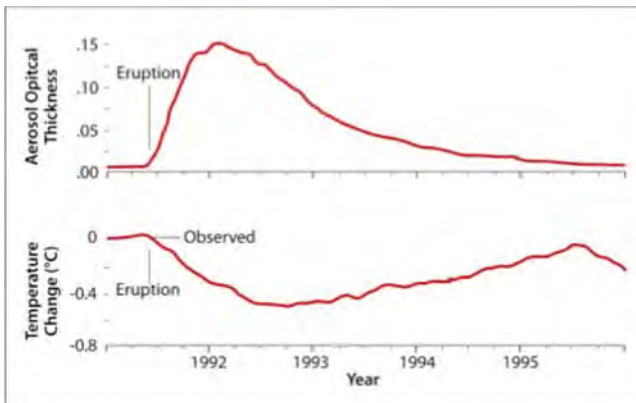
Other geoengineering proposals involve interrupting the radiative energy balance of the earth by reducing the net absorbed amount of shortwave solar radiation. These methods are termed "shortwave climate engineering" by Blackstock et al. (2009); this description accurately portrays both the mechanism and intended effect of these schemes and will be referred to throughout this paper. Shortwave climate engineering methods are expected to produce an immediate (less than one year) effect on the earth's climate; similarly, the effects are expected to be short-lived, so that no lasting impact will be result, should it be necessary to stop using the method. Moreover, we have a fairly good understanding of the short-term effects of altering the earth's solar input due to "natural experiments" such as volcanic eruptions. The immediacy of shortwave climate engineering makes it attractive as a means of responding to increased warming of the earth due to increased CO<sub>2</sub> concentration in our atmosphere, particularly if that warming were to take place more quickly than expected. The application of this climate engineering, or geoengineering, approach, is seriously debated among scientists - primarily due to a lack of reliable modeling to predict what unwanted effects may result from such action.

A number of mechanisms have been proposed for reducing solar input to the earth's surface, some more viable than others. Among the more prominent examples include placing a screen or spacecraft between the earth and the sun (Angel, 2006), and introducing aerosol

materials into the atmosphere; these include aerosolizing seawater in the troposphere in order to increase cloud cover (i.e., atmospheric albedo) over our oceans (Latham, 2008) or sulfate in the stratosphere (Crutzen, 2006) in order to scatter incoming light globally. Of the proposed mechanisms, injection of sulfate into the stratosphere has received the most attention in recent years and the bulk of this paper will focus on principles and developments as they pertain to sulfate injection, accompanied by discussion of some of the advantages and disadvantages of the other two schemes mentioned above.

### *Volcanic Eruptions and Shortwave Climate Engineering via Albedo/Aerosol Enhancement*

Sulfate ( $\text{SO}_4^{2-}$ ) is a naturally occurring aerosol component of our atmosphere. Sulfate in the troposphere originates from natural sources such as gaseous sulfur compounds ( $\text{H}_2\text{S}$ ) from anaerobic decomposition of organic matter and sulfur dioxide ( $\text{SO}_2$ ) from volcanic eruptions and from burning of coal. In the troposphere, sulfur gases are quickly (2-3 days) converted to  $\text{H}_2\text{SO}_4$  in clouds and fall with precipitation, resulting in acid rain. The picture for the stratosphere is rather different. Stratospheric sulfate primarily results from  $\text{SO}_2$  contributed by very large and explosive volcanic eruptions, such as the 1991 eruption of Mt. Pinatubo in the Philippines. Just as in the troposphere, stratospheric  $\text{SO}_2$  is converted to  $\text{H}_2\text{SO}_4$ , however, clouds do not exist in the stratosphere, and sulfate therefore agglomerates into aerosol particles that remain suspended for 1-2 years on average (Crutzen, 2006). These stratospheric aerosol particles scatter incoming solar radiation and thus cause less energy to be absorbed by the earth's surface. This effect can be seen from temperature data in the years following the eruption of Mt. Pinatubo (or any other very large volcanic eruption).



**Figure 1.** Optical and temperature effects in the years following the eruption of Mt. Pinatubo. (From Blackstock et al., 2009)

Since geoengineering through sulfate injection is similar to climate change caused by volcanic aerosols, it is important and helpful for us to study and understand how current and past volcanic eruptions have impacted climate. To do this, high quality data are needed



concerning eruption magnitudes and the atmospheric aftermath of the eruptions. In addition to data from modern volcanic eruptions, reliable ice core data, particularly those for the last 1000 years, are being increasingly developed through the measurement of sulfate concentration in ice cores. The ice core data have the advantages that they are quantitative, can be linked to paleoclimate records and can potentially differentiate between large stratospheric eruptions and short-lived tropospheric eruptions based on isotope fractionation (Cole-Dai, 2010). Ice core data also help to develop reliable climate models based on volcanic forcings. Climate models allow us to explore long term climate effects of large eruptions or the effect of multiple eruptions over a relatively short time period. Climate data from ice cores also corroborate the increasing greenhouse effect during the twentieth century and the apparent climate impact of several large eruptions in the latter half of the century.

## DISCUSSION

The shortwave climate engineering scheme discussed by Crutzen (2006) is designed to counter the greenhouse warming by emulating the global cooling seen after the eruption of Mt. Pinatubo by deliberately injecting sulfate (or a precursor) into the stratosphere. The amount of sulfate to be injected depends on the magnitude of cooling deemed necessary. It is estimated that the Mt. Pinatubo eruption injected approximately 10 Tg (1 Teragram= $10^{12}$ g=1 million tons) of sulfur into the stratosphere. While this amount of sulfur sounds (and is) huge, it is only about 20% of current annual anthropogenic sulfur emissions (Blackstock et al., 2009). The amount of sulfur required for climate cooling on a continuous basis would be much less than that, with estimated values ranging from 1-5 Tg per year at a cost on the order of \$30 billion per Tg.

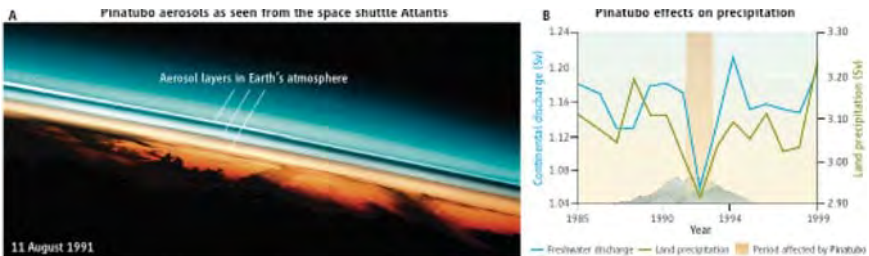
Wigley (2006) proposed that sulfate injection could be used in conjunction with CO<sub>2</sub> emission reduction in order to stabilize the climate in the short-term by the former while developing technology and infrastructure to achieve the latter for the long-term solution. Wigley's proposition would use shortwave climate engineering as a means to cover the time period between now and when substantial reductions in CO<sub>2</sub> emissions, which the scientific community generally argues are necessary to avoid catastrophic climate disruptions, can be achieved. While his proposed scheme has certain advantages (particularly in delaying the need for immediate CO<sub>2</sub> reductions and thus reducing associated costs and possible economic disruptions), the feasibility of the method is based on two assumptions about environmental effects: firstly, "the Mt. Pinatubo eruption caused detectible short term cooling but did not seriously disrupt the climate system" and adding sulfate to the stratosphere "should therefore present minimal climate risks;" secondly, adding sulfate to the stratosphere "would delay recovery of stratospheric ozone slightly but only until anthropogenic chlorine loadings returned to the levels of the 1980s" (Wigley, 2006).

Since 2006, when this scheme was initially proposed, evidence has emerged raising serious questions about these assumptions. First of all, Blackstock et al. (2009) argue that the lack of disruption of the climate system by the aerosols of a brief volcanic eruption is probably due to the fact that "thermal inertia due to the oceans' large heat capacity smoothes and delays the climate response to a change in radiative forcing". Were these stratospheric



sulfate loadings sustained over a longer period of time, temperature change would have likely been much greater, and other components of the climate system, precipitation in particular, might also be severely affected. Tilmes et al. (2008) address the second assumption by demonstrating that recent modeling indicates that addition of an aerosol component such as sulfate into the stratosphere will have significant negative effects on ozone depletion. This is because chlorine activation reactions that destroy ozone molecules take place on the surface of solid particles. Under normal stratospheric conditions, formation of significant solid particles only occurs under extremely cold conditions, i.e., in polar stratospheric clouds (PSCs). As a result, ozone depletion is more pronounced over the Antarctic than in the warmer Arctic. Sulfate aerosols would provide additional surface areas for chlorine activation, with the result that enhanced ozone depletion can be expected, particularly in the northern hemisphere. The expected recovery of the “ozone hole” over the Antarctic would be delayed by 15-30 years and possibly longer, pushing the expected date when pre-1980s conditions would be restored to 2090 or into the next century (Tilmes et al., 2008).

When the potential risks of stratospheric sulfate injection are elucidated, it becomes increasingly apparent that under most circumstances, this geoengineering approach to counter global climate warming is undesirable. Hegerl and Solomon (2009) argue that one problem with our current approach to assessing risks associated with the proposed geoengineering schemes is the single focus on temperature to the exclusion of other (potentially more critical) factors, such as precipitation. Hegerl and Solomon also note that current models do a good job of predicting temperature changes based on changes in radiative forcings because temperature response is “quite straightforward”; however, the evaporation of water in the hydrologic cycle is more dependent on net absorption of solar radiation than on the surface temperature of the earth (Figure 2). Additionally, Blackstock et al. (2009) point to drought in the Sahel region of Africa, from the 1950s to the 1980s, as a lesson in the potential risk of mixing increased greenhouse warming with aerosol-induced solar input reduction. Decreased tropical sea surface temperatures have been implicated as the primary cause, and there is general agreement that increased greenhouse effect alone cannot explain the conditions, but when paired with aerosol inputs into the troposphere by industry, the effect is adequately explained. Thus, “[shortwave climate engineering] intervention (such as stratospheric aerosol loading) could amplify climate change impacts already being generated by increasing CO<sub>2</sub> concentrations” (Blackstock et al., 2009).



**Figure 2:** Atmospheric (left) and precipitation (right) effects of the June, 1991 eruption of Mt. Pinatubo. From Hegerl and Solomon (2009).

Two other shortwave climate engineering schemes mentioned previously are: enhancement of maritime clouds and the use of spacecraft to shade the earth. Each of these plans has advantages and disadvantages when compared to sulfate injection. Maritime cloud enhancement (Latham, 2008) would involve generating fine aerosols of seawater in the ocean to increase cloud cover and therefore reflection albedo. The most significant advantages of this scheme are that only seawater aerosols, a natural component of the troposphere, are involved and that it is highly adaptive to real-time needs. Floating vessels would be used to produce the aerosol particles, and thus, actual cooling effects could be adapted so that they have the smallest possible impact on people by simply changing the positions of the vessels. In comparison, stratospheric sulfate injection would affect the entire globe, with very limited ability to control its effects once the sulfate is introduced to the atmosphere. A disadvantage of Latham's proposal (2008) is that no natural experiments have been found to predict the effectiveness or feasibility of the method; the proposal is based exclusively on modeling and experience with weather systems.

The use of spacecraft to effect cooling of the earth is a proposition that is somewhat futuristic in that many technologies would need to be developed in order to make it possible. Development of the required space technologies would make it very costly financially; it would take many years to deploy the technologies; constant maintenance would be needed in order to sustain the effectiveness over the long term. On the positive side, gaining the technical knowledge as outlined by Angel (2006) would certainly enhance our capabilities for space travel. The biggest problem, in addition to not knowing if the technical abilities required could possibly be developed in the required timeframe, is that the same resources could be used to develop technologies to solve CO<sub>2</sub>-related issues such as reducing our dependence on fossil fuels, or improving energy efficiency. The latter are the real issues at hand in the broad climate debate.

## COMMENTARY

Because of the possibility of a climate emergency in our future, research on pertinent factors surrounding geoengineering in response to climate change should begin immediately, with the understanding that it will likely never be desirable to implement such a response; however, the technology and an understanding of its risks should be in place to provide an option, should that be deemed necessary.

At this point, the risks of climate engineering with the proposed methods clearly outweigh the benefits that we might receive. Wigley's (2006) combined climate-engineering/CO<sub>2</sub>-reduction approach most likely would affect the temperature of the earth as expected, but climate is much more than temperature, and other parts of our climate system would almost certainly be affected. There remain questions on what and how other components of the system will be affected. It would hardly be of benefit to society if we cool the earth through geoengineering, only to find ourselves with widespread drought in critically important regions of the earth. Furthermore, sulfate injection would be continuous, for the aerosols are removed from the atmosphere in a year or so. We would need to replenish the stratosphere with sulfur every one or two years in order to maintain efficacy of cooling. How long do we want to commit ourselves to such an action that alters the atmospheric environment?

Another primary assumption with any of the proposed schemes is that, should severe consequences arise from climate engineering, we should be able to stop using the method and things will return to baseline within a few years. What if this is not true? For instance, after oceanic currents are altered by reduced solar radiation inputs, would they return to their normal patterns? All of this is to say that it is not in our best interest, as a global community, to apply any of the proposed techniques unless it is deemed necessary as a last resort to prevent certain catastrophe.

The expected impact of both global warming and climate engineering will vary by region. Some areas are expected to get warmer and dryer; others will likely get wetter and cooler. This means that shortwave climate engineering will likely produce “winners and losers” and could lead to serious international conflicts over water resources (Hegerl and Solomon, 2009). There are also serious concerns regarding deliberate alteration of the earth’s climate. Firstly, who will decide what geoengineering scheme will be used, when we should use it and how much cooling is necessary? What about the potential of using shortwave climate engineering as a political tool or as a weapon? What if severely negative impacts are felt by a certain region while other regions are less affected? How do we decide whose existence is more important? What about ecological impacts? Ocean acidification is already occurring and changes in precipitation patterns would almost certainly impact sensitive ecosystems.

It is apparent that the application of short wave climate engineering should not be undertaken lightly. There is a need for more research on both our natural climate system and on shortwave climate engineering (Blackstock et al., 2009; Crutzen, 2006). Cicerone (2006) argues that “refereed papers are to be encouraged in this field; they will permit poor or dangerous ideas to be seen as such and meritorious ones to develop further”. Both Cicerone and Blackstock et al. demonstrate that research should be broken into distinct phases, and that a moratorium should be placed on experiments that will affect the actual climate until more data is gathered and agreement is in place on risks involved and the acceptance of those risks. Our current understanding of the earth’s systems would be greatly expanded by such a research effort.

## CONCLUSION

It should be apparent that shortwave climate engineering as a stand-alone solution to the problem of greenhouse warming is not an option. The methods that have been proposed and examined so far do not account for non-temperature effects of rising atmospheric CO<sub>2</sub> concentration such as ocean acidification. As a society, we need to reduce our emission of CO<sub>2</sub> into the atmosphere. Given the current resistance to reduction efforts in international governing bodies, the prospects of quickly reducing CO<sub>2</sub> emissions appear less than encouraging. Therefore, we can expect CO<sub>2</sub> levels to increase into the future, with predictable warming and maybe unexpected effects on the earth’s climate. Given the possibility of catastrophic climate disruptions, it is prudent to examine shortwave climate engineering options as a means to combat such events and to allow for the development of a permanent and sustainable solution. Therefore, we must invest in climate and earth systems research, with a focus on development of models to accurately predict the effects associated with

proposed shortwave climate engineering schemes. Currently, the risks associated with deployment of such a scheme are very high. Much more information is needed before prudent use of such measures becomes likely.

In closing, shortwave climate engineering should not be deployed except in the case of utmost emergency; even then, it should not be considered unless we have adequate knowledge of the unintended effects (both short- and long-term). Beyond the technical obstacles, important human factors must be considered; moral and ethical issues surrounding climate engineering must be evaluated in a thorough manner. Thus, we must expand research of the proposed climate engineering schemes, of alternative energy and of the climate system in general. The payback will be likely be substantial. The only acceptable solution to climate change in the long term lies in reducing our emission of greenhouse gases. Myriad advantages will come along with reduced dependence on fossil fuels to power our lifestyle; these may include cleaner air and water due to reduced pollution by emissions and mining operations. Crutzen (2006) closes his geoengineering proposal by stating “Finally, I repeat: the very best would be if emissions of the greenhouse gases could be reduced so much that the stratospheric sulfur release experiment would not need to take place. Currently, this looks like a pious wish”.

## ACKNOWLEDGEMENTS

I would like to thank Dr. Julie Barst for her encouragement and assistance in bringing this work to fruition in its original public argument form and for encouraging me to submit the original paper for the Schultz-Werth Award. I would like to thank Dr. Jihong Cole-Dai for laying the groundwork for my understanding of the subject and for inspiring me to explore the topic on a more advanced level. Finally, I would like to thank my wife, Katie, and children, Anton and Basil, for their patience during the many hours that were spent researching and developing this work.

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# How Priming of Behavioral Symptoms May Affect College Students' Decision to Diagnose

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## ABSTRACT

Two disorders that have increased in diagnosis and in media awareness in the past two decades are Attention-Deficit Hyperactivity Disorder (ADHD) and autism. Psychologists use priming as a tool to test availability of schemas and concepts. The current study focuses on how priming of ADHD and autism symptoms affects college students' diagnoses of the corresponding disorder. Also considered is that the control group will diagnosis ADHD more often because of the vast media awareness of ADHD today. The participants in this study were male and female undergraduates at South Dakota State University. There was no significance found for the two hypotheses in this study.

*Keywords:* ADHD, autism, priming, symptoms, diagnosis, disorder

## HOW PRIMING OF BEHAVIORAL SYMPTOMS MAY AFFECT COLLEGE STUDENTS' DECISION TO DIAGNOSE

Today many college students are bombarded with information about ADHD through television, news, books, school, movies, and even the internet. ADHD is a disorder characterized by symptoms such as difficulty paying attention, impulsivity, hyperactivity, difficulty completing tasks, etc (Comer, 2010). Many college students know someone who has ADHD, or they might know about ADHD firsthand. According to Comer (2010), of the individuals diagnosed with ADHD, 22 percent are admitted to college. According to the National Institute of Mental Health (NIMH) (2010a), 8.1% of the U.S. adult population is diagnosed with ADHD. ADHD is usually diagnosed in school-age children because their problems with inattention and hyperactivity are not noticed until they start school where they are expected to pay attention, sit quietly, and take turns. According to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV-TR) (2000), the person must have had symptoms of ADHD before age 7, and the symptoms have to last for at least six months. The main categories of symptoms of diagnosis for ADHD are inattention, hyperactivity, and impulsivity (American Psychiatric Association, 2000).

Another psychological diagnosis on the rise today is autism (Levy, Mandell, & Schultz, 2009). Autism is a disorder characterized by symptoms of inadequacies in communication, socialization, and stereotyped or repetitive behaviors (Levy et al., 2009). Autism is a part of

the Autistic Spectrum Disorders (ASD), which are also known as Pervasive Developmental Disorders (PDD) (Wicks-Nelson & Israel, 2009). According to the NIMH (2010b), “1 in every 110 eight-year old children were diagnosable for an ASD.” According to Rosenberg, Daniels, Law, Law, and Kaufmann (2009), the changes and enhancements to the DSM-IV and the International Classification of Mental and Behavioural Disorders, Tenth Edition (ICD-10) can account for the great increase in ASD diagnoses. With the diagnosis of autism on the rise, college students have a greater chance of knowing someone with autism than the college students in the past two decades. The prevalence of children with ASD (0.01%) (NIMH, 2010b) is less than that of ADHD (9%) (NIMH, 2010c). Even though more college students may have more contact with people with autism than in the past, college students most likely have more contact with people with ADHD today.

Priming is a procedure in psychology used to influence a particular schema or behavior in an individual. According to Aronson, Wilson, & Akert (2010), psychologists may use priming as a tool to increase the recall of a specific concept or behavior. When someone has exposure to priming stimuli, the individual may react differently to subsequent stimuli than they would without the priming stimuli. In the current study, the priming tool is providing the participants with diagnostic symptom criteria of ADHD and autism. The participants in the group that are primed with ADHD symptoms may have increased ability to recall ADHD versus other disorders when they make their diagnosis. This would apply to the group that receives the diagnostic symptoms of autism as well.

The independent variable in the current study is priming with ADHD symptoms, autism symptoms, or not being primed with symptoms. There are two experimental groups; one group receives the symptoms of ADHD and the other receives the symptoms for autism. The control group will receive no symptoms. The dependent variable in the current study is the participants' diagnosis of the child in a video clip. This video clip shows adolescents playing video and card games. The choices of diagnosis are anxiety disorder, Obsessive Compulsive Disorder (OCD), ADHD, depression, Oppositional Defiant Disorder (ODD), and autism. In this study, the first hypothesis is that priming the participants with symptoms of ADHD or autism will influence their diagnosis of the corresponding disorder. The diagnostic criteria provided may influence them to notice only symptoms of the disorder they just heard over symptoms of other disorders. In addition, the second hypothesis of this study is that the control group, which receives no priming of symptoms, will diagnosis ADHD more than the other disorders because of the vast coverage of ADHD in the media. College students are more likely to be exposed to ADHD, so this disorder may be more relevant to them than other disorders when making a diagnosis.

## METHOD

### *Participants*

The participants were 23 South Dakota State University (SDSU) students between 18-25 years of age. There were 5 male and 18 female participants. All participants were from undergraduate psychology courses. One participant's data was deleted because of a video error. This participant's information was not included in the final data analysis.



The researchers recruited participants from the following classes: Criminal Justice, Psychology, Sociology, and French. The researchers also recruited participants with an advertisement in the university newspaper for one week, which was open to all undergraduates. Participants received extra credit if it was offered in their classes or were given an alternative opportunity to gain extra credit if they could not participate in the study. All participants received a 10% off coupon to Dunham's Sporting Goods after completion of a session. All participants could choose to be included in a drawing for gift cards and coupons from the following businesses: Pizza Ranch, Cubby's Sports Bar and Grill, Sunflower Salon and Spa, Nick's Hamburgers, Running's, and Bravo's. Only participants 21 years of age and older were put into the drawing for the gift cards and coupons from Cubby's and Bravo's.

Students that fell into any of the following categories were not eligible to participate in this study: students with a current or former diagnosis of any form of severe psychiatric or behavioral disorder; this included ADHD and autism; students who at the time of testing were under the influence of alcohol, illegal substances, any form of antidepressant or anti-anxiety drug, antihistamines or any form of cold medication; and students under 18 years of age. If any participant started to show signs of stress or anxiety, the researcher would immediately stop the session and refer them to the counseling center. This study was approved by the Institutional Review Board (1103003-EXP).

### *Materials*

The SuperLab (4.0) computer program was used to present the pre-questionnaire, symptom descriptions, video, and post-questionnaire material to the participants. The pre-questionnaire included basic demographic questions and questions concerned with six relatively common behavioral disorders: anxiety disorders; depression; OCD; ADHD; ODD; and autism. These disorders were on the pre-questionnaire so the participants did not know that the researchers were only looking at autism and ADHD.

Group 1 received DSM-IV-TR symptoms of ADHD and group 2 received DSM-IV-TR symptoms of autism. Only the symptoms that were relevant to the video were included. A copy of the symptoms used is included in the Appendix.

The video was of adolescents playing a game of Uno and a racing video game. The adolescents in the video were acquaintances of the researcher. The researchers received written parental consent and child assent for the videotaping. The adolescents were told about what disorders the researchers were interested in after the videotape was recorded, so it would not influence the behavior of the adolescents during filming.

The post-questionnaire contained two questions: did the child in the video display any atypical behaviors; and could they offer an opinion for a diagnosis for that child. For their choices, they had a list of the disorders mentioned in the pre-questionnaire and an option to choose that no atypical behaviors were present.

### *Procedure*

There were one to four participants in each session. At the beginning of the session, the researcher read the consent form to the participants and answered any questions regarding the consent form. The participants filled out the pre-questionnaire on the computer using the SuperLab program. After all the participants completed the pre-questionnaire, the researcher



read aloud symptoms of ADHD or autism depending on the group. The symptoms were also shown on the computer screen, so the participants could follow along. Group 3 was the control group and was not read any symptoms. The researcher instructed the participants to watch the video recording and focus on the behaviors of one particular adolescent in the video. The video clip lasted about four minutes. Participants completed a post-questionnaire after the video clip. At the end of the session, the researcher debriefed the participants and told them that this study is about measuring the prevalence of college students to diagnose a disorder when being primed with symptoms for either ADHD, autism, or no symptoms. The researcher also informed the participants that the adolescents in the video did not have any psychological disorders. The researcher gave each participant a 10% off Dunham's Sporting Goods coupon and asked them to sign a sheet asking for their name, age, and email address if they wanted to be included in the drawings for the rest of the coupons and gift cards.

### *Data Analysis*

The researchers transferred all the data from the pre- and post-questionnaire in the SuperLab program to Excel. The data were decoded and all of the statistics were calculated using Excel. Chi-square tests were used for the statistical analysis of the data for both of the hypotheses in this study.

## **RESULTS**

The first hypothesis tested is whether college students diagnose ADHD or autism more when given the corresponding symptoms. The first Chi-square test measures the total frequency of diagnoses for each group (ADHD symptoms, autism symptoms, and no symptoms). Overall, the majority of the participants chose there was no behavioral disorder present (34.78%), contrary to the first hypothesis. The next highest diagnosis is ADHD (30.43%), followed by anxiety (21.74%). Autism, OCD, and ODD were all diagnosed the same amount (4.35%). No participants diagnosed depression (0%).

For the group primed with symptoms of ADHD, the diagnosis for ADHD (25%), anxiety (25%), and no diagnosis (37.5%) were higher than expected. The percentage of diagnoses for ODD (12.5%) was lower than expected. The participants were more often correct in choosing the right diagnosis, which is no behavioral disorder.

For the group that received autism symptoms, the percentage of diagnoses for ADHD (25%), anxiety (25%), and no diagnosis (50%), were higher than expected. The percentage of diagnoses for autism (0%) was lower than expected. Similar to the group that received ADHD symptoms, the participants in the group that received autism symptoms were more correct in choosing no behavioral disorders. The participants did not choose autism for a diagnosis in either of the groups that received ADHD or autism symptoms. The participants in the group primed with autism symptoms diagnosed ADHD and anxiety the same amount. There is no statistical significance found between the percentages of being primed with symptoms of ADHD or autism and the corresponding diagnoses chosen and what was expected,  $\chi^2 (12, N = 23) = 8.61, p = 0.57$ . Figure 1 presents the percentage of diagnosis of the ADHD symptoms, autism symptoms, and no symptoms groups.

The second hypothesis tested is that the control group will diagnose ADHD more than the other disorders because college students have more exposure to information about ADHD. The percentage of diagnoses for ADHD (42.86%) was higher than expected, while the percentage of diagnoses for autism, anxiety, OCD, and no diagnosis were the same as expected. There was no statistical significance found for the second hypothesis,  $\chi^2(6, n=7) = 6, p = 0.42$ . Although the participants in the control group diagnosed ADHD more than the other disorders, the results were not significant.

## DISCUSSION

The first hypothesis of this study is that priming of diagnostic symptoms of ADHD and autism will increase the participants' diagnosis of the primed behavioral disorder, but was not statistically supported. Priming the participants with diagnostic criteria for these disorders improved their accuracy in diagnosing the adolescent as typical with no behavioral diagnosis. Providing college students with professional and updated information on disorders may actually increase their accuracy in diagnosing disorders instead of relying on their previous experience with these disorders in the media, which may be inaccurate assumptions. Overall, ADHD was diagnosed more than autism, which may suggest that college students have more experience or knowledge of ADHD than autism. This information corresponds with NIMH (2010c) that ADHD is diagnosed at a higher percentage than autism in children.

Another possible explanation for why college students diagnosed ADHD more is because of the illicit use of the medications used to treat ADHD. According to Advokat, Guidry, and Martino (2008), most college students who abuse stimulant medications report obtaining these drugs from peers and use these drugs to both improve academic performance as well as to get high. Although it did not reach significance, perhaps more college students chose the diagnosis of ADHD because of their familiarity with the medications and not because of their familiarity with the actual behavioral disorder.

The second hypothesis in the current study is that the control group, which does not receive priming of diagnostic symptoms, will diagnose ADHD more than the other disorders because of ADHD's prevalence in the media. ADHD was the most diagnosed in the control group, but it did not reach significance. One main reason why the data was not significant could be the small sample size.

In the future, more participants would be needed to be able to reach a level of significance, at least for the second hypothesis. One reason for the larger variety of diagnoses than expected could be because the participants could have personal experience with one or more of the disorders listed as a diagnosis choice. For example, one participant diagnosed the adolescent with ODD, although the adolescent in the video did not display oppositional behaviors. Two explanations of this could be that the participant has either personal experience or recent knowledge from a psychology course and noticed symptoms of ODD that were not present. Another reason that the data did not reach significance may be because ADHD and anxiety have some similar features and the participants might have had trouble distinguishing between these disorders. According to Wicks-Nelson & Israel (2009), "on

average, about 25 to 35% of youths with ADHD, either in clinic or in community samples, have anxiety disorders.” College students may not just have experience with ADHD alone and anxiety alone, but have experience with ADHD and anxiety diagnosed for one individual. This may cause confusion about distinctions between these disorders.

In continuing studies, researchers should focus on how giving participants professional information about disorders affects their accuracy for diagnosing. The data for this study did not support the first hypothesis that priming of symptoms would increase the diagnosis of the corresponding disorder. Future research could test whether presenting diagnostic criteria of disorders to college students will increase their accuracy in diagnosing than college students that are not presented with diagnostic criteria.

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## APPENDIX A

### *Group 1: ADHD Symptoms: DSM-IV Symptoms of Attention-Deficit Hyperactivity Disorder*

Symptoms of Inattention:

- Fails to attend to details or makes careless mistakes in activities.
- Has difficulty in sustaining attention.
- Does not seem to listen when spoken to.
- Does not follow through on instructions.
- Avoids or dislikes tasks requiring sustained mental effort.
- Is distracted by extraneous stimuli.

Symptoms of Hyperactivity-Impulsivity:

- Hyperactivity
  - Fidgets with hands or feet or squirms.
  - Leaves seat inappropriately.
  - Is often “on the go” as if “driven by a motor.”
  - Talks incessantly.
- Impulsivity
  - Has difficulty awaiting turn.
  - Interrupts or intrudes on others.

## APPENDIX B

### *Group 2: Autism Symptoms: DSM-IV Symptoms of Autism*

Qualitative impairment in social interaction manifested by at least two of the following:

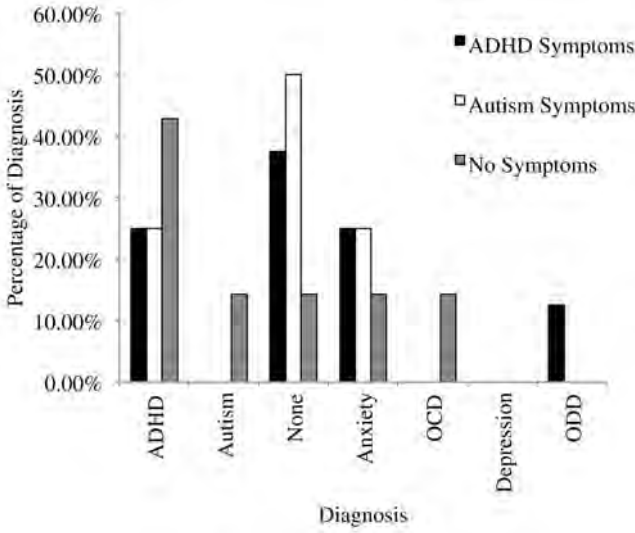
- Lack of spontaneous sharing of enjoyment or interests
- Lack of social or emotional reciprocity

Qualitative impairment in communication manifested by at least one of the following:

- When speech is adequate, impairment in initiating or sustaining conversation
- Stereotyped or repetitive language

Restricted, repetitive, stereotyped patterns of behavior, interests, or activities manifested by at least one of the following:

- Abnormal preoccupation with stereotyped and restrictive interests
- Inflexible adherence to nonfunctional routines or rituals
- Stereotyped and repetitive motor mannerisms



**Figure 1.** The percentage of diagnosis for the group that received ADHD symptoms, the group that received autism symptoms, and the control group, which did not receive symptoms.

## Tools of Horror: Servants in Gothic Novel

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### TOOLS OF HORROR: SERVANTS IN GOTHIC NOVEL

The servants within 18th- and 19th-century English literature play an undoubtedly vital role within everyday life. Elizabeth Langland highlights this point in her discussion of the middle class: “Running the middle-class household, which by definition included at least one servant, was an exercise in class management, a process both inscribed and revealed in the Victorian novel” (291). In Victorian England, especially, class and rank were everything. While during the Romantic period servants were common, rising concerns for their role in the household becomes more apparent during the Victorian Era. Gothic novelists take their concerns for these domestic issues and use the servants as easy targets to become scapegoats in the novel themselves. In both the *The Castle of Otranto* and *Wuthering Heights*, the fear of exploited power and class position leads the authors to use servants as ignorant tools in order to heighten the suspense and terror, thereby exhibiting the concerns for their role in society.

Nelly Dean in *Wuthering Heights*, for instance, interferes with dealings between the inhabitants of Thrushcross Grange and Wuthering Heights so much that some critics see her as the “villain.” When she has a chance to stop Isabella from entering Wuthering Heights, she neglects her duty and instead follows her inside. Other servants, such as Joseph, increase the terror by releasing the dogs to attack Lockwood as he leaves Wuthering Heights. In *The Castle of Otranto* the servants, especially Bianca, enhance the terror by telling of the horrific sights they encounter, like the giant hand. While it is true that they manage daily household duties and often care for children, they also have the opportunity to abuse their power, which causes anxiety among the ruling classes.

This anxiety over the abuse of power, which the upper class seems to fear, is a unique and interesting situation. The author Graeme Tytler says, “Although masters (and mistresses) ultimately have the upper hand of their servants, it is noteworthy how much power servants exercise within the sphere of domination to which they are subject” (44). The servants, although subordinate to their masters, hold much control over the domestic sphere. They are not only in charge of chores and cleaning, but the most trusted ones also help raise children and act as the master’s confidant—someone they can talk to and confide in.

The servants are constantly around the family and are able to observe all the inner-workings of the household. There was a massive fear during this time that servants, the more inferior beings, would rise up against the upper classes and assume control: “If the master lost status in the outside world, or if coalitions within the family, formed with or without the assistance of the servant, led to a decline of the master’s status within the family, the servant might well be tempted to betray a master who was no longer quite as masterful” (Coser 36). The master’s status, whether through social or financial loss, gave an excuse for servants to seek control. Servants could seek control and rise through the ranks, in theory, in a number of different ways.

One of these ways is to reveal the seemingly endless amounts of family knowledge that many of masters held as secretive family information. Lewis A. Coser says, “Servants have occasion to observe the behavior of their masters, being privy to many of their secrets. Hence they are able, at least potentially, to reveal these secrets to interested outsiders” (35). This idea of betrayal through the telling of secrets is most notable in the character of Nelly Dean. She tells the entire family history, even the most unfavorable parts, to a stranger (i.e. Mr. Lockwood). As will be discussed later, Nelly has the potential of raising her status by informing Lockwood of the story, and inciting a relationship between him and Cathy.

Marriage ties are the second most notable method for servants potentially gaining power. There was a great deal of stress placed upon “servants marrying into a higher class, [which] went hand-in-hand with a concomitant middle-class fear of falling into the lower ranks, revealing the insecurity of a fluctuating and competitive class formation, both of these process were reflected widely in Victorian literary production” (Lynch 94). The hands of the lower classes seem to hold the bulk of this idea of “a fluctuating and competitive class formation” of the gothic novel. This is evident in the novel *Jane Eyre*, where complications arise because Jane wants to marry Mr. Rochester, a man of a much higher class. In the eyes of Victorians, one of the few ways to place them on the same level is to have Bertha Mason, Rochester’s wife, locked away secretly in the attic. Charlotte Brontë, as well as other gothic novelists, uses horror as a way to highlight these problems and as a plot device to make these scenarios even remotely possible.

Turning towards the beginning of the Gothic novel, one must examine Horace Walpole’s *The Castle of Otranto*. This book is the first of its kind and helped to establish the Gothic genre. Although written in the 18th Century, this novel uses servants as a means of increasing horror, suspense, and the plot. Instead of being so outwardly expressive in their fear of servants, the early gothic novelists seemed to internalize these problems. However, these elements still break through the surface in the literature. George E. Haggerty writes, “By attempting in the *Castle of Otranto* (1764) ‘to blend . . . the ancient and the modern’ romance to enrich the nature-bound conventions of the novel by means of the ‘great resources of fancy,’ Horace Walpole set the Gothic novel on a course both self-contradictory and seemingly self-defeating” (379). These fantastic Gothic elements seem like they crashed-landed in the middle of an otherwise typical romance. The realistic elements and underlying societal problems surface in the text set against the contrasting Gothic background. This essay will examine three separate instances in the novel, that demonstrate this point.

The first notable instance of the use of servants in *The Castle of Otranto* appears when the two servants, Diego and Jaquez, see the giant leg and foot in one of the rooms. They go and tell their account to Manfred, which in turn invokes terror and advances the plot. The book reads, “For heaven’s sake my dear good lord, cried Jaquez, do not go into the gallery! Satan himself I believe is in the great chamber next to the gallery” (Walpole 34). Walpole uses servants as scapegoats here in order to advance the plot. He places the servants in the position to see the giant hand and foot, for it is certainly more acceptable for lower classes to give in to superstitions than upper classes. It also allows for greater terror and suspense, for it is certainly scarier for the audience when Manfred, an upper class man, begins to believe in the curse. Up to this point, the servants are “blockheads,” but once Manfred places their

accusations along with his own experiences, he is able to believe them a little—but still not respect them (34).

The second instance occurs when Bianca is talking with Matilda. In this passage, they discuss Hippolita's personal matters. The text reads:

What! was she sorry for what she had said? asked Bianca—I am sure, madam, you may trust me.—With my own secrets when I have any, I may, said Matilda; but never with my mother's: a child ought to have no ears or eyes but as a parent directs. Well! to be sure madam, you was born to be a saint, said Bianca, and there's no resisting one's vocation: you will end in a convent at last. But there is my lady Isabella would not be so reserved to me: she will let me talk to her of young men . . . (41)

This excerpt perfectly exhibits the fear of servants knowing too much information. Bianca is a trusted member of the household (especially by Isabella), since she is always present and close with the family. Bianca gets to examine the inner workings of the family and is able to see many of their dark secrets. It is of no surprise then that Bianca acts angry when Matilda refuses to discuss these matters with her. Bianca is even so upset that she begins to act insubordinate and steps outside her servant position, mocking Matilda that she will end up in a convent. Shortly afterwards, they are interrupted by a noise which they believe to be a "ghost" or "angry spirit" (42). This once again propels the plot forward and incites terror within the reader.

The third major example of this type of incident in Walpole's novel is the scene where Bianca bursts into the room and tells Manfred of the giant hand. The novel reads, "Oh! the hand! the giant! the hand!—Support me! I am terrified out of my senses, cried Bianca: I will not sleep in the castle to-night" (102). Bianca, the lower class servant, serves once again as the superstitious informer of the upper class man, Manfred. By being the informer, she has a significant amount of power in how the plot will develop. Servants as a class are also close to this idea of the terror from dismembered limbs. Eve M. Lynch makes a very important observation dealing with servants. She says, "body parts, especially hands, were the common way to signify the uncanny human void in the servants position. It is no wonder that the rising Victorian ghost story drew on the vast supply of servants from below the stairs to physically coordinate the haunted domestic space." It is possible that these dismembered limbs—the giant foot and hand—are representative of a disorganized and faulty social structure. Gothic literature often relies on the function of these servants to create the terror. Although there is no lack of servants in the novel, the "human void" means the lack of moral and intellectual capacity that the upper classes see the servants as having. In many of their eyes, servants are simply walking husks, devoid of life, and meant to serve the master's will. Walpole, being an upper class man himself, may be showing some of the contempt he has for servants and lower classes during his time.

The second major novel that requires analysis is *Wuthering Heights* by Emily Brontë. This novel is highly concerned with social structure and relationships, as exhibited between the Linton and Earnshaw families. One critic notes that, "*Wuthering Heights* participates in the socio-political upheavals of the era . . . where the subordinate do not remain in their places, and where dominant modes of power are disparaged" (Cory 6). This idea of insubordinate people runs rampant throughout the novel. The servants, Nelly Dean and



Joseph, are often insubordinate to their superiors, especially when they are outside members of the family. Heathcliff, not a servant, but who begins as a member of a lower class, rises in the ranks and gains power. Through his eventual marriage to Isabella and his sketchy relationship with Hindley (much due to gambling debt), he is able to become the owner of Wuthering Heights.

The roles of servants within the novel are difficult to place. They serve so many roles, many of which the essay discussed earlier, such as raising children, teaching, household chores, and letting their masters ‘confide’ in them. The multi-faceted roles of Nelly and Joseph provide them with a great deal of power. The author Graeme Tytler says:

...it is noteworthy how much power some servants, Nelly Dean and Joseph in particular, are vested with in the upbringing of the children under their care.

Joseph, for example, as well as being chiefly responsible for instructing them in religious doctrine, is now and then described as thrashing Heathcliff or boxing Catherine’s ears for their respective misdemeanors. (45)

The raising of children gives them extreme amounts of control over the family setting. They decide how to raise the children, and what moral values they should instill in them. Although the upper classes see servants as inferior beings, both intellectually and morally, they are for some reason giving them this huge responsibility. This aspect of the novel perhaps stresses the deterioration of the family unit, especially when the reader sees how Heathcliff and the other children they raise turn out. Rather than the mother raising the children, it is the servants. Even later in the novel, there is strong evidence of Joseph influencing Hareton’s upbringing: “Joseph had instilled into him a pride of name, and of his lineage; he would, had he dared, have fostered hate between him and the present owner of the Heights, but his dread of that owner amounted to superstition” (Brontë 178). There are several elements working together in this passage. First, Joseph has enough power over the domestic sphere to influence Hareton. He encourages the pride of the Earnshaw name, which in turn perpetuates the hatred between the opposing families. Second, the novel lowers Joseph as a servant by his “superstition.” This is another example of the degraded servant instigating the conflict.

Nelly also is a significant instigator of conflict between the families. One of the best examples of this is when Catherine is dying. Nelly realizes that Catherine is slowly dying and becoming delirious, however, she insists on keeping Edgar ignorant. There were multiple opportunities for Nelly to seek help. Catherine, in one of her rants, brings to light Nelly’s true character. Catherine says, “‘Nelly is my hidden enemy—you witch! So you do seek elf-bolts to hurt us! Let me go, and I’ll make her rue! I’ll make her howl a recantation!’” (Brontë 125). *Wuthering Heights* portrays servants as meddling enemies of society. Nelly manipulates situations, which she is able to do because of her social position as a servant and trusted member of the family.

Some authors have gone as far as to say that Nelly Dean is the villain of *Wuthering Heights*. She meddles with the family affairs so much, placing her own spin upon the action when she relays it to Lockwood, that she seems to be the primary instigator of many of the problems. Much of this has to do with Nelly struggling to place her identity among the families. James Hafley says that Nelly believes herself “as rightly belonging to the same social level as the Earnshaws” (203). Nelly especially places herself among the higher ranks of society as she begins to further in age. She becomes the main caretaker of The Grange

after the death of Edgar Linton. The fear of servants rising in class is also extremely evident in the case of Nelly. Through her tale to Lockwood, she attempts to fulfill her own goals. James Hafley makes the argument against her character: “She has, of course, not told this long story to Lockwood without a very good reason: he is gullible, he is weak, he is disposed to like her. He would, in short, make a very good ‘master’ for her should he marry Cathy now that young Linton has died; it is her purpose to arrange his desiring such a marriage” (212). By this rationale, it is Nelly’s intentions to have a weak master, so that she can gain further control within the family and household. However, Nelly fails in her plan of having Lockwood pursue a relationship with Cathy. Instead, a relationship develops between Hareton and Cathy, which also ends up helping Nelly’s status (although perhaps not to the extent she wants). Nelly ends up running most of the family and looking over Cathy, Hareton, and the other servants.

The servants within both of these novels, *The Castle of Otranto* and *Wuthering Heights*, highlight the fears and anxieties of the upper class. The Gothic novel evolved into a warning of the faulty organization of the class hierarchy. There was a fear that servants and the lower class would rise in rank and usurp power. Servants can achieve a higher class through marriages and family meddling, such as the case with Nelly Dean. Due to these societal fears, the Gothic novel places servants in positions that enable them to increase horror within the literature. They lie, spy, and increase suspense through ignorance and strive for social position. Masters, on the contrary, degrade and punish them for their insubordination. By examining these pivotal characters within the Gothic novel, one begins to realize the societal underpinnings and problems with 18th- and 19th-century society.

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# Deception Detection Accuracy Using Verbal or Nonverbal Cues

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## ABSTRACT

In this 2 (cue type) x 2 (statement type) two-way within-subject ANOVA design study, investigators look at the differences in average accuracy in determining whether a statement is a truth or a lie. Participants, college students, and professors from South Dakota State University, were assessed in their ability to detect deception. The participants had to determine whether a statement was a truth or a lie based on the actor's verbal or nonverbal cues, each presented independently. The results suggest no significant effect of cue type (verbal or nonverbal) or statement type (truthful or deceitful) with participants' accuracy being no better than guessing rate.

## DECEPTION DETECTION ACCURACY USING VERBAL AND NONVERBAL CUES

Everyone is caught in a lie sometime in their life, and this event seems to stick in most people's memory. Stories are constantly told about these experiences of being caught red-handed. According to Vrij, Edward, Roberts, and Bull (2000), a liar can be caught three different ways. One strategy is by observing the behavior of the person in question (i.e. if they are making fidgety movements or averting gaze). The second strategy is to analyze what they are saying (i.e. if they are stuttering, fluctuating pitch, or have long pauses in speech). Lastly, a liar can be caught by measuring physiological correlates, which can be explicitly measured (i.e. heart rate, GSR). Nonverbal cues are clues of deceit that are expressed through facial expressions, eye movements, and body language. Verbal cues are linguistic clues of deceit that are expressed in an individual's statement, such as stuttering, differentiation in pitch, etc. (Wang, Chen, & Atabakhsh, 2004a). In order to make a credible discrimination between a truthful and a deceitful statement, verbal and nonverbal cues may need to be considered (Henningesen, Valde, & Davies, 2005). DePaulo, Rosenthal, Green, and Rosenkrantz (1982) found that individuals who based their decisions solely on verbal cues were more accurate than solely nonverbal cues. Fabbro, Gran, and Bava (1993) also found that individuals made more correct than incorrect judgments when using only verbal cues.

The current study of deception detection accuracy using verbal and nonverbal cues focuses on the first two strategies of Vrij et al.'s (2000) principles. Verbal cues are used to help distinguish between truthful and deceitful statements (Wang, Chen, & Atabakhsh, 2004b). Verbal cues help this differentiation because these cues are more likely to occur in

deceitful statements than in truthful statements. According to Wang et al. (2004b) nonverbal cues, even when observed by a trained officer, are usually too elusive to be noticed. When comparing verbal versus nonverbal cues in detecting truthful statements, Wang et al. (2004b) found otherwise. Accuracy when using nonverbal cues in detecting truthful statements varied from 51-82% in comparison to a steady 76% when using verbal cues. The fluctuation in nonverbal cue accuracy implicates that using nonverbal cues to distinguish statements is not reliable.

Based on the literature review, the authors expect to find that participants will be more accurate in detecting deception when utilizing verbal cues, than when using nonverbal cues. It is also expected that participants will be more accurate at identifying deceitful statements than truthful statements.

## METHODS

### *Participants*

Participants in this study included one male actor (for the video/audio recording), 22 undergraduate students, and three professors of South Dakota State University. The average age for 20 of the participants was 20.06 (SD=.80), the last five participants all exceeded the age of 22. The undergraduate students were recruited using a PowerPoint presentation given to a pseudoscience and psychology class. These participants had the opportunity to receive ten points extra credit for their participation. Those who did not want to, or could not participate, were given an alternative opportunity for the extra credit. All those who participated also were given a chance in a \$20 raffle. Professors and the male actor were recruited by request of the investigators. The male actor and professors who participated received no compensation. All participants were informed of participation criteria. The exclusion criteria included were: no individuals with psychiatric or behavioral disorders; no one under the influence of alcohol, illegal substances, any form of antidepressants or anti-anxiety drug, antihistamines or any form of medication; no one who had a history of epilepsy or seizure; no one taking medication for any form of Attention Deficit Disorder; no one under the age of 18 years. The institutional review board (IRB) approved this study and recruitment, approval number is IRB-1103007-EXP.

### *Materials and Procedures*

Prior to the recording of the video, the investigators received consent from the student actor. The actor was recorded using a small handheld camera, while answering simple investigator-generated questions such as, "What scholarships have you received at SDSU?" These questions were randomly assigned to be a true statement or a false statement based on the knowledge the investigators had of the actor. The actor was not practiced in telling these lies and the investigators did not inform the actor of any of the questions until the time of the recording.

All testing occurred at SDSU. One of the investigators tested one to four students in a single twenty minute session. Each session began with the investigator reading the consent form to all of the participants and an additional information sheet was provided for the

participants' own records. Participants were then instructed to complete an investigator generated five minute pre-questionnaire (pencil and paper). After completing the survey, participants answered two practice questions on SuperLab (Version 4.0 & 4.5), following a detailed description of the task. SuperLab is electronic software used to present visual or auditory stimuli and to read accuracy of responses. Each participant listened to the recording of the actor using Vic Firth Insulation headphones, and at a separate time watched the video of the actor making true and false statements. All participants received the same questions, the difference was in the way the statements were presented (verbal or non-verbal). Half of the participants listened to the recording first, and then they watched the video. The other half watched the video first, and then they listened to the recording. The participants were then asked to discriminate if the statement made by the actor is a truth or a lie. The responses were recorded through SuperLab on a Dell computer. To eliminate any order effect, investigators counterbalanced the type of presentation style. Half of the participants received the statements visually first and half of the participants listened to the statements first. The actual discrimination task took about ten minutes. Following the task, the participants were asked to complete a three minute investigator generated post-questionnaire regarding the assessment (pencil and paper). Investigators then debriefed the participants as to the purpose of the study. They were told that the investigators believed that individuals would be more accurate at detecting lies during the verbal presentation style. Any participants wishing to see their results on the task were shown a summary data file from SuperLab. Investigators retrieved data for the analysis through Super Lab Cedrus Data Viewer.

## RESULTS

Table 1 illustrates the 2 (cue type) x 2 (statement type) within-subject ANOVA which revealed cue type (verbal or nonverbal) as producing no significant main effect on the participants' accuracy. Results in Table 1 also show that statement type (truthful or deceitful) produced no significant main effect on accuracy of participants. There was no significant effect of the interaction between the cue and the statement type on accuracy of participants, as seen in Table 1. Figure 1 illustrates that average percent correct (accuracy) was no different following true statements during nonverbal ( $M=56\%$ ,  $SD=16.97$ ) and verbal cues ( $M=54\%$ ,  $SD=13.66$ ). Although participants had a lower average percent correct for the lie statements during the nonverbal ( $M=51.33\%$ ,  $SD=17.29$ ) and verbal cues ( $M=46.67\%$ ,  $SD=15.22$ ), this difference was not significant.

## DISCUSSION

In this study, accuracy during the detection task varied only slightly between the verbal presentation style and the visual presentation style. The accuracy during each presentation style was at chance rate. The frequency of correctly identified truths did not differ significantly across presentation style. Investigators also found insignificant differences between the frequency of correctly identified truths and lies during each presentation style.

Finally, accuracy insignificantly decreased when using the verbal presentation style when compared to the non-verbal presentation style.

Contrary to Vrij, Edward, Roberts & Bulls (2000), and Reinhard (2010), participants who were detecting deception using only verbal cues did not yield higher accuracy frequencies than when using non-verbal cues. Stromwall and Granhag (2003) state that individuals who are detecting lies using non-verbal cues achieve higher accuracy rates than individuals who are detecting lies using verbal cues.

Riggio (1992) and Malcolm and Keenan (2005) support the current findings. Accuracy of deception detection was at chance levels (50%). Participants in the current study did no better than if they were guessing. Even if the participants were confident in their deception detection abilities, accuracy did not change (Malcolm and Keenan 2005).

There were several possible confounds in the current study. The primary possible confound would be the lack of motivation from the participants. Several of the participants were simply pressing buttons and not paying attention to the actual content of the video. Another possible confound is the quality of the video. The video was recorded on a low-end camera so the picture quality was poor. Also, the background of the video recording room may have been cluttered and therefore distracted the participants from the actor in the video.

The sample size, number of statements, and content of the statements could affect the outcome of the study. The study only consisted of 25 participants, which is not an adequate sample size. Malcolm and Keenan (2005) used 112 pre-recorded statements whereas the current study used only 30. Of the 30 statements, four were practice questions. This may have altered the results because participants might not have fully understood the task, therefore more practice questions should be integrated. Finally, the content of the actual statements were too detached from the actor, which resulted in no noticeable emotion to the actor's true or false answers. Other studies suggest that accuracy depends on the severity of the lies. It was revealed that lies that are more severe are easier to detect than less severe lies (DePaulo, Rosenthal, Green, and Rosenkrantz 1982). Due to this, the ability to lie may have also hindered the results. The investigators attempted to account for this by randomly selecting questions the actor never encountered before. Another confound that should be noted is that there was no control group where participants received the verbal and non-verbal cues simultaneously. Vrij, Edward, Roberts and Bull (2005) stated that when using both cues, 80.82% of participants correctly identified true and false statements. A possible future revision of this study controlling these specific confounding variables could result in finding differences between the average accuracy of participants.

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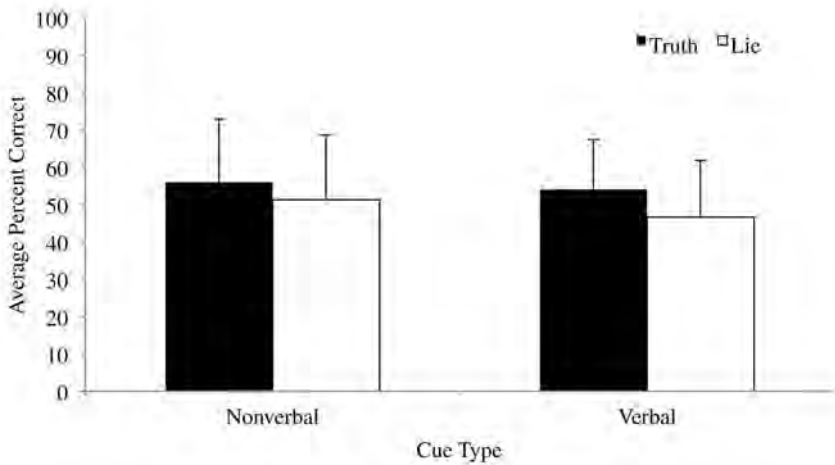
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**Table 1.** A Two-Way Analysis of Variance for Effect of Statement Type (Truthful or Deceitful) and Cue Types (Nonverbal or Verbal) on Accuracy

Source	SS	df	MS	F	p-value
Non-Verbal/Verbal	277.69	1	277.69	1.14	0.3
Error	5859.7	24	244.15		
Truth/Lie	900	1	900	2.69	0.14
Error	8032.42	24	334.68		
Interaction	44.41	1	44.41	0.27	0.61
Error	4009.23	24	167.05		
Total	19123.5		1967.98		



**Figure 1.** The average percent correct (accuracy) of all participants during verbal and nonverbal cues. Error bars represent standard deviation.

# Re-examining “In a Different Voice” for the New Millennium

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## ABSTRACT

Carol Gilligan’s *In a Different Voice* (1982) first presented the concept of different moral reasoning as key to understanding how men and women seem to arrive at different conclusions in similar situations. Contrasting her work with the influential model of Kohlberg, Gilligan argues that women’s concept of moral decision-making is inherently relational, rather than reflecting the acceptance of abstract justice deemed to be the highest level of decision-making by Kohlberg. Here, I explain this contrasting perspective, and then examine modern integration of Gilligan’s perceptions as seen through print and broadcast media.

## INTRODUCTION

Carol Gilligan’s *In a Different Voice* speaks of women’s empowerment on a unique level. It argues for a restructuring in the analysis of human development and it calls attention to the complexity of the moral judgment that occurs within every human being. Gilligan uses her book as an expression of the countless women who have been ranked inferior with regards to masculine developmental standards. She poses questions that people have either been too uninformed or unconcerned to ask. Most importantly, she has brought “the woman” to the spotlight and exposed her moral judgment. *In a Different Voice* truly is just that. It is a forgotten voice in our society. In writing this work, originally published in 1982, Gilligan has brought the woman’s voice forward and this is what it has to say.

## SECOND-WAVE FEMINISM

*In a Different Voice* reveals several important concepts with regards to the female population and how as individuals they have evolved into people morally different from their male counterparts. Exemplary of second wave feminism, Gilligan’s concept of women’s moral nature and reasoning creates a place for women to grow and reside within a society where the male has been considered superior. It is in this second wave of feminism where the slogan “the personal is political” came to be. West (2010) states, “With the rise of the Civil Rights Movement and other social movements for equality, and during the 1960s and 1970s, Second Wave Feminism would arise to question the domination of patriarchy and gender inequality in all walks of life” (p. 1). It is within this mindset of equality during the second

wave of feminism Gilligan's book is written. She argues for the equality of women with regard to how they form conclusions on moral judgments. She further argues for equality in the developing of original theories of developmental processes. These items, along with many others, will be taken into consideration throughout this paper.

## LIBERAL FEMINISM

Gilligan's book follows the tenets, too, of liberal feminism. According to Lucy Brookes (2011), "Liberal feminism is an individualistic form, concentrating on women having the ability to maintain their equality through being responsible for their own actions and choices" (p. 1). This broad definition is clearly represented within *In a Different Voice*. Gilligan contrasts women's capability to make decisions in a unique way to that of men in our same society. She further argues that it is this unique capability that gives women the individual power to make responsible decisions and take actions within society. The system as a whole has left this difference in judgment out of all developmental scales; instead society has placed women into categories meant for men. It is within liberal feminism where Gilligan makes her argument that through varying choices it becomes apparent that the need for an individual developmental scale for women must be created. It is through this creation that women will begin to be treated equally to their male counterparts.

Throughout her book, Gilligan examines equality of moral reasoning by highlighting how men and women view moral dilemmas differently, challenging previous models which rank one as superior over the other. For example, Gilligan (1982) states:

While Jeffrey sets up a hierarchical ordering to resolve a conflict, between desire and duty, Karen describes a network of relationships that includes all of her friends. Both children deal with the issues of exclusion and priority created by choice, but while Jeffrey thinks about what goes first, Karen focuses on who is left out. The contrasting images of hierarchy and network in children's thinking about moral conflict and choice illuminate two views of morality which are complementary rather than sequential or opposed. (p. 33)

Gilligan argues that all developmental theories have failed to take these differences and look at them in a more cohesive fashion rather than hierarchical one. She believes the system has focused simply on the boys' track of moral judgment and thus has left the thought process of the girls as inferior to that of the boys.

## THE FAMOUS CASE OF "HEINZ"

Gilligan's work stands in contrast to the influential approach presented by Lawrence Kohlberg, which is wide-spread in the discipline. Kohlberg created a moral developmental scale which scientifically placed children in categories of moral development. He argued that children go through three different stages of development: pre-conventional, conventional, and post-conventional. At the pre-conventional level, children are said to obey authority and look to it for undeniable truths. It is at this stage that children are more interested in what the

law regards as right and wrong and less concerned about what they believe to be correct. At the conventional level, children begin to do what they believe to be right and avoid doing things they believe to be wrong. At this stage, children look to society and the ideals of love, trust and empathy with regards to what they should and should not do. At the final stage, post-conventional thought, Kohlberg argues that children move into the concept of justice. These individuals often attempt to obey the laws until what is morally right and what is right by the law come into conflict. When this conflict occurs, Kohlberg believes one must look at the child's intentions in order to determine to which stage he or she belongs (Crain, p 118, 1985). Within this developmental framework, Kohlberg finds that girls are more likely to fall within the pre-conventional or conventional stages whereas boys are more likely to fall into the post-conventional category. Kohlberg argues that boys regard moral justice more so than girls. Girls, on the other hand, are more likely to reflect on what is most beneficial for others that are close to them rather than what is just or right toward society.

The "Heinz" experiment is an interviewing tool created by Kohlberg to place children at particular stages according to their response to the situation. The situation posits a man (Heinz) who has a wife with cancer. A drug maker has created a drug to help Heinz's wife; however Heinz cannot afford it. The situation ends with the question as to whether or not Heinz should steal the drug for his wife. Kohlberg is not interested in the child's "yes" or "no" to the situation but rather how he or she goes about reasoning through it.

Gilligan strongly critiques Kohlberg's moral development theory. She argues his theory is focused around the male development regarding moral judgment and disregards the female's process of developing. According to Carol Gilligan, girls differ greatly from boys with regards to moral development. When reviewing two children's responses to the Heinz situation Gilligan notes:

If the trajectory of development were drawn through either of these children's responses, it would trace a correspondingly different path. For Jake, development would entail coming to see the other as equal to the self and the discovery that equality provides a way of making connection safe. For Amy, development would follow the inclusion of herself in an expanding network of connection and the discovery that separation can be protective and need not entail isolation. (1982:39)

In other words, while the male begins to focus on the effect his decisions have on others; the female begins to understand the effect of her decisions on herself. Within the female population, it becomes a moral dilemma of the fine balance between self and others. Additionally, Gilligan argues that while Kohlberg's theory places a hierarchy of development on individuals, she believes developmental processes between women and men should be seen as cohesive and in conjunction with one another.

## **GILLIGAN'S STAGES OF MORAL DEVELOPMENT**

In direct contrast with Kohlberg's stages of moral development, Gilligan has created a system orientated towards a woman's mental development with regards to moral and responsible decisions. At the first stage of development, women are geared toward individual survival. In connection with this stage is the idea that if the woman does not survive, no other

individuals related to them will be created. This stage is the primal concept of evolution. The next stage of moral development is the moral responsibility to others. At this stage, a woman begins to recognize her responsibility to society and predominantly those individuals who are close to her. Gilligan further argues that it is at this stage when women often forget about their needs and purely focus on the needs of others. Women at this stage may even be willing to sacrifice themselves and their values for the safety or the responsibility they feel towards others. At the final stage of moral development, the reintegration of the self appears. It is at this stage where women recognize the importance of creating a balance between what is right in accordance with others feelings and needs, and what is right for them. This can be a difficult balance and one that often comes with personal growth and experience.

## EXAMINING THE MORAL DILEMMA OF ABORTION

Throughout *In a Different Voice*, Carol Gilligan uses several interviews with women who are going through the process of abortion, in order to evaluate the three different stages of her moral developmental scale. A wonderful example that demonstrates the moral stages of development is the story of Ellen, a young woman in her late twenties. Although she defined herself as a career-focused musician, she finds herself caught up in a love affair. Shortly after entering this relationship, she conceives a child. When Gilligan interviews her about her recent decision to have an abortion, Ellen brings up the following moral dilemma, "The pregnancy poses a conflict between her 'moral' belief that 'once a certain life has begun, it shouldn't be stopped artificially,' and her 'amazing' discovery that, to have the baby, she would need much more support than she had thought" (Gilligan, 1982:88). This conflict leads Ellen to question her moral obligation to have the child and at the same time to question whether it is responsible to have a child in her current circumstances. She finds that although she feels responsibility to have the child, she also feels the lack of support she has in order to raise it properly. Gilligan argues this particular situation demonstrates the moral dilemma of promoting care and reducing hurt. It also brings up the complicated dilemma between care for self and care for the other. It is by highlighting the unique moral reasoning based on relative care, as seen in studies such as the one with Ellen, which reveals the extremely complicated process of moral development found within women. Kohlberg's model cannot account for the moral balancing of care, emphasizing as it does the "higher" calling of impersonal justice.

## FEMINISM OF DIFFERENCE

Another form of feminism that defines Carol Gilligan's perspective of women is that of the feminism of difference. Many argue that it was Carol Gilligan who in fact coined this term to define how one should view both women and men. Difference feminism, according to Joan Mandle (2006), "emphasizes the unique identity of women as a group, stressing and usually celebrating essential female characteristics which it believes make women different from - indeed even opposite to - men" (p. 1). Within this same article, difference feminism is further

defined to recognize that although differences exist, it is in these differences that men and women should celebrate and look to one another for a cohesive solution to social dilemmas rather than ranking one as superior over the other. Inherent even in the title, it is in this context that Gilligan's book both challenged and expanded understandings of moral reasoning and human development.

Gilligan's work was, as previously noted, written in 1982. The question remains: Are her work and insights still relevant in our society today? While many declare us to be in a "post-feminist" era, it is also clear that many of the thoughts and ideas of second-wave feminism have been incorporated into our current society, especially through representation in modern media. In the second part of this essay, I examine whether Gilligan's insights of women's difference can be seen to be among those integrated into modern culture and understandings, or if they remain needed insights which we have unfortunately left behind.

## **MODERN MEDIA AND THE REPRESENTATION OF WOMEN: PRINT MEDIA**

When looking at current media such as journals, television, newspapers, books and the like, it becomes evident that our society still struggles with the concept of cohesion versus hierarchy. It is quite apparent that little has been done to reflect Gilligan's idea of difference feminism within society, but rather the gap between men's and women's positions remain quite large. Magazines are prime examples of such a gender gap. For example, in the latest Glamour magazine, there are multiple articles regarding how to please a man sexually, what the latest fashions are, and how to become skinnier, more beautiful, and more likable. However, there is not a single article that discusses a woman's ability to become a successful business woman, how to build on one's ability to judge particular situations, or how to handle the dual roles women often face. To take this idea even further, the range of magazines out there for women are quite limited. If the article is not discussing how to look younger, it is teaching one how to cook, clean, or become fit. Most women's magazines only reinforce a woman's stereotypical role of "housewife". This lack reduces the significance for the need of a woman's moral judgment and simply reinforces the idea that women are developmentally inferior to men. In contrast to this, men's magazines come in a wide variety of topics. For example, one can find business magazines, sports, hunting, homebuilding, and magazines with attractive women in the spread. Although there are magazines that are solely for pleasure, more magazines exist that suggest the man is the "business-type". It is magazines such as these that suggest men are responsible for making sound decisions and moral judgments.

## MODERN MEDIA AND THE REPRESENTATION OF WOMEN: BROADCAST MEDIA

Another source that demonstrates the lack of integration of Gilligan's theory is the television. Today, there are countless shows that reinforce the man's role in making moral decisions, and the lack of responsibility of the woman. For example, shows such as *Everybody Loves Raymond*, *The Real Housewives*, *Sex and The City* and *The Office* all have men in higher positions than the women. It is also apparent, especially in *The Real Housewives*, that women are regarded as sex symbols whereas men are responsible for the income and major decisions of the households.

In contrast to these television shows, however, there are a few where the woman is stepping into the male's area regarding career status. Shows such as *Grey's Anatomy*, *King of Queens*, and *Private Practice* are building upon Gilligan's argument that women, although they morally develop differently than men, are still capable of making responsible decisions. In her book, Gilligan (1982) notes, "The essence of moral decision is the exercise of choice and the willingness to accept responsibility for that choice" (p.67). For Gilligan, women's difference is that when faced with the need for a difficult moral decision, women take into consideration the self as well as others, rather than reflecting abstract models of justice. This difference is demonstrated throughout the previously noted television shows. For example, *Private Practice* does an excellent job of showing the conflict between the self and others. The main character, Dr. Addison Montgomery, is responsible for pregnancies as well as abortions that are performed within the clinic. She is constantly speaking with other characters about the inner struggle she faces with regard to what is ethically right and what is right for the patient. This show is a strong example of Gilligan's argument. This character is in the highest position at the clinic even though she does not "think like a man." However, she demonstrates time and time again that as a woman she is capable of making moral decisions.

## CURRENT RELEVANCE AND A COMMON CONFLICT

Gilligan's theory of moral development and responsibility does an effective job of describing the complex thought process pursued by women when facing moral decisions. It further describes and helps explain women's role in society and the significant need to hold women as equals to men. Her framework helps us not only understand the moral decision-making processes concerning abortion, but also many other aspects of women's lives.

Today, many women struggle with the burden of household responsibilities, such as taking care of the children and housework, and the desire to dedicate themselves to careers. I argue that Gilligan's theory does quite a nice job explaining what women are faced with in this particular dilemma which men do not appear to share. If one were to follow the linear theory of Kohlberg, one may find it rather difficult to explain why a woman feels the need to play both the role of housekeeper and the role of financial provider. His linear and abstracted model would simply lead to a conclusion of the separation of roles, and the attribution of one role being valued more highly than the other—in this case that of financial provider being perceived as the most important support for the caretaking role. However, Gilligan's

relational model allows us to see this situation differently, and indeed as one containing conflict. A woman’s instinct to care for others is fulfilled through providing nurture to her children and taking care of the household in general. For example, the basic idea of cooking for the family provides a basic need for individuals within the family. As a result, when a woman cooks, she receives fulfillment for her desire to care for others. However, a woman also has a basic desire to take care of the self. Many women today are finding this need fulfilled through striving for career goals or passions. This need for self-fulfillment is where the moral conflict arises. Gilligan’s theory demonstrates the process many women go through when trying to find the balance of caring for others through time and dedication within the home, and the caring for the self through time and dedication to career. Traditionally, men focus on career development rather than trying to find an equal balance between two very different expectations.

Overall, Gilligan’s theory of moral development consistently emphasizes the need for the understanding of a different developmental system for women as those derived from masculine perspectives are not suitable for explaining a woman’s process of responsible and relational decision-making. She underscores the difference in “difference” feminism. While Gilligan’s work was accomplished over 30 years ago, her book *In a Different Voice* still highlights the need for us to understand the differing moral development of women and the importance of relational moral decision-making in our current society.

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# Parental Influence on Adolescent's Academic Performance

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## ABSTRACT

The purpose of this survey research was to uncover how the relationship of parental involvement and parenting styles influence their adolescent's academic performance and success. Parents need to be actively involved in their adolescent's life, support and provide assistance with school and help instill motivation and confidence. This research was conducted by personally distributing surveys to a class of students at the Brookings High School in October 2010. The survey found that half of the participating adolescent's stated that their parents had a strong influence on their academic performance. This was critical information because it supported previous research conducted regarding the topic. I found that adolescent's perceptions of their own abilities were strongly linked to their parent's beliefs about them. Over half of the participants stated that their parents help them work through and cope with stressful situations or school problems. The more involved and supportive a parent is towards their adolescent the higher self-esteem they will gain allowing the adolescent to feel confident and focused during school.

*Keywords:* academic performance, parental involvement, adolescent

## INTRODUCTION

Parental involvement and genuine interest in an adolescent's school life has a significant influence on their academic performance and ability to focus and efficiently manage homework. Brown & Iyengar (2008) noted that adolescents who lack parental acceptance, behavioral supervision and psychological autonomy start out at a disadvantage by lacking vital skills needed to be academically successful. Adolescents gain and build upon values and academic goals based on those of their parents. When parents are supportive listeners, caring and active in their adolescent's life then there is less home life stress, allowing the adolescent to have a positive and esteemed attitude towards school. The purpose of this research was to analyze how parental involvement and parenting styles influence adolescent's academic performance.

## LITERATURE REVIEW

Brown & Iyengar (2008) analyzed all the aspects of parents' vital roles in adolescent lives. Critical examination of the research done on the influence of parenting styles was evaluated

through the five main aspects, (1) Parental Control; (2) Gender and parenting style; (3) Parental education; (4) perceptual differences between parents and their children; and (5) ethnicity and diversity. Parents' firm, yet warm and authoritative parenting style proves to be the most successful in creating positive performance and achievements in adolescents. Parents who create reasonable rules and take active roles in an adolescent's life will find the student having higher grades and greater performances in school.

Parents should facilitate and encourage independent problem solving, choices and self-determination in their adolescent if parents want them to be independent and motivated in school. Wong (2008) analyzed the effects of parental involvement and autonomy support in relation to academic performance of adolescents. Accurate and informative results were produced from interviewing 171 adolescents with different socioeconomic backgrounds, ethnicities and parental education. The study evaluated the participant's response to the impact of parental involvement such as, the extent to which parents are interested in, knowledgeable about, and willing to take an active role in the day-to-day activities of their children (Wong, 2008). Proven through multi-group analysis, statistics and results from the participating adolescents, parental involvement had a positive relation with an adolescent's successful academic performance. Parents who actively participate and are interested in their child's life will result in them having greater academic performances in school.

Research and studies conducted by other scholars have also proved that the impact of parental roles and involvement positively affect adolescents' school performance. Spera (2006) analyzed 184 adolescents' perception of parental involvement in school, authoritative parenting styles and parental monitoring at home proving that parental values and interaction positively related to the adolescent's interest in school, internal academic self-regulation and goal pursuit. According to the same study authoritative parents provided a higher level of emotional security supplying their children with comfort, independence and success in school. Critical analysis of the results confirmed that aspects of parenting are strong predictors of adolescent school achievement and motivation (Spera, 2006). Authoritative parents who engage in bidirectional communication with their children boost the development of interpersonal skills creating positive student adjustment and peer relations, increasing success levels in school both socially and academically. Numerous studies within this research article have been conducted to provide accurate and in-depth analysis on the positive results of parental involvement and authoritative parenting in relation to an adolescent's success in school.

Cassidy & Conroy (2006) established the idea that parents' interactions with adolescents shape how they evaluate themselves through self-esteem and achievement levels. Adolescents' perceptions of their own abilities are strongly linked to their parent's beliefs rather than to the adolescent's actual level of ability. The higher level of parental support and interest in the adolescent the greater amount of self-esteem and confidence the adolescent will feel, thus creating strong, more motivated attitudes towards academics. When an adolescent is confident and content with who they are, it produces self-confidence in school when answering questions and taking exams.

Parents who play an active role in their adolescent's school attend school activities and help with homework, have proven to increase the adolescent's academic performance and the amount of time they are willing to put into homework. Spera (2005) analyzed and proved

that parental monitoring, goals, values and aspirations were the basis of where and how their adolescent developed their own. Adolescents who come from parents of a positive, loving, authoritative structure, tend to be more motivated, focused and academically successful. Parents who provide a rationale for behavior and actions at home are teaching self-control and respect in their adolescent at school towards their teachers and fellow students. When life at home is satisfactory, then life at school becomes much better.

## METHODOLOGY

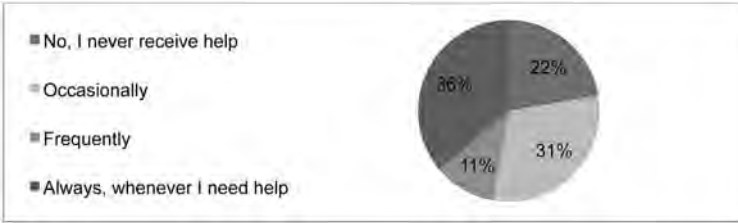
The research for this paper was conducted on October 26th, 2010 at the Brookings High School. Questionnaire forms were personally distributed to a class of thirty six high school students and thirty six forms were returned by those students who actively participated. The survey included questions of how parental guidance, style and involvement in an adolescent's life affected the academic performance of the adolescent. In-depth questions about parental interest and guidance towards the adolescent were required to fully comprehend how each parent cared for them and to understand the adolescent's relation between academics and parents. Questions pursued the adolescents' opinion on their parents' ability to help them work through and cope with stressful situations or school problems. More descriptive questions were asked about the involvement of the parent in the school and what activities they volunteered for to discover the level of participation in their adolescent's life. A more personal look at the parent to adolescent relationship was questioned through the parent's ability to provide discipline and explanations to inappropriate adolescent behavior. The questions were presented with multiple choice or yes and no answers as to receive more specific responses of actual adolescents' perception of their parental experience. Appendix A shows further information on the questions asked from the exact questionnaire form.

## RESULTS

The results were collected from thirty six high school students ranging from the ages fourteen to eighteen years old and surveyed the relationship of their parents.

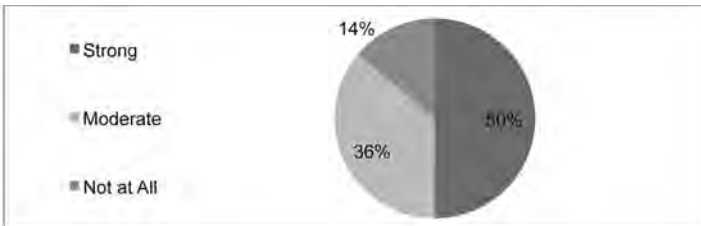
**Table 1:** Characteristics of the participants.

Variable	Frequency
<b>Age:</b>	
14 & Under	7
15-17	28
18 & Older	1
<b>Parents Currently Married:</b>	
Yes	26
No	9



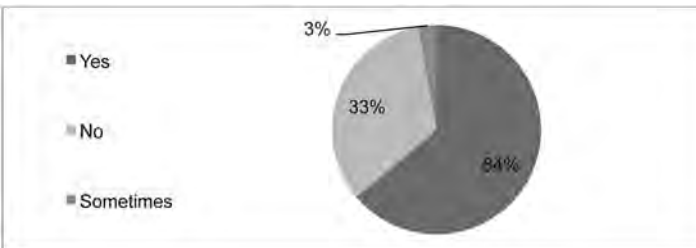
**Figure 1:** Frequency of parental involvement with homework.

Thirteen of the thirty six participants when asked “Do your parents help you with homework?” stated ‘always, whenever I need help.’ Eleven said they ‘occasionally’ receive help and four said they ‘frequently’ get help. A surprisingly high number of eight participants said ‘no, I never receive help.’



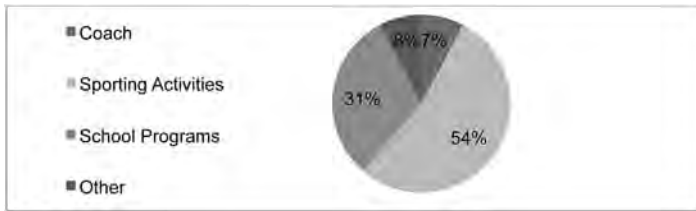
**Figure 2:** Parental influence on adolescent's academic performance.

The degree at which a parent influences the academic performance of the participants was defined as either strong, moderate or not at all. Eighteen participants said their parent's had a strong influence on their academic performances. Thirteen said their parent's had moderate influence on their academic performance and five claimed they had no influence.



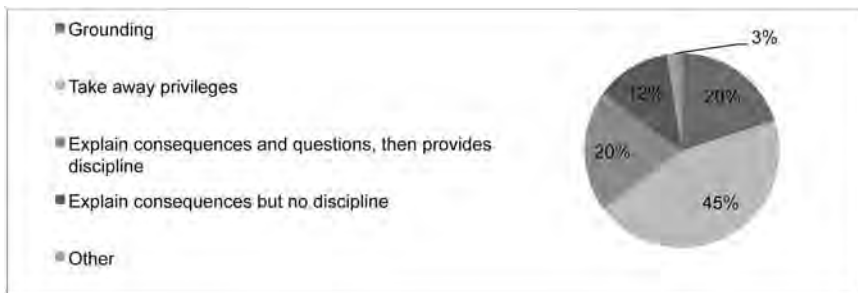
**Figure 3:** Parental guidance through stressful situations and school problems.

Over half of the participants, twenty three, agreed when asked “Do your parents help you work through and cope with stressful situations or school problems?” Twelve participants said ‘no’ they do not receive help and support through stressful situations, leaving one participant with the response that they only receive help ‘sometimes.’



**Figure 4:** Type of parent’s participation in their adolescent’s school activities.

Nine participants said their parents volunteer or take part in their school. The other twenty seven said their parents do not. For the parents who do volunteer or take part in their child’s school participated mostly in ‘sporting activities,’ followed by ‘school programs’. The least amount of results came back for ‘coaching’ and ‘other’.



**Figure 5:** Type of parental discipline and explanations for inappropriate behavior.

A total of twenty eight participants stated their parents provide discipline and explanations if their behavior is inappropriate, leaving eight other participants stating their parents provide no discipline or explanations. The most common action taken by parents was ‘taking away privileges’. ‘Grounding’ and ‘explaining consequences and questions, then providing discipline’ was the next response to inappropriate behavior. ‘Explaining consequences’ and ‘other’ brought up the lowest response from parent’s actions.

## CONCLUSION

The results from the high school students supported the research from other scholars in that parents have a significant influence on their adolescent’s academic performance and goal achievement. Half of the participants stated that their parents had a strong influence on their academic performance. The result of this study is consistent with Spera’s (2006) findings confirming how parental values and interaction are positively related to the adolescent’s interest in school, internal academic self-regulation and goal pursuit. Parents are the first people to teach their adolescent values and morals and to prepare them for school and

academic success. The majority of the students agreed that their parents help them work through and cope with stressful situations or school problems. The ability to have their parents supporting them and helping work through issues so they do not feel alone creates a less stressful life which will build a stronger, more motivated student. This is in line with the previous research that adolescents' perceptions of their own abilities are strongly linked to their parents' beliefs rather than to the adolescent's actual level of ability, as found in Cassidy & Conroy's (2006) critical analysis. The results showed that a small amount of student's parents volunteered or took part in their school. Research shows that parents who spend a considerable amount of time with their adolescent and play an active role within the school have proven to increase the adolescent's academic performance in school and the amount of time they are willing to put into homework (Spera, 2005). It is critical that parents increase the amount of time they volunteer or take part in their adolescent's school.

Strengths within a family need to be recognized to establish a foundation for growth in the family. Otto (1962) was credited with building the foundation for the Family Strengths Framework theory. He identified that commitment to the family, spending enjoyable time together, spiritual well-being, successful management of stress and crisis, positive communication and showing appreciation and affection to family members are all qualities that make a healthy family (Otto, 1962). Healthy families create a positive lifestyle for the adolescents by having little conflict within the family; each member should provide affection, appreciation, encouragement and embrace spiritual well-being. When an adolescent's home life is satisfactory, their academic performance will be strong and school behaviors will be much more appropriate. The use of positive communication within a family will help the adolescent learn how to communicate with teachers and other students. As shown in Moore & Asay (2008), decision making regarding adolescent educational participation is linked to central family values. Parents have a strong impact on the basic life values and educational plans of their adolescent.

The information developed from surveying South Dakota adolescents provides other scholars and readers with direct adolescent comments on their statement of parental involvement and influence. This offers insight into a stronger view of the research on parents' influence on their adolescent's academic performance. However, some limitations on the data gathered from high school students should be noted, including a limited sample size. A broader age category of students and a wider variety of ethnic backgrounds could have increased the generalization of the results. A socially desirable response bias may have occurred during the completion of the survey as well; some individuals may feel uncomfortable telling how they feel about their family or academics causing them to complete the survey with what they think the "appropriate" answer is. Future study on the effect of parental influence on adolescents' academic performances can benefit by addressing these issues.

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## APPENDIX A – QUESTIONNAIRE FORM

We are conducting a survey for CA 340-Work Family Interface. These questions are confidential, for research and research only; they will not be shared with anyone outside of this project. These answers are voluntary; you do not have to answer all of them. Do not put your name on this. Please circle all that apply.

Age \_\_\_\_\_

1. Are your biological parents currently married?

Yes                      No

2. Do your parents help you with homework?

No, I never receive help                      Occasionally  
Frequently                      Always, whenever I need help

3. At what degree do your parents influence your academic performance?

Strongly                      Moderately                      Not at all



4. Do your parents help you work through and cope with stressful situations or school problems?

Yes            No

5. Do your parents volunteer or take part in your school?

Yes            No

5-1. If yes, what do they do?

Coach          Sporting activities          School programs          Other

6. Do your parents provide discipline and explanations if your behavior is inappropriate?

Yes            No

6-1. If yes what actions do they take?

Grounding          Take away privileges

Explain consequences and questions, then provides discipline

Explain consequences, but no discipline

Other

# Comparison of Three Physical Activity Measurement Tools to Assess Physical Activity Guideline Compliance in Children

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## ABSTRACT

Current physical activity recommendations suggest that children should have 60 minutes of moderate-to-vigorous physical activity (MVPA) per day. Purpose: The purpose of this study was to compare the ability of three different physical activity measurement tools to assess whether children were meeting physical activity recommendations. Methods: Physical activity was assessed for one week via accelerometer (ActiGraph GT3X), pedometer (New Lifestyles NL-1000), and for one day using a self report questionnaire (Self-Administered Physical Activity Checklist, or [SAPAC]) in thirty 5th-grade students. A total of 15 students, ( $11 \pm 1$  yrs; 11 female, 4 male) met compliance standards and were used for data comparisons. Minutes spent in MVPA per day were calculated from the SAPAC and accelerometer data using Sallis specifications and Freedson cut-points, respectively. Data from the SAPAC and accelerometers were compared with Centers for Disease Control and Prevention physical activity guidelines. Steps per day from the pedometers were compared with BMI referenced steps per day cut-point guidelines. All data are presented as mean  $\pm$  SD. Results: SAPAC indicated MVPA of  $460 \pm 473$  minutes per day. Accelerometer assessment indicated MVPA of  $40 \pm 15$  minutes per day. Pedometer assessment indicated  $8994 \pm 3047$  steps per day. Conclusions: Within this sample, 6% of subjects met minimum physical activity recommendations based on accelerometer data, whereas 20% met minimum physical activity recommendations using the pedometer. However, 100% of subjects met recommendations using the subjective self-report recall questionnaire. This pilot study indicates 5th-grade students dramatically over report estimated MVPA via self-report questionnaire. Therefore, objective physical activity assessment tools, such as accelerometers and pedometers may be better suited than self-report questionnaires to assess compliance with physical activity guidelines in 5th-grade students. *Keywords:* physical activity, children, accelerometer, pedometer, questionnaire

## INTRODUCTION

In the United States, approximately 9 million preschool to high school students are considered obese<sup>1</sup>. Current physical activity recommendations suggest that children should have 60 minutes of moderate-to-vigorous physical activity (MVPA) per day<sup>2</sup>. Unfortunately,

fewer than half of children actually meet these guidelines<sup>3</sup>. Physical activity in youth supports healthy growth and development and promotes social interaction and mental health<sup>4</sup>. Physical inactivity is a major contributor to childhood obesity and subsequent chronic diseases such as hypertension, hypercholesterolemia, and Type II diabetes<sup>5-8</sup>. However, in order to combat the escalating rates of childhood obesity, we must understand their current levels of activity. Three common tools used to assess physical activity are self-report questionnaires, pedometers, and accelerometers. Each of these tools use different mechanisms for data collection and also vary in expense and technical skill required for data analysis.

Self-report recall questionnaires are a common and inexpensive subjective tool used to assess physical activity. By tailoring questions to meet the needs of the research query, a self-report recall questionnaire asks the subject to consider the frequency of a designated behavior during a predetermined timeframe. Due to the ease of administration and low-cost, questionnaires are ideal for use with large sample sizes. In contrast, the pedometer and accelerometer are both objective tools used to assess physical activity. Pedometers operate by recording the number of steps the wearer accumulates during the day<sup>9</sup>. They are moderately priced but differ in expense primarily based on precision of the device<sup>9</sup>. Accelerometers are costly tools capable of detecting and recording frequency and duration of physical activity<sup>5</sup>. In addition, they classify physical activity as low, moderate, or vigorous intensity<sup>10</sup>. However, due to the expense and technical skill required, some of these tools may not be suitable for use by the general public.

A majority of physical activity research has been conducted on the adult populations. Previous studies that have been conducted comparing objective and subjective measurement tools have suggested that self-report questionnaires have valuable advantages in the assessment of physical activity type and intensity in adults<sup>5</sup>. Advantages stem from the low cost of distribution and minimal skill required from subject for completion and from researchers for analysis<sup>5</sup>. In addition, many self-report questionnaires have been validated for use in a general population by verifying data obtained from a questionnaire with an objective measurement tool such as an accelerometer<sup>5</sup>. Because most research has been done in adult populations, it is unclear if questionnaires are reliable for use with children<sup>4</sup>.

Therefore, the purpose of this study was to compare the ability of three different physical activity measurement tools to assess whether children were meeting physical activity recommendations. More specifically, a comparison was made to establish the most appropriate tool for physical activity assessment because of the evident need for an precise, practical, and reasonably priced measurement tool that could be utilized in elementary school age children.

## METHODS

### *Participants*

Thirty fifth grade children from Elkton and Rosholt, SD participated in this study. Written informed consent was obtained from the children and their parents as a component of the Kid Quest nutrition and physical activity intervention program. The participants' physical activity was assessed via accelerometer, pedometer, and self-report questionnaire.

### *Measurement tools and protocol*

Physical activity was assessed for one week via accelerometer (ActiGraph GT3X), pedometer (New Lifestyles NL-1000), and a self report questionnaire (Self-Administered Physical Activity Checklist, or [SAPAC]). The Actigraph GT3X is a triaxial accelerometer which detects accelerations in three anatomical planes: vertical (x), anteroposterior (y), and mediolateral (z)<sup>7</sup>. Activity counts in each vector are then calculated into vector magnitude or intensity of the physical activity<sup>5</sup>. The New Lifestyles NL-1000 pedometer uses a motion sensitive piezoelectric mechanism to detect and record step counts<sup>4</sup>. The accelerometer and pedometer were attached to an elastic belt and worn on the hips of the participants. Participants were instructed to wear the belt at all times with the exception of sleep time, bathing, or anytime when the instruments could come in contact with water. The SAPAC, which has been validated for use with fifth grade students, was self-completed in a group setting<sup>11</sup>. The questionnaire required the participants to report the minutes they spent engaging in 21 common physical activities (i.e. bicycling, ball playing, chores, etc.), and time spent viewing TV/video and playing video/computer games during the previous day<sup>11</sup>. The day was segmented into 3 time periods: before school, during school, and after school. This was to assist the participant with activity recollection as well as to determine which segment had the most minutes of physical activity<sup>11</sup>. The participants were instructed to only record having engaged in an activity if they did so for 5 or more minutes at one time<sup>11</sup>.

### *Treatment of results*

A total of 15 students, (11 ± 1 yrs; 11 female, 4 male) met compliance standards and were used for data comparisons. Compliance standards required minimum wear time to include 3 week days, 1 weekend day, and no more than 2 hours of non-wear time during the minimum 4 recorded days. Data from the accelerometer was uploaded to a computer and analyzed via ActiLife software. Minutes spent in MVPA per day were calculated from the SAPAC and accelerometer data using Sallis specifications and Freedson cut-points, respectively<sup>11,8</sup>. Data from the SAPAC and accelerometers were compared with Centers for Disease Control and Prevention physical activity guidelines<sup>2</sup>. Steps per day from the pedometers were compared with BMI referenced steps per day cut-point guidelines of 12,000 steps per day for girls and 15,000 steps per day for boys<sup>12</sup>. All data are presented as mean ± SD.

## **RESULTS**

SAPAC indicated MVPA of 460 ± 473 minutes per day with 100% meeting physical activity recommendations. Accelerometer assessment indicated MVPA of 40 ± 15 minutes per day with 6% of subjects meeting physical activity recommendations. Pedometer assessment indicated 8994 ± 3047 steps per day with 20% meeting physical activity recommendations.

Males indicated MVPA of 385 ± 280 minutes per day with 100% meeting recommendations using the SAPAC, MVPA of 46 ± 18 minutes per day with 25% meeting recommendations using the accelerometer, and 7830 ± 5348 step counts per day with 25% meeting recommendations using the pedometer.

Females indicated MVPA of  $488 \pm 535$  minutes per day with 100% meeting recommendations using the SAPAC, MVPA of  $38 \pm 14$  minutes per day with 0% meeting recommendations using the accelerometer, and  $9418 \pm 1918$  step counts per day with 18% meeting recommendations using the pedometer.

Table 1 presents the data collected from the 3 physical activity assessment tools. Table 2 presents the percentage of participants meeting minimum physical activity guidelines from each tool.

**Table 1.**

Physical Activity Assessment			
	Total	Males	Females
SAPAC (minutes MVPA/day)	$460 \pm 473$	$385 \pm 280$	$488 \pm 535$
Accelerometer (average MVPA/day)	$40 \pm 15$	$46 \pm 18$	$38 \pm 14$
Pedometer (average steps/day)	$8994 \pm 3047$	$7830 \pm 5348$	$9418 \pm 1918$

All data is presented as Mean  $\pm$  SD

**Table 2.**

Percent Meeting Physical Activity Guidelines			
	Total	Males	Females
SAPAC	100%	100%	100%
Accelerometer	6%	25%	0%
Pedometer	20%	25%	18%

## DISCUSSION

The purpose of this study was to compare the ability of three different physical activity measurement tools to assess whether children were meeting physical activity recommendations and determine which tool is most appropriate for use with this age group. Comparisons were made between the SAPAC, a pedometer, and an accelerometer. These devices were selected due to differing cost, accuracy, reliability, and the technical skill required to operate and analyze data.

The SAPAC provides a summary of each activity the participants engaged in, which segment of the day the activity was performed, and number of minutes the activity was performed<sup>11</sup>. While the questionnaire is inexpensive and can be administered to large sample sizes, our results indicated that the 5th grade students dramatically over reported their physical activity minutes, thus providing overestimation of MVPA. Overestimation of physical activity is a common problem with self-recall questionnaires. However, previous studies that compared self-recall questionnaires with accelerometers found significant correlation between data collected<sup>5,11</sup>. The results of this study contradicted previous findings. The limitations specific to the SAPAC could be due to response bias, where the subjects record the amount of physical activity that they thought they should have done rather than what was actually done.

While accelerometers are acknowledged as an accurate, objective tool for evaluating free-living physical activity, they are inadequate in their inability to precisely detect stationary activities<sup>13</sup>. They do not register activities such as arm movements, cycling, stair climbing, or weight lifting accurately<sup>6</sup>. Accelerometers cannot capture all movement all the time, and because of lack of body acceleration during light or sedentary activities, estimates of total daily energy expenditure from movements captured by the accelerometer will be underestimated<sup>14,15</sup>.

Pedometers provide a basic measurement of physical activity by recording step counts. Researchers have recognized the usefulness of the pedometer as a motivational device to increase daily physical activity<sup>16</sup>. However, unlike the SAPAC and accelerometer, there is no way to determine from the pedometer what activity was being performed and the intensity at which it was performed<sup>17</sup>.

Unlike the results obtained from the SAPAC where all subjects met minimum physical activity recommendations, most of the children do not meet these recommendations when assessed via pedometer and accelerometer. Although the data gathered via pedometer and accelerometer indicated similar percentages of children meeting physical activity guidelines, the accelerometer is significantly more expensive and requires more technical skill to operate and analyze data than the pedometer.

## CONCLUSION

Implications of this study suggest that although the SAPAC is cost-effective and easily administered, this tool should be used with caution in this age group when assessing MVPA. In contrast, the accelerometer provides an objective assessment of physical activity, but the cost exceeds the budgets of most schools and facilitates that may want to assess physical activity. Accelerometers are more appropriately used in settings such as research facilities and institutions of higher academia. These institutions can provide the funding necessary for a high cost device and the support and technical skill required to analyze the data. Therefore, these data suggest the pedometer is the most appropriate tool for the general public to assess physical activity as it provides the best balance of cost, accuracy, reliability, and required skill for assessment of physical activity in 5th graders.

## LIMITATIONS

This pilot study has limitations that should be addressed when considering future exploration of this topic. A major limitation of this particular study was the small sample size. The sample size was limited due to available resources and the number of subjects that met compliance standards. With a larger sample size, more definite conclusions could have been made regarding the differing results between the subjective and objective measurement tools. Selection bias is another limitation of this study. The sample of 5th grade students used for this study were from small, rural towns. Significant differences may be observed in physical activity levels of students in urban settings. Therefore, the sample used for this study may not

be an accurate representation of the entire population as a whole. Future studies could incorporate a larger sample size as well as a wider variety of students residing in rural and urban locations in order to obtain results that more accurately represent the entire 5th grade population.

## ACKNOWLEDGMENTS

We wish to express our most sincere appreciation to the individual who has assisted us with this research study. Thank you to our senior faculty advisor, Dr. Jessica Meendering for providing us with this valuable experience. This research study has served as a springboard for our interest in physical activity research and childhood obesity prevention. We have been motivated to continue our higher education through graduate school to pursue our Ph.D.s in exercise science/physiology. We would like the opportunity to make a difference through the mechanism of continued study of the effect of physical activity on childhood obesity.

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# Real Number Rado Numbers for the Equation $\sum_{i=1}^{m-1} x_i + c = x_m$

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## ABSTRACT

For every integer  $m \geq 3$  and for every real number  $c$ , let  $r_{\mathbb{R}}(m, c)$  be the least real number such that for every 2-coloring of the interval  $[1, r_{\mathbb{R}}(m, c)]$  there exists a monochromatic solution to the equation

$$x_1 + x_2 + \dots + x_{m-1} + c = x_m.$$

In this paper, it is shown that

$$r_{\mathbb{R}}(m, c) = \begin{cases} m^2 - m - 1 + c(m + 1) & \text{for } c \geq 2 - m \\ \frac{1 - c(m + 1)}{m^2 - m - 1} & \text{for } c < 2 - m. \end{cases}$$

## INTRODUCTION

Many undergraduate mathematicians may be unfamiliar with the branch of discrete mathematics known as Ramsey theory. Named after Frank Plumpton Ramsey and a fundamental theorem he wrote and was able to prove in 1928, Ramsey theory is most simply described as “the study of the preservation of properties under set partitions.” [4]. A *partition* of a set  $X$  is formally defined as a finite collection  $S$  of nonempty subsets of  $X$  such that every element in  $X$  belongs to exactly one member of  $S$ . Mathematicians Landman and Robertson further expand on the idea that Ramsey theory is the study of preservation of properties under set partitions by explaining, “When given a set  $S$  that has a property  $P$ , is it true that whenever  $S$  is partitioned into finitely many subsets, one of the subsets must also have property  $P$ ?” [4]. The answer to this very type of question is sought when Ramsey theory mathematicians research original problems.

This paper will examine the type of Ramsey theory concerned with the preservation of solutions to specific linear equations under set partition. That is, if a solution to a linear equation exists in the natural numbers, must one also exist within one set of a partition of the natural numbers? To differentiate sets of a partition of the natural numbers from one another, it is convenient to use colors. Then a solution in just one set of a partition of the natural numbers can be referred to as a *monochromatic solution*, or a solution in a single color. Because more than one color is used when partitioning the natural numbers, we use the term *t-coloring* to refer to a specific coloring pattern of the natural numbers that uses  $t$  colors. For instance, if the natural numbers were partitioned such that the odd numbers were red and the even numbers were blue, that coloring would

be a 2-coloring of the natural numbers because 2 colors were used. If we were looking for a solution to the linear equation  $x + y = 6$ , then  $x = 2$ ,  $y = 4$  would be a monochromatic solution because both 2 and 4 are even numbers and were colored blue.

While Ramsey theory has been named after Frank Plumpton Ramsey, its origins trace back to the results of an earlier mathematician, Issai Schur. In 1916, Schur was attempting to prove Fermat's Last Theorem, but his attempt was unsuccessful. In the process though, Schur was able to prove a lemma that later became known as Schur's Theorem [2]. Today, Schur's Theorem is viewed as one of the earliest results in Ramsey theory. In this paper, we will state Schur's Theorem without its proof.

**Schur's Theorem [4].** *For any integer  $t \geq 1$ , there exists a least positive integer  $n = s(t)$  such that for any  $t$ -coloring of the natural numbers  $\{1, \dots, n\}$  there is a monochromatic solution to  $x_1 + x_2 = x_3$ .*

Notice that Schur's Theorem states that these least positive integers,  $s(t)$ , known as *Schur numbers*, must exist for any number of colors  $t$ , but it says nothing as to the actual value of  $s(t)$ .

For clarification, we will next work through an example of Schur's Theorem. Consider a 2-coloring of the natural numbers; that is, each natural number is colored one of two possible colors. Schur's Theorem states that for  $t = 2$ , there must exist a least positive integer  $n = s(2)$  such that a monochromatic solution set to the equation  $x_1 + x_2 = x_3$  exists among the natural numbers  $\{1, \dots, n\}$ . In fact, we will use a method known as a "finite sufficient set" to demonstrate that not only does this least integer exist, but that  $s(2) = 5$ .

In order to demonstrate that a monochromatic solution to the equation  $x_1 + x_2 = x_3$  exists among the natural numbers  $\{1, 2, 3, 4, 5\}$  colored with 2 colors, we try to color these natural numbers in a way that avoids a monochromatic solution for as long as possible. Without loss of generality, the number 1 can be colored red. At this point, because  $1 + 1 = 2$ , the number 2 cannot be colored red, or a monochromatic solution to  $x_1 + x_2 = x_3$  would exist. Therefore, we color the number 2 blue. Next,  $2 + 2 = 4$ , so the fact that 2 is colored blue means that the number 4 must be colored red or a monochromatic solution to  $x_1 + x_2 = x_3$  would exist. Now notice that 1 and 4 are both colored red. Since  $1 + 3 = 4$ , if 3 would also be colored red, we would have arrived at a monochromatic solution to  $x_1 + x_2 = x_3$ . Therefore, we color the number 3 blue. So far, our natural numbers have been colored as follows:

- 1 : red
- 2 : blue
- 3 : blue
- 4 : red.

Finally, we arrive at an impasse. If we color 5 red, then  $1 + 4 = 5$  and a monochromatic solution to  $x_1 + x_2 = x_3$  exists. If we color 5 blue, then  $2 + 3 = 5$  and a monochromatic solution to  $x_1 + x_2 = x_3$  also exists. Because a monochromatic solution to  $x_1 + x_2 = x_3$

results when either color is assigned to the number 5, but we were able to avoid a monochromatic solution up until that point, 5 is the least positive integer such that a monochromatic solution to the equation  $x_1 + x_2 = x_3$  is guaranteed to exist among an arbitrary 2-coloring of the natural numbers  $\{1,2,3,4,5\}$ . Therefore, returning to our prior notation,  $s(2) = 5$ .

It may be interesting to note that since 1916, when Schur's Theorem was written, the only Schur numbers that have been discovered include  $s(1) = 2$ ,  $s(2) = 5$ ,  $s(3) = 14$ , and  $s(4) = 45$  [4]. The number of possible colorings becomes so great with five or more colors that human and computer power available today have not been able to determine the exact value of any other Schur numbers. However, some bounds are known for other Schur numbers; these bounds include  $161 \leq s(5) \leq 316$ ,  $s(6) \geq 537$ , and  $s(7) \geq 1681$  [7].

While Schur's Theorem first introduced the concept of a least positive integer such that a monochromatic solution to a linear equation must exist, Schur's Theorem only considered the specific equation  $x_1 + x_2 = x_3$ , which is today known as the *Schur equation*. Richard Rado, a graduate student of Schur, further studied these least integers and was able to generalize the concept of a Schur number to arbitrary systems of linear equations. Rado published a series of articles in the 1930s that provided necessary and sufficient conditions to determine if an arbitrary system of linear equations admits a monochromatic solution under every  $t$ -coloring of the natural numbers [4]. Today, the concept of a Schur number, when generalized to a system of linear equations, is called a *Rado number*, which we define below.

**Definition 1 [5].** For a given system  $L$  of one or more linear equations, the least positive integer  $n$ , provided that it exists, such that for every  $t$ -coloring of the natural numbers  $\{1, \dots, n\}$  there exists a monochromatic solution to  $L$  is called the  $t$ -color *Rado number* for the system  $L$ . If such an integer  $n$  does not exist, then the  $t$ -color Rado number for the system  $L$  is said to be infinite.

Rado's publications established the existence of finite  $t$ -color Rado numbers for systems of linear equations having certain properties, but, much like Schur's Theorem, Rado said nothing as to the actual value of a Rado number for a system  $L$ .

In order to build to the linear equation whose 2-color Rado number is the result of this paper, we will next trace a series of mathematicians who have, in more recent years, spent time researching and discovering the exact value of Rado numbers for specific families of linear equations. The first such example is that of Albrecht Beutelspacher and Walter Brestovansky. In 1982, Beutelspacher and Brestovansky published the exact formula of the 2-color Rado number for the Schur equation modified with  $m$  variables. That is, Beutelspacher and Brestovansky proved that for every integer  $m \geq 3$ , the equation

$$x_1 + x_2 + \dots + x_{m-1} = x_m$$

has a 2-color Rado number equal to  $m^2 - m - 1$  [5].



Similar to Beutelspacher and Brestovansky, mathematicians S. A. Burr and S. Loo also considered a variation of the classical Schur equation. Burr and Loo considered the addition of an integer constant  $c$  and proved that for every integer  $c \geq 0$ , the equation

$$x_1 + x_2 + c = x_3$$

has a 2-color Rado number equal to  $4c + 5$  [5].

In 1993, these two results were taken together and generalized. Daniel Schaal showed that for every integer  $m \geq 3$  and for every integer  $c \geq 0$ , the equation

$$x_1 + x_2 + \dots + x_{m-1} + c = x_m$$

has a 2-color Rado number equal to  $m^2 - m - 1 + c(m + 1)$  if  $m$  is odd or  $c$  is even and an infinite 2-color Rado number if  $m$  is even and  $c$  is odd [5].

Next in the sequence of modifications considered, the 2-color Rado number for the same generalized equation was determined for when the integer constant  $c$  is negative. Wojciech Kosek and Daniel Schaal discovered a formula for the 2-color Rado number for the equation

$$x_1 + x_2 + \dots + x_{m-1} + c = x_m$$

for every integer  $m \geq 3$  and for every integer  $c$ . In this instance, if  $m$  is even and  $c$  is odd, the 2-color Rado number is still infinite. If  $m$  is odd or  $c$  is even, the 2-color Rado number depends upon the value of  $c$ . For  $c > 2 - m$ , the 2-color Rado number corresponds with earlier results for positive  $c$  and is equal to  $m^2 - m - 1 + c(m + 1)$ . For  $-(m - 1)(m - 2) \leq c \leq 2 - m$ , the 2-color Rado number becomes quite irregular. Kosek and Schaal provide a table of these irregular Rado numbers in [3], but because the exact values are not necessary to the results of this paper, that table is not replicated here. Finally for  $c < -(m - 1)(m - 2)$ , the 2-color Rado number is equal to  $\left\lceil \frac{1-c(m+1)}{m^2-m-1} \right\rceil$  [3]. Recall that the notation  $\lceil x \rceil$  is a ceiling function that maps  $x$  to the least integer that is greater than or equal to  $x$ .

We have now developed the necessary background knowledge to consider a natural variation to the classical Rado numbers. Historically, Ramsey theorists searched for Rado numbers among colorings of the natural numbers beginning at 1, but only in the last few years have any mathematicians examined Rado numbers among colorings of the real numbers beginning at 1. It may be helpful to also formally define this concept.

**Definition 2.** For a given system  $L$  of one or more linear equations, the least real number  $a$ , provided that it exists, such that for every  $t$ -coloring of the real numbers  $[1, a]$  there exists a monochromatic solution to  $L$  is called the  $t$ -color real number Rado number for the system  $L$ . If such a real number  $a$  does not exist, then the  $t$ -color real number Rado number for the system  $L$  is said to be infinite.

It may be interesting to note that every solution to a system  $L$  of linear equations consisting of natural numbers is also a solution to  $L$  in the real numbers, so it follows that the real number Rado number for  $L$  is less than or equal to the classical Rado number for  $L$ . In this paper, we focus on the following equation and use the notation for the 2-

color real number Rado number also defined below.

**Definition 3.** For every integer  $m \geq 3$  and every real number  $c$ , let  $L(m, c)$  represent the system consisting of the single equation

$$L(m, c): x_1 + x_2 + \dots + x_{m-1} + c = x_m.$$

**Definition 4.** For every integer  $m \geq 3$  and every real number  $c$ , let  $r_{\mathbb{R}}(m, c)$  represent the 2-color real number Rado number for the equation  $L(m, c)$ .

Notice that  $L(m, c)$  is the same equation whose classical Rado number was most recently and completely considered by Kosek and Schaal.

## MAIN RESULTS

It is now our intent to prove the following original theorem using the method of the finite sufficient set.

**Theorem.** For every integer  $m \geq 3$  and every real number  $c$ ,

$$r_{\mathbb{R}}(m, c) = \begin{cases} m^2 - m - 1 + c(m + 1) & \text{for } c \geq 2 - m \\ \frac{1 - c(m + 1)}{m^2 - m - 1} & \text{for } c < 2 - m. \end{cases}$$

*Proof.* Let an integer  $m \geq 3$  and a real number  $c$  be given. If  $c = 2 - m$ , then  $x_1 = x_2 = \dots = x_m = 1$  would be a solution to  $L(m, c)$  and this solution would be monochromatic because only one real number is colored. Therefore, for  $c = 2 - m$ , we are guaranteed a monochromatic solution once the real number 1 is colored and  $r_{\mathbb{R}}(m, c) = 1$ . Also note when  $c = 2 - m$ , that  $m^2 - m - 1 + c(m + 1) = 1$  and  $\frac{1 - c(m + 1)}{m^2 - m - 1} = 1$ , so in the statement of the theorem, either case could include the equality. We will now consider the two cases of  $c > 2 - m$  and  $c < 2 - m$ .

**Case 1:** Assume  $c > 2 - m$ .

*Lower Bound:* We will first show that

$$r_{\mathbb{R}}(m, c) \geq m^2 - m - 1 + c(m + 1)$$

by exhibiting a 2-coloring of the interval  $[1, m^2 - m - 1 + c(m + 1))$  that avoids a monochromatic solution to  $L(m, c)$ .

Let a function  $\Delta: [1, m^2 - m - 1 + c(m + 1)) \rightarrow \{0, 1\}$  be defined by

$$\Delta(x) = \begin{cases} 0 & \text{for } 1 \leq x < m - 1 + c \\ 1 & \text{for } m - 1 + c \leq x < (m - 1 + c)(m - 1) + c \\ 0 & \text{for } (m - 1 + c)(m - 1) + c \leq x < m^2 - m - 1 + c(m + 1). \end{cases}$$

Notice that  $\Delta$  maps every real number  $x \in [1, m^2 - m - 1 + c(m + 1))$  to either color 0 or color 1.

To see that  $\Delta$  avoids a monochromatic solution to  $L(m, c)$ , let  $x_1, x_2, \dots, x_m \in$

$[1, m^2 - m - 1 + c(m + 1)]$  be a solution to  $L(m, c)$ .

If  $\Delta(x_1) = \Delta(x_2) = \dots = \Delta(x_{m-1}) = 1$ , then  $x_m = \sum_{i=1}^{m-1} x_i + c \geq (m - 1 + c)(m - 1) + c$ . Therefore  $\Delta(x_m) = 0$ , and we have avoided a monochromatic solution to  $L(m, c)$ .

Now if  $\Delta(x_1) = \Delta(x_2) = \dots = \Delta(x_{m-1}) = 0$ , there are two cases. If  $x_1, x_2, \dots, x_{m-1} < m - 1 + c$ , then  $m - 1 + c \leq x_m < (m - 1 + c)(m - 1) + c$ . Therefore,  $\Delta(x_m) = 1$  and we have avoided a monochromatic solution to  $L(m, c)$ . Secondly, it is not possible for  $x_i \geq (m - 1 + c)(m - 1) + c$  for even one  $i \in \{1, 2, \dots, m - 1\}$  because then we would have  $x_m \geq m^2 - m - 1 + c(m + 1)$  and  $x_m \notin [1, m^2 - m - 1 + c(m + 1)]$ .

Hence  $\Delta: [1, m^2 - m - 1 + c(m + 1)] \rightarrow \{0, 1\}$  as defined above is a 2-coloring that avoids a monochromatic solution to  $L(m, c)$ . We may conclude  $r_{\mathbb{R}}(m, c) \geq m^2 - m - 1 + c(m + 1)$ .

*Upper Bound:* We will next show that

$$r_{\mathbb{R}}(m, c) \leq m^2 - m - 1 + c(m + 1)$$

by demonstrating that an arbitrary 2-coloring of the interval  $[1, m^2 - m - 1 + c(m + 1)]$  must contain a monochromatic solution to  $L(m, c)$ .

Let a function  $\Delta: [1, m^2 - m - 1 + c(m + 1)] \rightarrow \{0, 1\}$  be an arbitrary 2-coloring. Without loss of generality, we may assume  $\Delta(1) = 0$ .

Because  $x_1 = x_2 = \dots = x_{m-1} = 1$  and  $x_m = m - 1 + c$  is a solution to  $L(m, c)$ , we know that if  $\Delta(m - 1 + c) = 0$ , then we have a monochromatic solution to  $L(m, c)$ . Therefore we may also assume  $\Delta(m - 1 + c) = 1$ .

Now because  $x_1 = x_2 = \dots = x_{m-1} = m - 1 + c$  and  $x_m = (m - 1 + c)(m - 1) + c$  is a solution to  $L(m, c)$ , we know that if  $\Delta((m - 1 + c)(m - 1) + c) = 1$ , then we have a monochromatic solution to  $L(m, c)$ . Therefore we may also assume  $\Delta((m - 1 + c)(m - 1) + c) = 0$ .

Next because  $x_1 = 1, x_2 = x_3 = \dots = x_{m-1} = m + c(m - 1)/(m - 2)$ , and  $x_m = (m - 1 + c)(m - 1) + c$  is also a solution to  $L(m, c)$ , we know that if  $\Delta(m + c(m - 1)/(m - 2)) = 0$ , then we have a monochromatic solution to  $L(m, c)$ . Therefore we may now assume

$$\Delta\left(m + \frac{c(m - 1)}{m - 2}\right) = 1.$$

Finally because  $x_1 = (m - 1 + c)(m - 1) + c, x_2 = x_3 = \dots = x_{m-1} = 1$ , and  $x_m = m^2 - m - 1 + c(m + 1)$  is a solution to  $L(m, c)$ , we know that if  $\Delta(m^2 - m - 1 + c(m + 1)) = 0$ , then a monochromatic solution to  $L(m, c)$  exists. Similarly, because  $x_1 = m - 1 + c, x_2 = x_3 = \dots = x_{m-1} = m + c(m - 1)/(m - 2)$ , and  $x_m = m^2 - m - 1 + c(m + 1)$  is also a solution to  $L(m, c)$ , we know that if  $\Delta(m^2 - m - 1 + c(m + 1)) = 1$ , then again a monochromatic solution to  $L(m, c)$  exists. Since for either

value of  $\Delta(m^2 - m - 1 + c(m + 1))$  we have a monochromatic solution to  $L(m, c)$ , we may conclude

$$r_{\mathbb{R}}(m, c) \leq m^2 - m - 1 + c(m + 1).$$

Because we have previously shown that  $r_{\mathbb{R}}(m, c) \geq m^2 - m - 1 + c(m + 1)$ , we have now proven that

$$r_{\mathbb{R}}(m, c) = m^2 - m - 1 + c(m + 1).$$

**Case 2:** Assume  $c < 2 - m$ . For clarity, let  $a = \frac{1-c(m+1)}{m^2-m-1}$ .

*Lower Bound:* We will first show that

$$r_{\mathbb{R}}(m, c) \geq a$$

by exhibiting a 2-coloring of the interval  $[1, a)$  that avoids a monochromatic solution to  $L(m, c)$ .

Let a function  $\Delta: [1, a) \rightarrow \{0,1\}$  be defined by

$$\Delta(x) = \begin{cases} 0 & \text{for } 1 \leq x < a(m-1)^2 + mc \\ 1 & \text{for } a(m-1)^2 + mc \leq x < a(m-1) + c \\ 0 & \text{for } a(m-1) + c \leq x < a. \end{cases}$$

Notice that  $\Delta$  maps every real number  $x \in [1, a)$  to either color 0 or color 1.

To see that  $\Delta$  avoids a monochromatic solution to  $L(m, c)$ , let  $x_1, x_2, \dots, x_m \in [1, a)$  be a solution to  $L(m, c)$ .

If  $\Delta(x_1) = \Delta(x_2) = \dots = \Delta(x_{m-1}) = 1$ , then  $x_m = \sum_{i=1}^{m-1} x_i + c < a(m-1)^2 + mc$ . Therefore  $\Delta(x_m) = 0$ , and we have avoided a monochromatic solution to  $L(m, c)$ .

Now if  $\Delta(x_1) = \Delta(x_2) = \dots = \Delta(x_{m-1}) = 0$ , there are two cases. If  $x_1, x_2, \dots, x_{m-1} \geq a(m-1) + c$ , then  $a(m-1)^2 + mc \leq x_m < a(m-1) + c$ . Therefore  $\Delta(x_m) = 1$  and we have avoided a monochromatic solution to  $L(m, c)$ . Secondly, it is not possible for  $x_i < a(m-1)^2 + mc$  for even one  $i \in \{1, 2, \dots, m-1\}$  because then we would have  $x_m < 1$  and  $x_m \notin [1, a)$ .

Hence  $\Delta: [1, a) \rightarrow \{0,1\}$  as defined above is a 2-coloring that avoids a monochromatic solution to  $L(m, c)$ . We may conclude

$$r_{\mathbb{R}}(m, c) \geq a.$$

*Upper Bound:* We will next show that

$$r_{\mathbb{R}}(m, c) \leq a$$

by demonstrating that an arbitrary 2-coloring of the interval  $[1, a]$  must contain a monochromatic solution to  $L(m, c)$ .

Let a function  $\Delta: [1, a] \rightarrow \{0,1\}$  be an arbitrary 2-coloring. Without loss of generality, we may assume  $\Delta(a) = 0$ .

Because  $x_1 = x_2 = \dots = x_{m-1} = a$  and  $x_m = a(m-1) + c$  is a solution to  $L(m, c)$ , we know that if  $\Delta(a(m-1) + c) = 0$ , then we have a monochromatic solution to  $L(m, c)$ . Therefore we may also assume  $\Delta(a(m-1) + c) = 1$ .



Now because  $x_1 = x_2 = \dots = x_{m-1} = a(m-1) + c$  and  $x_m = a(m-1)^2 + mc$  is a solution to  $L(m, c)$ , we know that if  $\Delta(a(m-1)^2 + mc) = 1$ , then we have a monochromatic solution to  $L(m, c)$ . Therefore we may also assume  $\Delta(a(m-1)^2 + mc) = 0$ .

Next because  $x_1 = a$ ,  $x_2 = x_3 = \dots = x_{m-1} = am + c(m-1)/(m-2)$ , and  $x_m = a(m-1)^2 + mc$  is also a solution to  $L(m, c)$ , we know that if  $\Delta(am + c(m-1)/(m-2)) = 0$ , then we have a monochromatic solution to  $L(m, c)$ . Therefore we may now assume

$$\Delta\left(am + \frac{c(m-1)}{m-2}\right) = 1.$$

Finally because  $x_1 = a(m-1)^2 + mc$ ,  $x_2 = x_3 = \dots = x_{m-1} = a$ , and  $x_m = 1$  is a solution to  $L(m, c)$ , we know that if  $\Delta(1) = 0$ , then a monochromatic solution to  $L(m, c)$  exists. Similarly, because  $x_1 = a(m-1) + c$ ,  $x_2 = x_3 = \dots = x_{m-1} = am + c(m-1)/(m-2)$ , and  $x_m = 1$  is also a solution to  $L(m, c)$ , we know that if  $\Delta(1) = 1$ , then again a monochromatic solution to  $L(m, c)$  exists. Since for either value of  $\Delta(1)$  we have a monochromatic solution to  $L(m, c)$ , we may conclude  $r_{\mathbb{R}}(m, c) \leq a$ .

Because we have previously shown that  $r_{\mathbb{R}}(m, c) \geq a$ , we have now proven that

$$r_{\mathbb{R}}(m, c) = a = \frac{1 - c(m+1)}{m^2 - m - 1}.$$

The proof is complete.

After the author of this paper had first written the proof printed above, it came to the author's attention that mathematicians Caitlin Brady and Ruth Haas had already published a theorem and valid proof for the case in which  $c \geq 2 - m$  [1]. However, because the theorem printed above and the proof for the case in which  $c < 2 - m$  represent original work of Melanie Zinter and Daniel Schaal that has never before been published in a mathematics journal, Zinter and Schaal submitted a draft of the theorem and the proof for the case in which  $c < 2 - m$  to a mathematics journal. That paper was accepted and has appeared in the 2010 volume of *Congressus Numerantium* [6].

## ACKNOWLEDGEMENTS

This material is based upon work supported by the NASA South Dakota Space Grant Consortium.

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# "Born Again Hard": Sexualized Violence in the Creation of American Warriors

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## INTRODUCTION

Cultures are built upon myths that reinforce and glorify the way citizens wish to view themselves as part of a larger, stronger whole. These myths are central to the strength of a culture due to the shared sense of greatness, responsibility, and cohesion mutual belief instills. Globally, examples of cultural myth include French elegance, Arabic divine religious sanction, and British diplomatic proficiency. Specifically American mythology includes the pioneer mentality, equality for all citizens, and global caretaker. These myths, as with those of other countries, were born of historic actuality or ideology. The basis for each of these American myths, however, is the embedded, overarching myth of the American warrior. The myth of the uniquely American warrior, rather than European warrior mythology, is rooted in the militia man of the Revolutionary War. The militia man was a citizen called upon to serve his belief in the "new" American ideal of democracy. After the Revolutionary War, American warriors were men who served their country by protecting their families during the westward expansion of the United States, often in conjunction with, or in addition to, military service. As American civilization has progressed, the need for each household to have its own warrior-protector has been negated, and the warrior role has shifted from the social realm of individual citizens to the specific, specialized realm of soldiers in the armed forces. The creation of warriors in this new esoteric realm requires that warriors be constructed to meet rigid standards of physical prowess, belief, and behavior. Specifically, the American warrior should be in superior physical condition, uphold American beliefs of cultural and social supremacy, and act according to the highest moral and ethical standards. The inherent conflict of this idealized construction requires that American citizens who desire to become warrior-soldiers be reborn through the extremely violent, and explicitly sexual, purgatory of military training. This rebirth and its negative effects upon American warriors and culture is elegantly illustrated in contemporary American war film and literature such as Stanley Kubrick's 1987 film *Full Metal Jacket*, Wallace Terry's oral history collection of Vietnam veterans *Bloods*, and Anthony Swofford's 2003 Gulf War I memorandum *Jarhead*.<sup>1</sup>

Kubrick's film investigates the role of sexualized violence in the creation of the ultimate American warrior, the Marine, through the interaction of Gunnery Sergeant Hartman and

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<sup>1</sup> Stanley Kubrick co-wrote the screen play for *Full Metal Jacket* with Michael Herr whose book, *Dispatches*, is based on Herr's experiences as a reporter in Vietnam. The character of Joker and second portion of the film draw heavily from *Dispatches*, often using the exact dialogue and similar scenes. Herr will be cited as the author though the quotes appear in the film.

Gomer Pyle in the basic training section, and Joker and Animal Mother during the Vietnam (Tet Offensive) sequence<sup>2</sup>. The opening scenes of *Full Metal Jacket* indoctrinates the recruits, as well as the viewer, into the military environment by erasing their individuality through physical conformity. Their hair is cut to match, their dress is identical, and their quarters are devoid of any personal touches or differentiating factors. The effect of this studied stripping away is to render the recruits *tabulae rasa*: blank slates to be re-born into Marines. Gunnery Sergeant Hartman, splendidly acted by actual Drill Instructor R. Lee Erney, masterfully breaks down the mental structures of his "maggots" by verbally insulting their sexual proclivities and personal beliefs, in many cases even renaming the recruits as he sees fit—thus depriving them of their last link to the outside world.<sup>3</sup> The effect of this conditioning is to force the recruits to rely solely upon Hartman for validation, erasing their familial and social ties to the outside world. In short, they have been reborn into the Marine Corps with Hartman serving as a hyper-sexualized parental figure.

Hartman's position of ultimate authority allows him to violently condition the recruits, mentally and physically, into hardened Marines. Sexuality lies at the heart of this conditioning, as emphasized by his repeated references to "pussy," homosexual acts, and the weakness of the female sex, referred to collectively as "Mary Jane Rottencrotch."<sup>4</sup> Hartman equates weakness in any form with the female sex, suggesting that the only way for the recruits to become "men" is to adopt his system of beliefs.<sup>5</sup> This point is laboriously illustrated by Kubrick during the basic training sequences of naming and sleeping with their rifles, "the only pussy you people are going to get," and the equation of rifle and penis while marching, hand on crotch, and reciting, "This is my rifle. This is my gun. This is for fighting. This is for fun."<sup>6</sup> The equation of sexual aggression and violence suggested in this scene is reinforced by the fact that the only women to appear in *Full Metal Jacket* are hookers during the Vietnam sequence. This portrayal of women as only acceptable for sexual release objectifies the female gender, suggesting and excusing violent treatment of anything feminine due to their role as "lesser" or "weaker" beings.

While the rifle as phallus is a standard gender symbol, Kubrick uses this symbolism creatively to illustrate the transformation of Private Pyle (Vincent D'Onofrio) from weak to hardened Marine. Paul Williams's essay entitled "'What a Bummer for the Gooks': Representations of White American Masculinity and the Vietnamese in the Vietnam War Film Genre 1977–87" provides an excellent discussion of Pyle's deviant role within the Marine Corps family. Pyle begins the film as an inept, overweight disgrace to the Marine Corps summed up by Williams as ". . . a 'disgusting fatbody', [who] betrays white racial virility. He obstructs the Marine Corps' production of 'indestructible men'. . .'"<sup>7</sup> Pyle's continual failure at physical training and mental ineptitude, showcased during practice of close order drill, set him apart from the other Marines, branding him a deviant due to his inability to conform and endangering group cohesion.<sup>8</sup> Under the tutelage of Joker, Pyle makes great strides; but it is not until the platoon as a whole turns against him and delivers a "motivational" beating that Pyle is able to be re-born "hard."

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<sup>2</sup> *Full Metal Jacket*, DVD, directed by Stanley Kubrick (Burbank: Warner Brothers, 1987).

<sup>3</sup> *Ibid.*

<sup>4</sup> *Ibid.*

<sup>5</sup> *Ibid.*

<sup>6</sup> *Ibid.*

The sexual aspects of this scene are not subtle: dim lighting, restraint, heavy breathing, underclothes, and Joker's (supposedly Pyle's friend) obvious satisfaction at having delivered the final blow, all suggest sexual sadism.<sup>9</sup> This scene reinforces Hartman's powerful parental position, this action is a result of his subtle suggestion that the other recruits were not providing Pyle with the proper motivation, further bonding the platoon as a family through coordinated violence. Pyle's transformation into a hard soldier is completed when he is accepted by Hartman after becoming an excellent marksman, outshooting all in the platoon, and mastering close order drill. Hartman delivers praise, in the form of a sexual pun, after Pyle is able to recite a general order, which all Marines are supposed to memorize, Joker has forgotten: "Private Pyle, you are definitely born again hard."<sup>10</sup> Hartman's use of the word "hard" to describe Pyle suggests that he has achieved masculine virility under Hartman's instruction in addition to his physical (hardened) transformation and mental mastery of Marine Corps general orders. Pyle's mastery of his rifle symbolizes his mastery of himself, stripping away feminine weakness and mental ineptitude to reveal a potent hard-body and a mind capable of precision killing. The American warrior.

Hartman's death is significant; in the process of recreating Pyle, he, ironically, trained his own killer. The murder/suicide scene is rife with sexual connotation similar to the set up of the "motivational" beating. The backlighting of the men's scantily clad, hardened physiques reinforces Pyle's physical transformation as he delivers Hartman's oedipal death sentence with his rifle/phallus, essentially killing his father and fornicating with his mother in one fell stroke. Pyle's immediate suicide is also blatantly sexual as he orally embraces the weapon he loves, and that made him a man, as the means of eliminating the deviance he has recognized within himself.<sup>11</sup>

Kubrick's jarring transition from Pyle's suicide to Vietnam combat fails to allow the viewer an opportunity to reflect on Pyle's rejection of himself as a creation of sexually violent Marine Corps training. The training methods used to reform Pyle's mind and body resulted in violent rejection of himself and the murder of Hartman, whom Pyle deemed responsible for his learned deviance. Joker's failure to address the implications of Pyle's death suggests that he has become numbed to violence because he does not care enough about Pyle, to whom he became a surrogate older brother, to contemplate the reasoning behind Pyle's actions. Though the audience is supposed to be following Joker's narrative transformation, one became deeply involved with Pyle through his trials, which leaves the viewer with a sense of alienation from Joker. Kubrick may have meant this transition to impart the inevitability of war and the life-goes-on mentality of the Corps, but, more importantly, by choosing to sweep Pyle aside, he emphasizes the incredible level of psychological numbing basic training achieves.

Kubrick develops Joker through his portrayal as an "everyman," to whom the viewer can relate; who also happens to be intelligent enough to understand what is going on around him. However, Joker's inability, or unwillingness, to take counter action suggests that he has

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<sup>7</sup> Paul Williams, "What a Bummer for the Gooks": Representations of White American masculinity and the Vietnamese in the Vietnam War Film Genre 1977-87," *European Journal of American Culture* 22, Issue 3 (2003): 233.

<sup>8</sup> *Ibid.*

<sup>9</sup> Full Metal Jacket.

<sup>10</sup> *Ibid.*

<sup>11</sup> Williams, 233.

become deviant through training in his acceptance of sexually violent ideals and the psychological numbing he exhibits after Pyle's suicide.<sup>12</sup> Joker, as noted by Claude J. Smith, Jr., in his article entitled "Full Metal Jacket and the Beast Within," is constructed in such a way that he "should be the voice of acerbic reason," providing a scathing critique of the physical and mental conditioning he has endured and that is responsible for Pyle's suicide.<sup>13</sup> Joker's confused identity exploration occurs during the Vietnam sequence of the film in contrast to Animal Mother, who takes the place of Hartman as the oppositional character.<sup>14</sup> Joker ought to represent humanity surviving vicious conditioning, but his words and actions belie this ideal. He cannot divorce his humanitarian impulses from his warrior training, stating: "I wanted to be the first kid on my block to get a confirmed kill!" while, simultaneously, wearing a peace symbol and expressing a desire to explore the "duality of man."<sup>15</sup>

Joker embraces the sexually violent attitude toward women learned in basic training, legitimizing their objectification during the Tet Offensive portion of the film. Through his language, "Ya know, half of these gook whores are serving officers in the Viet Cong; the other half have got T.B. Be sure you only fuck the ones that cough," and his lack of reaction, psychological numbing, to the door gunner who proudly shoots women and children to "Get Some!" violent sexual satisfaction Joker rejects the humanity of women and illustrates his acceptance of their characterization as "weak."<sup>16</sup> Joker further demonstrates the effectiveness of sexually violent training by being more than willing to purchase a Vietnamese hooker and haggling about the prices in Da Nang and taking part in the platoon wide recreational use of a conveniently appearing hooker during a break in the combat sequence.<sup>17</sup> What appears as his crowning humanitarian action, the mercy killing of the female sniper, is in fact violent sexual satisfaction—she is quite literally begging for it—and he inducts himself into warrior culture by satisfying her desire for death and his own desire to be a "killer."<sup>18</sup>

In contrast, Animal Mother appears to be the cookie cutter construction of a Marine: "The Marine Corps does not want robots. The Marine Corps wants killers. The Marine Corps wants to build indestructible men, men without fear."<sup>19</sup> He has been mentally and physically engineered through training and combat into a hard-bodied and unquestioning killer. Animal Mother provides an example of the effects of sexually violent conditioning through his treatment of the hooker, "I'll skip the foreplay," reinforcing the bestial nature created by this training.<sup>20</sup>

However, the viewer must question this interpretation due to the fact that Animal Mother quite obviously realizes exactly what he is, evidenced by his comment during the discussion of American engagement in Vietnam: "This isn't about freedom; this is a slaughter. If I'm gonna get my balls blown off for a word, my word is 'poontang'."<sup>21</sup> This comment underlines his realization of his own insignificance, and that of idealized beliefs within this environment, resulting in his eschewing of humanity for sexual gratification.

<sup>12</sup> Claude J. Smith, "Full Metal Jacket and the Beast Within," *Literature Film Quarterly* 16, no. 4 (1988): 228.

<sup>13</sup> *Ibid.*

<sup>14</sup> *Ibid.*

<sup>15</sup> *Full Metal Jacket*.

<sup>16</sup> *Full Metal Jacket* and Herr, 35.

<sup>17</sup> Michael Herr, *Dispatches*, (New York: Vintage, 1977), 40.

<sup>18</sup> *Full Metal Jacket*.

<sup>19</sup> *Ibid.*

<sup>20</sup> *Ibid.*

<sup>21</sup> *Ibid.*

While Kubrick certainly uses Animal Mother to illustrate the inhumanity produced by sexually violent military training, his function is not simply that of a bestial warrior. As suggested by the second part of his name, Animal Mother's role includes the parental position of hardened alpha-warrior. Although not the official leader of the platoon, he blatantly ignores orders to leave a fellow Marine behind and goes to the aid of his friend without regard to his own safety in the same manner a parent would to a child. This valorous action brings into sharp focus the intimate bond facilitated by military training and his role as a surrogate parental figure for the men of his platoon. Though he is unable to save his friend/child, he leads the remainder of the platoon into the sniper's lair and exacts revenge by refusing to shoot the female sniper and end her misery. His action is parental revenge and a blatant disavowal of the feminine in his refusal of her satisfaction, highlighting Joker's confused humanitarian/warrior impulses and reinforcing Animal Mother's superiority. Animal Mother is the ultimate warrior, showing courage under fire and respect for the Corps, as evidenced by his participating in a war he obviously does not believe in while respecting his fellow soldiers in combat. Kubrick's portrayal suggests that Animal Mother's inhumanity is superior to Joker's mental moral confusion through his rejection of feminine ideals such as peace and "duality."

*Full Metal Jacket* illustrates sexually violent training methods and the mental and moral confusion resulting from psychological numbing. However, it does not present a complete picture of the ramifications of this type of sexually violent training and objectification of women upon young men freed from social constraint. Wallace Terry's collection of oral histories from Vietnam veterans, entitled *Bloods*, graphically presents the actions of young men who feel entitled to force their sexual desires upon Vietnamese women. Specialist Woodley, Jr., age nineteen at the time, recalled:

One night we were out in the field on maneuvers, and we seen some lights. We were investigating the lights, and we found out it was a Vietn'ese [sic] girl going from one location to another. We caught her and did what they call gang-rape her. She submitted freely because she felt if she had submitted freely that she wouldn't have got killed. We couldn't do anything else but kill her because we couldn't jeopardize the mission . . . So we eliminate her. Cut her throat so you wouldn't be heard . . . This other time we were in a ambush site. This young lady came past. She spotted us. It was too late. We had to keep her quiet. We captured her. We thought, Why kill a woman and you had no play in a couple weeks? We didn't tie her up, because you can't seduce a woman too well when she tied up. So we held her down . . . We found out she was pregnant. Then we raped her. We still had five days to go out there without any radio contact. So we wouldn't let her go. We didn't want the enemy to know we were there. She had to die. But I don't think we murdered her out of malice. I think we murdered her because we didn't want to be captured.<sup>22</sup>

Woodley's account is echoed by several other soldiers', though no one else admitted to participating in a gang rape. Instead, gang rape was accepted as normal, "We passed these two black guys raping a woman at the door of the hootch . . . And the protocol of the folks in my squad was just keep moving, not to interfere, everything was all right."<sup>23</sup> Susan Jeffords,

<sup>22</sup> Specialist 4 Arthur E. "Gene" Woodley, Jr., in *Bloods*, ed. Wallace Terry (New York: Ballantine, 1984), 247-248.

<sup>23</sup> Specialist 4 Haywood T. Kirkland, in *Bloods*, ed. Wallace Terry (New York: Ballantine, 1984), 93.



in her book *The Remasculinization of America: Gender and the Vietnam War*, explains gang rape and its acceptance as: “. . . combin[ing] collectivity and display as the masculine bond performs as a group, with itself as audience . . . raping and watching others rape leaves no position for any other action within the bond; if you challenge the rape you risk being rejected by the collective.”<sup>24</sup> A soldier cannot afford to be rejected by his peers because his life may well depend on them. The necessity for maintaining group cohesion forced officers to allow sexual violence, as noted by Specialist 5 Emmanuel J. Holloman:

A lot of time they raped the women in the villages they were suppose [*sic*] to be protecting. That happened quite a bit, and nobody said anything about it. Even the lieutenant who was in charge of a platoon let it happen. He’s about their age, not experienced enough to control them. He goes along with it. He’d be crazy if he went against his own platoon. He doesn’t want to criticize his men, he wants one big happy family.<sup>25</sup>

Though some soldiers spoke out against gang rape, most participated because they feared rejection by their peers; this behavior is evidence, and reinforcement, of the sexually violent training and objectification of women the men received at boot camp which complicated their repatriation into American society after coming home.

American society demands the creation of warriors through sexually violent military training to support the American Warrior myth. These soldiers are excellent warriors, but socially stunted after their service because of this training. Their rebirth through sexually violent basic training and subsequent violent experiences has trained them for death, not life. Robert Jay Lifton’s book, *Home From the War: Learning from Vietnam Veterans*, discusses the experiences of Vietnam veterans upon returning home and attempting to repatriate into American society, as well as their feelings and attitudes toward the Vietnam War. The experiences of Vietnam veterans, drug and alcohol use and abuse, chronic unemployment, and societal exclusion, are familiar themes within this work, nicely summarized by Lifton’s quote from Charles Omen: “the best of soldiers while the war lasted . . . [but] a most dangerous and unruly race in times of truce or peace.”<sup>26</sup>

The “danger” of these warriors lies not only in their training, but also in the guilt they carry, which defines their relationships after returning home. Lifton defines this guilt as specific to the Vietnam War: “The American survivor of Vietnam carries within himself the special taint of his war. His taint has to do with guilt evoked by death.”<sup>27</sup> Death guilt is experienced by veterans not only in relation to their actions while in Vietnam. Death guilt, combined with sexually violent training methods, left Vietnam veterans unable to form romantic attachments, in the words of one returned soldier: “If I’m fucking, and a girl says I love you, then I want to kill her . . . [because] if you get close . . . you get hurt.”<sup>28</sup> The possibility of love was terrifying to these men due to their trained rejection of the feminine and the weakness they feared would result from decreased psychological numbing, summarized by Lifton as “Love or intimacy . . . posed the threat of corruption and

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<sup>24</sup> Susan Jeffords, *The Remasculinization of America: Gender and the Vietnam War*, (Bloomington: Indiana University Press, 1989), 69.

<sup>25</sup> Specialist 5 Emmanuel J. Holloway, in *Bloods*, ed. Wallace Terry (New York: Ballantine, 1984), 83.

<sup>26</sup> Robert J. Lifton, *Home From the War: Learning from Vietnam Veterans* (New York: Other, 2005), 39.

<sup>27</sup> *Ibid.*, 99.

<sup>28</sup> *Ibid.*, 271.

disillusionment, of still another 'death.'<sup>29</sup> These soldier's actions, experiences, and guilt went on to influence the next generation of warriors through their personal, family experiences and the legacy of film and literature inspired by the Vietnam War.

Anthony Swofford's 2003 memoir, *Jarhead*, highlights the burden the next generation carried in relation to the unsatisfactory outcome of Vietnam and the social confusion that resulted from sexually violent training methods. Swofford's father was career Air Force and served in Vietnam, about which "he only spoke once," and suffered from mysterious ailments during Swofford's childhood, migraines and myotonic dystrophy of the hands, that Swofford believes to be directly related to his father's refusal to obtain psychiatric help after returning from Vietnam.<sup>30</sup>

Swofford's childhood was lived in the expectation that he would join the military as a means of fulfilling his initiatory rite of passage; an expectation his father attempts to derail by refusing to sign a contract allowing him to enlist early, stating: "As soon as you can sign that contract on your own, go ahead. Until then I am responsible for you . . . I know some things about the military that they don't show you in the brochures."<sup>31</sup> Swofford ignores this advice, undoubtedly based on his father's knowledge of the training he would undergo, and joins the Marines at seventeen and half as part of the generation living the legacy of Vietnam.

*Jarhead* provides a real-life perspective in relation to and building upon the sexually violent training Kubrick showcased in *Full Metal Jacket*. Unlike *Full Metal Jacket*, Swofford's narrative does not unfold chronologically from his induction into basic training. Instead, the reader is given the introductory image of an older Swofford remembering his Marine service, no longer hard bodied, but able to tell his story in a way that he could not have when he was closer to it. His careful attention during the introductory chapter to inform the reader that he cannot tell what is "true nor false but *what I know*" lends credibility, because he does not pretend to have discovered answers or meaning in his experience, leaving the burden of interpretation on the reader.<sup>32</sup>

Swofford begins by illustrating the effects of sexually violent Vietnam War films on his generation with the unit activation of Surveillance and Target Acquisition Platoon of the Second Battalion, Seventh Marines (STA 2/7), who immediately "rent all of the war movies they can get their hands on" and "buy a hell of a lot of beer."<sup>33</sup> By his own admission, Swofford and his platoon find themselves entranced and romanced by the war films they watch: "we get off on the various visions of carnage and violence and deceit, the raping and killing and pillaging" because they want to believe that they are akin to the warriors depicted in the films.<sup>34</sup> He further states that they enjoy the films because:

. . . Vietnam films are all pro-war, no matter what the supposed message . . . because the magic brutality of the films celebrates the terrible and despicable beauty of their fighting skills. Fight, rape, war, pillage, burn. Filmic images of death and carnage are pornography for the military man . . . getting him ready for his real First Fuck.<sup>35</sup>

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<sup>29</sup> Ibid.

<sup>30</sup> Anthony Swofford, *Jarhead* (New York: Scribner, 2003), 49.

<sup>31</sup> Ibid., 207.

<sup>32</sup> Swofford, 2.

<sup>33</sup> Ibid., 5.

<sup>34</sup> Ibid., 6.

The violence of these films is explicitly sexual to Swofford and his Marine Corps family in its erotic celebration of their superiority as American warriors. This interpretation reinforces the effectiveness of the mental conditioning, similar to that seen in *Full Metal Jacket*, Swofford received and absorbed during his "birth through the bloody canal of boot camp."<sup>35</sup>

Swofford's mental conditioning included objectification and dehumanization of women, noted in his unabashed recollection of "that special whore."<sup>37</sup> He is able to move beyond objectification in his relationship with Yumiko in Japan and his exchange of letters with Katherine. However, these relationships were doomed from the beginning, either due to rotation out of country or Katherine's engagement. Swofford's relationship with his long time girlfriend, Kristina, reveals his inability to create a true relationship by allowing her to insist they stay together while he knows she is unfaithful. Though he does eventually reject her by taping her picture to the "Wall of Shame," Swofford offers no later evidence that he has been able to eschew his training and hold a meaningful relationship.<sup>38</sup> Swofford exhibits the confusion caused by sexually violent Marine Corps training and the glorification of sexualized violence, as illustrated in popular Vietnam film and narrative, through his failure to form meaningful romantic attachments.

The most explicitly sexual scene in *Jarhead* occurs, not as an obvious rejection of the feminine, but rather an expression of the dehumanization the Marines have undergone as a result of sexually violent mental conditioning. A pick-up game of football in the desert, meant to showcase their physical prowess as highly trained warriors, degenerates into a:

Field Fuck: an act wherein marines violate one member of the unit, typically someone who has recently been a jerk or abused rank or acted antisocial; ignoring the unspoken contracts of brotherhood and camaraderie and esprit de corps and the combat family.<sup>39</sup>

The Marines of Swofford's platoon hold the offender on hands and knees and take turns mock-violating him from behind.<sup>40</sup> The fact that this act does not involve actual sexual contact only makes it more disturbing; the frustration that these men feel at their situation is vented through sexual domination of one of their own. Swofford and his platoon have been taught the same lessons of the recruits in *Full Metal Jacket*, that sexual aggression is an acceptable method of release: ". . . we're angry and afraid and acting the way we've been trained to kill, violently and with no remorse."<sup>41</sup>

The effectiveness of their tactical training is showcased by the successful completion of the Gulf War mission to "liberate" Kuwait; though that success is marred by incidences of friendly, "Fucked Fire."<sup>42</sup> Friendly fire is the result of the need for release after too much build-up time and too little combat action, which is, for these men, a type of sexual frustration.

Marines are trained for combat, and when combat is not forthcoming the eventual release will be more deadly due to the delay. Edward Tick, in his book *War and the Soul*,

<sup>35</sup> Ibid., 5.

<sup>36</sup> Ibid., 43.

<sup>37</sup> Ibid., 174.

<sup>38</sup> Ibid., 92.

<sup>39</sup> Ibid., 20-21.

<sup>40</sup> Ibid.

<sup>41</sup> Ibid., 22.

<sup>42</sup> Ibid., 219.

explains that in war:

The waiting and watching make us wakeful beyond the possibility of sleep . . . Yet though we are on permanent vigilance and cannot rest, days may pass with nothing to do but the most routine tasks. Boredom reaches the extreme and can be worse than battle. We long to break the tedium. Nervousness, grief, rage, and terror need outlets. The only means of release is the gun.<sup>43</sup>

Swofford further explores the situation by stating: "To be a Marine, a true marine, you must kill. With all of your training, all of your expertise, if you don't kill, you're not a combatant . . ."<sup>44</sup> These young men all want to be true Marines; they have been trained until they must expend their aggression. When a combat situation does not materialize, they create one; either through aggression toward their own, Friendly Fire, or a feminine substitute, as is in the case of the "Field Fuck," in an effort to gratify the violent desire their training has instilled.

Swofford, surprisingly, does retain his humanity through his sexually violent training and service in the Marine Corps. Though his ties to his Marine family are arguably stronger than those to his biological family, he is able to see beyond the mental conditioning he has received and view the Iraqi soldiers as human while, also, holding out hope for a "normal" life when he musters out. Regardless of this intact humanity, Swofford carries with him the legacy of his training:

You consider yourself less of a marine and even less of a man for not having killed while in combat. There is a wreck in your head, part of the aftermath, and you must dismantle this wreck . . . It took years for you to understand that the most complex and dangerous conflicts, the most harrowing operations, and the most deadly wars, occur in the head.<sup>45</sup>

Swofford's realization is one that must be taught to American society as a whole: a lesson in the dangers of creating warriors through physical and mental sexualized violence. Once warriors are made, they cannot be unmade into ordinary citizens. They cannot forget the objectification of women and feminization of all things weak. Warriors cannot be turned on and off as needed to serve their country; their country must serve them by refusing to allow the creation of a race of warriors unable to function within the society they have sworn to protect.

It should be no surprise, given the previous examples of sexually violent conditioning and objectification of women, that some male members of the Armed Forces show a greater incidence of spousal violence. This disturbing trend is highlighted by the 2003 study "The Effects of Peer Group Climate on Intimate Partner Violence among Married Male U.S. Army Soldiers" by Leora N. Rosen, Robert J. Kaminski, Angela Moore Parmley, Kathryn H. Knudson and Peggy Fancher. The work of Rosen et al. takes into account factors such as alcohol use, childhood abuse, depression, race, and rank to conclude that the factor with the greatest influence is "a climate of hyper-masculinity, . . . associated with increased IPV [Intimate Partner Violence]."<sup>46</sup> Though a self-reporting study, the effect of hyper-masculine ideals upon the soldier's ability to relate to his family suggests that the creation of American warriors through the use of sexually violent conditioning is deeply damaging to the

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<sup>43</sup> Edward Tick, *War and the Soul*, (Wheaton: Quest, 2005), 26.

<sup>44</sup> *Ibid.*, 247.

<sup>45</sup> *Ibid.*, 247-48.

<sup>46</sup> Leora N. Rosen et al., "The Effects of Peer Group Climate on Intimate Partner Violence among Married Male U.S. Army Soldiers," *Violence Against Women* 9, no.9 (2003):1065.

individual and their role within the society that insisted on their creation.<sup>47</sup> Based upon this study, and investigation of sexually violent conditioning, it is reasonable to conclude that the American system of cultural beliefs based on the warrior myth is self-destructive.

The detrimental nature of current cultural reliance on the outdated American Warrior myth requires a rewriting of these myths to embrace the changing needs and interactions of increasingly global cultures and civilizations. American soldiers can no longer be "like Jolly Green Giants, walking the Earth with guns" reducing all in their path to rubble.<sup>48</sup> Instead, warriors must be conditioned to recognize the humanity within themselves and others as a positive reflection of the ability of a global society to solve its problems with reason and thought, before bullets and bombs. As noted by Anthony Swofford, "Some wars are unavoidable and need well be fought, but this doesn't erase warfare's waste."<sup>49</sup> It is imperative that the waste of warfare not be the humanity of young people through sexually violent training.<sup>50</sup> Sexually violent training also extends "warfare's waste" into the family unit through acts of spousal violence.<sup>51</sup> A culture based upon a myth that is inherently conflicting, the moral killer, and relies upon sexually violent training methods and the objectification of women is not sustainable. Instead, American culture will consume itself while clinging to the brutality of tradition. The glorification of sexualized violence in the film and literature representative of American national myths must be recognized as dangerous to society and rewritten accordingly.

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# Vibrational Analysis of Soloflex Whole Body Vibration Platform

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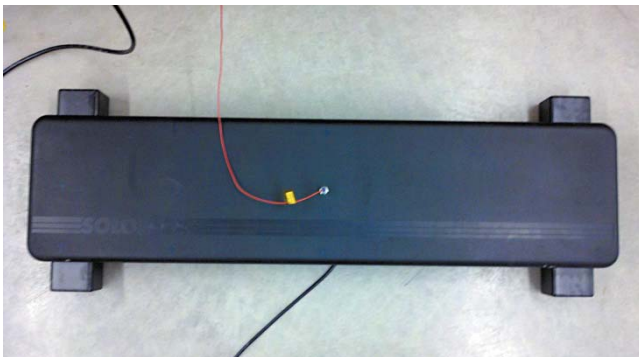
## ABSTRACT

A Soloflex Whole Body Vibration (WBV) Platform was tested for its frequency and magnitude of vibration at multiple settings on the supplied dial. An accelerometer was used to measure the vibrations on different points mapped across the platform. The motor attached to the board was also tested for its frequency using a high-speed camera. The amplitude measurements found from the accelerometer data was compared to the readings on the supplied control module to “calibrate” the platform for medical testing.

*Keywords:* vibration, whole body vibration plate, bone density

## INTRODUCTION

Whole body vibration platforms have become increasingly popular for home use as well as use in gyms for professional athletes. The company leading the market in this area is



Soloflex. Figure 1 below shows the platform that was used for the testing and research.

**Figure 1.** Soloflex Whole Body Vibration Platform

The platform for this project was analyzed for medical research. The platform is going to be used to test the theory that children’s bones stimulated with vibration will gain more



density than children without the same treatment. The plate needs to be analyzed to ensure that the testing is controlled. The testing data was compared to settings printed on the control module supplied with the platform. This was done to ensure the medical researchers know exactly what amplitude and frequency of vibration their test subjects will receive. The tested board will also be used for calibration of other boards used with different test subjects.

## METHODS

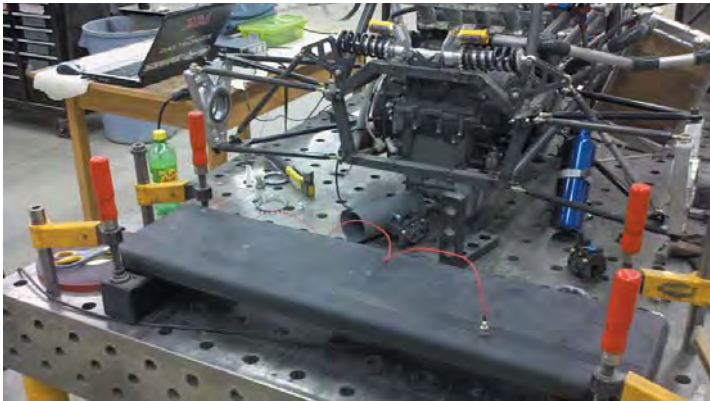
### Materials

The test setup can be seen in the figures below and table 1 shows the equipment and its information. Figure 1 shows the oscilloscope and the signal conditioner used to record the data from the accelerometer. The platform was attached to a heavy table to ensure the board did not move and would not excite what it was resting on. This is shown in figure 2. Finally the control module that was supplied with the board is shown in figure 4.

Equipment			
Type	Brand	Model #	Serial #
Four Channel Digital Storage Oscilloscope	Tektronics	TDS 2024B	C033112
Signal Conditioner	Endevco	133	CB71
Accelerometer	Columbia	5005 HT	1521
Soloflex WBV Platform	Soloflex		



**Table 1.** Equipment [1-3]



**Figure 2.** Signal Conditioner and Oscilloscope



**Figure 3.** WBV Platform Clamped to a Large Fixture Table

**Figure 4.** Supplied Control Module

### *Methods*

The first assumption to simplify and accelerate the test was to consider the vibration of the platform to be symmetrical. Points were then marked on the platform as shown in figure 5 below. The accelerometer was placed at each point and a time history of the vibration was recorded, using the oscilloscope and a signal conditioner, at 3 different settings on the supplied control module: 0.3 g, 0.7 g and 1.0 g. The data taken for each point and each setting was graphed and analyzed to find the magnitude and frequency of the vibration at each point on the board. Because the user would not have their legs spread as far as the grid was made, only points D – L were used in testing.

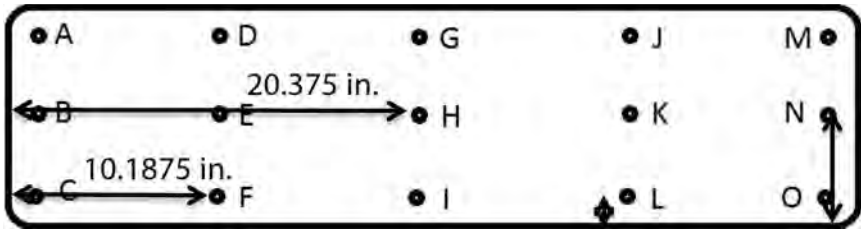


Figure 5. Test Point Map

## RESULTS

The recorded data were compared to the data shown in the FAQ section of the Soloflex website, which is shown below [4]:

- .3 g's = 28 Hz
- .5 g's = 30 Hz
- .7 g's = 35 Hz
- .8 g's = 45 Hz
- .9 g's = 50 Hz
- 1.0 g = 55 Hz
- 1.1 g's = 60 Hz

The data in the tables below shows the recorded data for points E and H of figure 5. These data were compared to the data from the Soloflex website as well as between the two pints themselves.

Dial Setting (g)	Accelerometer Reading (g)	Acceleration % Difference	Accelerometer Frequency (Hz)	Soloflex Frequency (Hz)	Frequency % Difference
0.3	0.16	46.67	40.11	28	43.25
0.5	0.234	53.2	46.59	30	55.3
0.7	0.364	48	46.82	35	33.77
0.8	0.59	26.25	48.79	45	8.42
0.9	0.74	17.78	49.12	50	1.76
1	0.96	4	49.89	55	9.29
1.1	1.01	8.18	50.28	60	16.2

Table 2. Point E Data

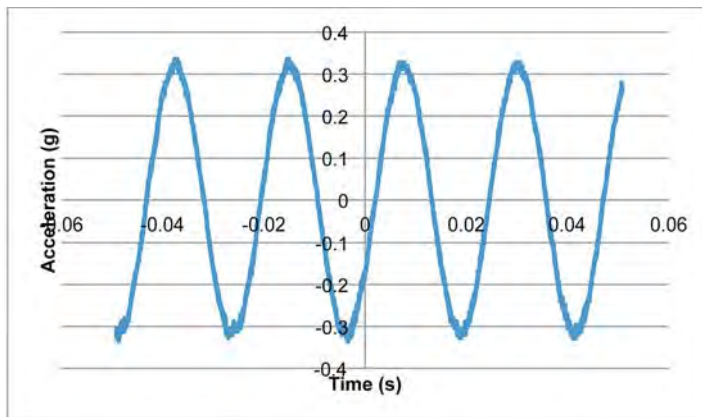
**Table 3.** Point H Data

Dial Setting (g)	Accelerometer Reading (g)	Acceleration % Difference	Accelerometer Frequency (Hz)	Soloflex Frequency (Hz)	Frequency % Difference
0.3	0.16	46.67	40.26	28	43.79
0.5	0.336	32.8	44.37	30	47.9
0.7	0.612	12.57	46.48	35	32.8
0.8	0.92	15	47.54	45	5.64
0.9	1.36	51.11	49.02	50	1.96
1	1.67	67	49.29	55	10.38
1.1	1.75	59.09	49.63	60	17.28

**Table 4.** Comparison of Point E and Point H Data

Dial Setting (g)	Middle Acceleration (g)	Left-Middle Acceleration (g)	Percent Difference
0.3	0.16	0.16	0
0.5	0.336	0.234	30.36
0.7	0.612	0.364	40.52
0.8	0.92	0.59	35.87
0.9	1.36	0.74	45.59
1	1.67	0.96	42.51
1.1	1.75	1.01	42.29

The following two figures are examples of the recorded curves from each test point.



**Figure 6.** Point H 0.5 g Dial Setting

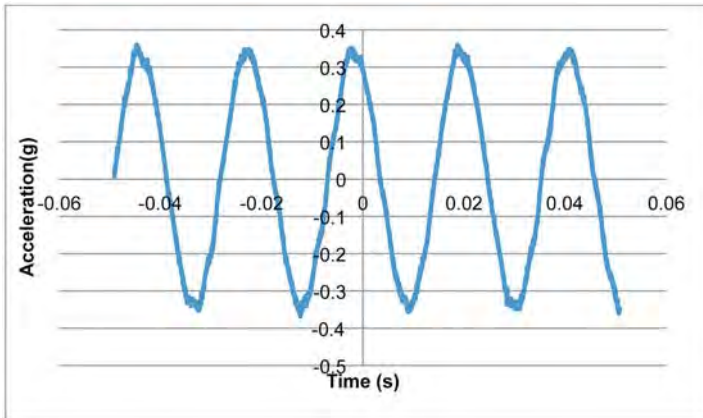


Figure 7. Point E 0.5g Dial Setting

## DISCUSSION

It can be seen in the tables above that the dial settings are inaccurate when compared to the accelerometer data that was recorded. The data for point E was consistently lower than the reading the dial was set to. The point H data was lower until the 0.8 g dial setting and then it became greater. Some dial settings for both points had low differences while some had very great differences.

Comparing the point accelerations to each other shows some great differences but this was to be expected because of factors such as, distance from the motor and distance from the supports.

The frequency readings were calculated from the average period of the recorded vibration wave. These frequency readings, when compared to the Soloflex website data, had very large differences except for the 0.9 g dial setting. The point frequencies, however, were very similar.

## LIMITATIONS

The vibration of the plate would be greatly affected if the same test had been conducted with a mass on the platform.

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# Biosolar Conversion of N<sub>2</sub> and H<sub>2</sub>O to Ammonia by Engineered N<sub>2</sub>-fixing Cyanobacteria

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## ABSTRACT

The cyanobacterium *Anabaena* sp. PCC 7120 is capable of using solar energy to produce ammonia through conversion of atmospheric dinitrogen in differentiated cells called heterocysts. Harnessing this system could enable cyanobacteria to be used in ammonia-fertilizer production, creating a renewable alternative to the current Haber-Bosch process. The genes *patA* and *alr3304* in the *Anabaena* 7120 genome are important in heterocyst formation; an increase in heterocyst formation is seen with over-expression of *patA* or inactivation of *alr3304*. This research aims to create a novel mutant that forms more heterocysts by simultaneously over-expressing *patA* and inactivating *alr3304*, producing higher amounts of ammonia. These two genes were isolated using Polymerase Chain Reaction (PCR) amplification. The resulting amplicons were then inserted into pTOPO 2.1 vectors, creating pZR855 and pZR854, respectively. *PatA* was removed from pZR855 using enzymatic digestion and then ligated into pZR618 to create pZR856, which enabled the successful transformation of NEB 10-beta *Escherichia coli* competent cells with pZR856 and later plasmids. Plasmid pZR857 was created by fusing *patA* from pZR856 to the native *Anabaena* promoter *PpsbA* in pZR811. The 2.7kb fragment *PpsbA-patA* was inserted within *alr3304* in pZR854 to create pZR858, thereby disrupting *alr3304*. PCR and sequencing were used to verify different stages of the plasmid constructions. Results from colony PCR and enzymatic digestion indicated that pZR858 was successfully created. Further progression in this research will potentially create a mutant strain of *Anabaena* 7120 that forms more heterocysts and therefore produces ammonia at a commercially viable level.

## INTRODUCTION

The current process for converting atmospheric nitrogen to ammonia is through a synthetic process known as the Haber-Bosch process. This method utilizes various fossil fuels for energy and involves high temperatures and pressures to create the desired ammonia, which means large energy inputs. In fact, the Haber-Bosch process accounts for more than 1% of the total energy that is used by humans (9). When this energy requirement is broken down to just the fertilizer production market, specifically ammonia production, astonishing results are seen. The energy required to produce ammonia, the main ingredient in almost all nitrogen

fertilizers, is 87% of the energy consumed by the industry (4). To help alleviate the cost of fossil fuel consumption, the Haber-Bosch process has adapted many types of fossil fuels. Oil, coal, and even natural gas are now used in the process of creating ammonia; however, with the rising price of oil and the decreasing availability of petroleum, the cost of energy for making synthetic ammonia will increase dramatically (3).

The enormous requirement of fossil fuels is not the only drawback of the Haber-Bosch process. Along with the energy consumption are the greenhouse gasses (GHGs) produced as byproducts of the ammonia production. These GHGs that are produced include carbon dioxide, methane and nitrous oxide; 98% of the mass emitted is carbon dioxide while 0.6% is N<sub>2</sub>O (11). Both carbon dioxide and nitrous oxide are important factors in global warming. The overall industry produces about 465 Tg CO<sub>2</sub>-eq (Equivalent Carbon Dioxide) through the process of fertilizer manufacturing (4). With the high cost of energy and the environmental impact caused by GHGs, the Haber-Bosch process will need to be retired for a renewable, efficient, and environmentally friendly alternative. A promising candidate is the usage of cyanobacteria, which create ammonia as a product of its metabolism within specially differentiated heterocysts.

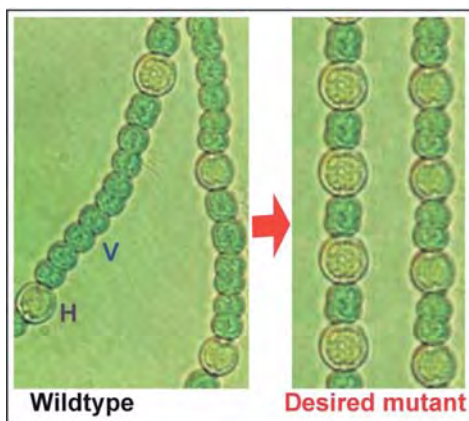
Cyanobacteria are microorganisms that have evolved over billions of years, thus gaining the ability to use solar energy through photosynthesis. This unique organism, specifically *Anabaena* sp. strain PCC 7120, is a filamentous cyanobacterium and has developed a metabolic pathway to create ammonia from atmospheric dinitrogen in specialized cells named heterocysts. These specialized cells create a microoxic environment which allows the O<sub>2</sub>-labile enzyme nitrogenase to convert the dinitrogen to ammonia (1). When environmental ammonia levels become depleted, approximately every tenth vegetative cell differentiates into a heterocyst in order to produce ammonia for surrounding vegetative cells. The necessary nitrogenase is tightly regulated and only made within heterocysts (2).

The regulation of heterocyst formation is still widely being researched, but numerous genes have been identified that play a role in the conversion from vegetative cell to heterocyst. A major controlling factor in the regulation of heterocyst formation, and an intricate part of this research, is *patA*. PatA is one of two necessary proteins for heterocyst formation, mutant *Anabaena* without *patA* showed significant decrease in the ability to form heterocysts (8). The role that PatA plays in the formation of heterocysts is still unanswered. However, Orozco et al. (7) proposes that PatA, HetN, and PatS all play an important role in heterocyst formation and that PatA interacts with both PatS and HetN signaling pathways in a way that overcomes the inhibitory effects of the two pathways on heterocyst formation, both the HetN and PatS pathways caused a decrease in heterocyst formation when *patA* was deleted.

Another gene that plays an important role in heterocyst formation is *alr3304*, which has the ability to prevent heterocyst formation at specific stages of development (10). However, research showed that the silencing of *alr3304* decreases the ratio of vegetative cells to heterocysts, 5.3 in the mutant compared to the wildtype ratio of around 9 (10). Such a result leads to the conclusion that Alr3304 has some inhibitory effect on heterocyst formation. On the contrary, the over-expression of *patA* increases the ratio of heterocysts to vegetative cells (5). Theoretically, the combination of these two mutants could produce a novel *Anabaena* mutant with a higher ratio of heterocysts to vegetative cells than either of the single mutations (desired mutant in Fig. 1).



Overall, by silencing *alr3304* with an insertion of *pata*, the combined over-expression of *pata* and knock-out of *alr3304* could potentially create a strain of *Anabaena* able to form more heterocysts and produce ammonia at a concentration that is commercially viable. Such a mutant could reduce the usage of fossil fuels from the production of ammonia and decrease the GHGs released into the atmosphere by replacing the Haber-Bosch process. This alternative method utilizing cyanobacteria would also be a renewable source of ammonia, powered by clean, cheap, and readily available solar energy.



**Figure 1.** Projected *Anabaena* mutant. The cell indicated by H represents a heterocyst while the cell indicated by V is a vegetative cell. The desired *pata*<sup>+</sup>/*alr3304*<sup>-</sup> *Anabaena* mutant is projected to have a higher ratio of heterocysts as compared to the wildtype and *pata*<sup>+</sup> or *alr3304*<sup>-</sup> mutants.

## METHODS

### *Bacterial Strains and Growth Conditions*

Top10 *Escherichia coli* competent cells were used with pTOPO 2.1 vectors for initial bacterial transformation. Subsequent bacterial transformations utilized NEB 10-beta *E. coli* competent cells. All *E. coli* were grown at 37 °C in a bacterial incubator. Luria Bertani (LB) agar was used for all growth media. Antibiotics were added to the LB agar for selection of transformed *E. coli* in appropriate concentrations. *Anabaena* sp. PCC 7120 was grown at 30 °C in flasks containing AA/8(N) liquid media under fluorescent lights or sunlight.

### *Gene Amplification*

Chromosomal DNA from *Anabaena* 7120 was used in PCR to amplify the genes *pata* (1.2 kb) and *alr3304* (3.0 kb). Specific upstream and downstream primers (Table 1) created by our lab were used to amplify the target sequences. All PCR used the same program parameters of 94 °C to denature the DNA, followed by an annealing temperature of 50 °C,



and the standard Taq DNA Polymerase elongation temperature of 72°C. Gel electrophoresis was used with 0.8% agarose gels containing ethidium bromide (EB). Gels were run at a constant 170mA submerged in 1xTAE using a gel box apparatus. Ultraviolet Violet light imaging of the gels after gel electrophoresis was done to visualize the DNA banding.

**Table 1.** PCR Primers. Primer sequences are listed from 5' to 3'.

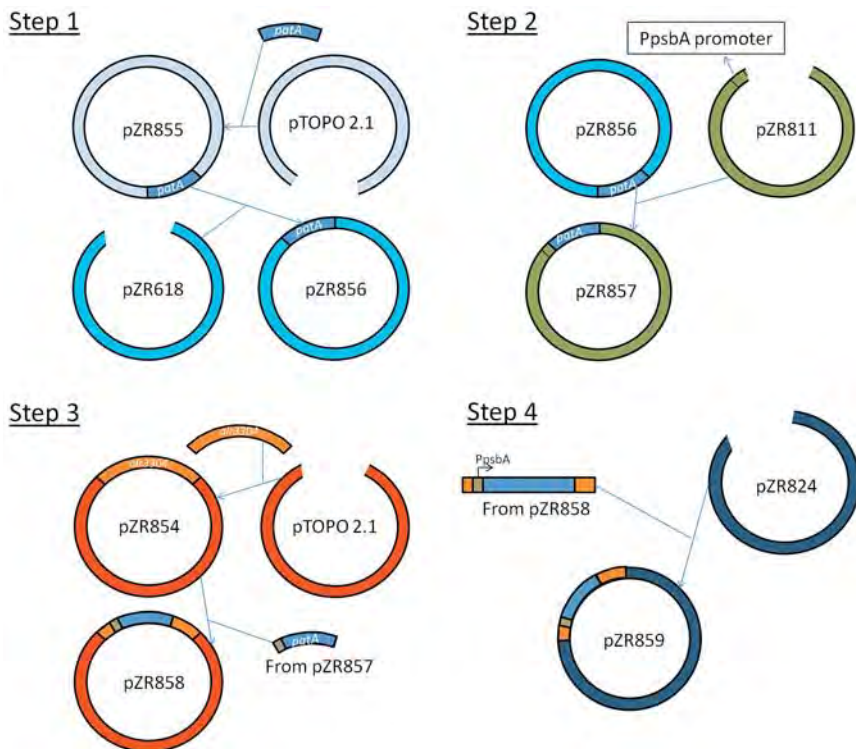
Primer	Sequence	Notes
M13F	GTAAAACGACGGCCAG	Upstream primer for recombinant pTOPO
M13R	CAGGAAACAGCTATGAC	Downstream primer for recombinant pTOPO
T7	TTAATACGACTCACTATAGGG	Anneals to T7 promoter
T7 term	GGGTTATGCTAGTTATTGCTC	Anneals to T7 terminator
ZR127	CGTACCGGTGTCGACTCGCGCAATT-GCTAGCTTAAGACGTCAT	Anneal to ClaI region in pZR811
ZR191	TGGATCTGAGGATTCACCTTTAGCC	Upstream for <i>alr3304</i>
ZR192	TCTCGAGTAGATTACGAAATTTTCAGTAC	Downstream for <i>alr3304</i>
ZR193	TCATATGGGATCCATGAAAACACTTCCGATTAC	Upstream for <i>pata</i>
ZR194	TGTCGACCGTAATGTGTTAAAAAATTACT	Downstream for <i>pata</i>

### Bacterial Transformation

*PatA* and *alr3304* were inserted into separate TOPO 2.1 *E. coli* vector plasmids, containing both kanamycin and ampicillin resistance. X-Gal was used to identify the colonies that received the inserted genes; white colonies had a disruption in the beta-galactosidase (*lacZ*) gene that prevented the enzyme from being expressed, indicating a positive colony with an insertion in *lacZ*. Blue pigmented colonies appeared through the metabolism of the X-Gal, indicating that no insert disrupted *lacZ*. White colonies were screened using PCR with M13 forward and reverse primers in order to verify the presence of the insert within the pTOPO 2.1 vector. Colonies containing the desired inserts were grown overnight in a LB broth culture and then used to isolate the plasmid DNA via a QIAprep Miniprep purification kit.

### Plasmid Construction

Plasmids were sequentially constructed by digesting the isolated plasmids from the minipreps with various endonucleases, depending on the recipient vector and the insert (Fig. 1). The digestion was allowed to incubate overnight at 37°C before gel electrophoresis was used to separate the plasmid fragments in a 0.8% agarose gel. Long wavelength UV was used to visualize the banding in order to reduce DNA damage. The appropriate bands were cut out from the gel and purified using a silica (glassmilk) purification procedure. The purified digested inserts and vectors were then ligated using T4-DNA ligase and transformed into NEB 10-beta *E. coli* competent cells. Transformants were grown on LB agar plates with the antibiotics that corresponded to the resistance(s) on the vector. Colony PCR was used to screen the colonies that grew on the LB agar plates for the correct size of insert using specific primers designed in our lab (Table 1).



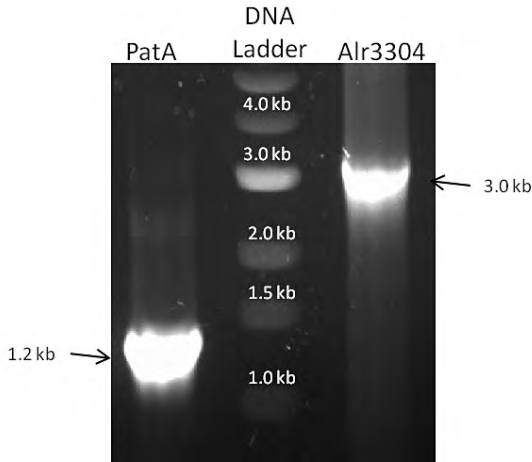
**Figure 2.** Plasmid construction outline. (Step 1) Amplified DNA from the *Anabaena* genome is inserted into a pTOPO 2.1 vector. Then *patA* is removed with restriction enzymes such that NdeI-*patA*-Sall is the insert. This fragment is then inserted into NdeI-Sall digested pZR618, creating pZR856, and transformed into *E. coli*. (Step 2) pZR856 is isolated and digested to provide a BamHI-*patA*-XhoI fragment which is ligated to BglII-XhoI digested pZR811, fusing the insert to the *PpsbA* promoter and creating pZR857. (Step 3) *Alr3304* amplified from the *Anabaena* genome is inserted into a pTOPO 2.1 vector, creating pZR854. NruI-*PpsbA*-*patA*-XhoI is removed from pZR856 and inserted to HpaI-Sall site within *alr3304* to create pZR858, knocking out *alr3304*. (Step 4) A BamHI-3.7kb-XhoI fragment is removed from pZR858 and inserted into BglII-XhoI digested pZR824 to create pZR859. This plasmid can then be used for conjugative transfer into *Anabaena*.

## RESULTS AND DISCUSSION

In order to create the desired mutant containing an over-expression of *patA* and a knock-out of *alr3304*, the genes were isolated from the genomic DNA of *Anabaena* 7120 (Fig. 3). The amplified *patA* was 1.2kb in length and targeted using primers created by our lab, ZR193 and

ZR194. *Alr3304* was amplified using the upstream primer ZR191 and the downstream primer ZR192, yielding an amplicon of size 3.0kb. Both amplified products were the expected sizes.

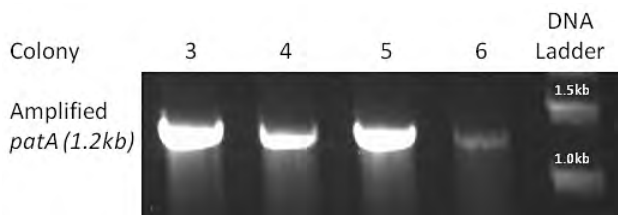
The amplified products of the PCRs were cloned into pTOPO 2.1 vectors, which would be used to transfer the isolated genes into other vectors. Plasmids containing *alr3304* were named pZR854, while plasmids with *patA* were named pZR855.



**Figure 3.** *PatA* and *alr3304* amplification. Primers ZR193 and ZR194 were used to amplify *patA* from *Anabaena* genomic DNA using PCR. The resulting amplicon was 1.2kb in length. *Alr3304* was amplified from *Anabaena* genomic DNA using PCR with primers ZR191 and ZR192. An amplicon of 3.0kb resulted from PCR.

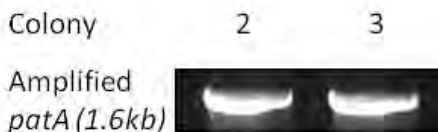
Transformants were selected using the antibiotic resistance of kanamycin and ampicillin. The isolated colonies were tested with M13F and M13R primers to verify the presence of the inserts (data not shown). Also, isolated plasmid DNA pZR855 and pZR854 were sequenced to verify the sequence of the inserts within the respective plasmids. The sequencing results showed that the genes *patA* and *alr3304* were in their respective plasmids correctly (data not shown). These sequenced plasmid samples were then used to create further plasmids.

Using the restriction enzymes NdeI and SalI, *patA* was removed from pZR855, creating a segment NdeI-*patA*-SalI. The segment was transferred to the vector pZR618, cut with the same restriction enzymes, and produced pZR856. Colonies were selected using ampicillin resistance from pZR618, and PCR was used to confirm the presence of the inserts within the transformants. The usage of PCR primers T7 and T7Term (Table 1) produced an amplicon the size of 1.2kb, indicating the presence of *patA* within pZR856 (Fig. 4).



**Figure 4.** Colony PCR amplification of *patA* in pZR856. After *E. coli* transformation with pZR856, colony PCR was used to amplify the segment of plasmid DNA where *patA* was inserted. The primers T7 and T7 term were used to identify the correct insert. Only colonies with strong amplification were stored and used in further experiments.

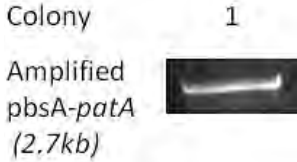
Isolated plasmid DNA pZR856 was used to create pZR857 by digesting pZR856 with the restriction enzymes BamHI and XhoI, creating a segment BamHI-*patA*-XhoI, which was inserted into BglII-XhoI digested pZR811. This plasmid construction represents an important step in the execution of the whole goal of this research. By inserting *patA* into pZR811 at a specific location, the *Anabaena* promoter *PpsbA* became linked to *patA*. Attaching the promoter to *patA* will enable PatA to be produced in excessive amounts through normal cell functions, causing an increased ratio of heterocysts to vegetative cells (5). Transformed *E. coli* were selected for with kanamycin resistance from pZR811 and tested for the presence of the insert *PpsbA-patA* with PCR primers ZR127 and ZR194 (Table 1). Results of the PCR showed the correct amplified product, shown by a band with a size of roughly 1.6kb (Fig. 5). This verifies that the promoter was correctly attached to *patA*, enabling further plasmid development.



**Figure 5.** Colony PCR amplification of *patA* in pZR857. Primers ZR127 and ZR194 were used to amplify the region of plasmid DNA containing *patA*. This region also contains the promoter *PpsbA*, accounting for the increase in amplicon size.

With the creation of pZR857, the product *PpsbA-patA* can be inserted within *alr3304* of pZR854 to create the desired knock-out. pZR857 was digested with restriction enzymes NruI and XhoI, creating the insert NruI-*PpsbA-patA*-XhoI. The insert was ligated to HpaI-SalI digested pZR854, creating pZR858. This new plasmid contained the *alr3304* with *PpsbA-patA* inserted within it in order to create the knock-out. *E. coli* containing the correct plasmids were selected for using ampicillin and kanamycin resistance. Upon isolation of *E. coli*, pZR858 was verified with PCR using primers M13R and ZR194. The correct size of the amplified region is 2.7kb in length, which was seen with visualization of the gel under UV light (Fig. 6). Work proceeded with the construction of pZR859. However, PCR of *E. coli*

containing pZR859 showed a lack of the desired insert, length 3.7kb. Results of enzymatic digestion of pZR859 with Sall also concurred with PCR results; the enzyme digestion should have produced fragments of size 5.3kb, 2.6kb, and 1.6kb. However, only a plasmid DNA band and a band of size 6.5kb were seen (data not shown). Therefore, construction of pZR859 was unsuccessful.



**Figure 6.** Colony PCR amplification of *alr3304-PpsbA-patA* in pZR858. The primers M13R and ZR194 were used to amplify the 2.7kb segment of plasmid pZR858 containing *PpsbA-patA* that was inserted into *alr3304*. The length of the amplicon is expected to be 2.7Kb.

Future directions with this research entail fixing the problems in pZR859. Once the insert has been verified within pZR859, the recombinant *E. coli* will be conjugated with *Anabaena* 7120 in order to transfer the insert into the genomic DNA of *Anabaena*. This process will be done through double cross-over. Both ends of the *PpsbA-patA* fragment have both (5' and 3') flanking sequence of *alr3304*, which will allow the entire fragment to be inserted into the genomic location of *alr3304*. Such a double cross-over recombinant will both silence *alr3304* and over-express *patA*. This recombinant *Anabaena* will theoretically produce more heterocysts than either of the two separate mutants (5, 10). An increase in heterocyst formation will then enable the cyanobacteria to produce a higher amount of ammonia than would be normal. Using a photobioreactor, the cyanobacteria can be grown in large quantities on cheap solar energy and nitrogen and carbon dioxide from the atmosphere. Also, as long as essential nutrients are being supplied, the cyanobacteria will not need replacing. This continuous production of ammonia has the possibility to change the ammonia production industry in drastic ways, both reducing costs and environmental pollution.

## ACKNOWLEDGEMENTS

I thank Chuck Halfmann and Kangming Chen for the help they provided throughout the course of my research and the Joseph Nelson Mentorship program for support and funding.

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# Still Free, Still Alive: Images of Haitian Collective Values Portrayed Through Child Characters in Lamartine's *Toussaint Louverture* and Agnant's *Alexis d'Haiti*

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## INTRODUCTION

At the beginning of the nineteenth century, Haiti (then Saint-Domingue) became the first black republic in the world, founded on the will and spiritual force of rebellious African slaves who fought for their independence from Napoleon Bonaparte and the French empire. They were seized from their native African homelands and sold through the infamous Triangular Slave Trade to white colonists in Caribbean nations such as Saint-Domingue. Today, more than two hundred years after the country gained its independence, Haiti is one of the poorest and most turbulent countries in the world.

After breaking the chains of colonial oppression, Haiti's march towards true independence suffered a great setback in 1825 when France imposed a so-called "independence debt" of 150 million gold francs in order to recognize Haiti's independence. Almost a century after, in 1915, Haiti saw its territory once again invaded and occupied—this time by the United States—in the name of investments and national interests. Threats to American businesses, such as the Haitian-American Sugar Company, the instability of the U.S.-supported government of Jean Vilbrun Guillaume Sam and the increasing popularity of anti-American leader Rosalvo Bobo at the time, were some of the reasons that triggered U.S. involvement in the island (Minster). The U.S. finally withdrew from the small island in 1934, but this did not mean the end of oppression for Haiti.

A new era of domestic-led terror arrived in 1964, when François "Papa Doc" Duvalier declared himself president-for-life. With the help of his brutal private militia, the Tonton Macoutes, he drove Haiti into the abyss of bloody dictatorship. It is estimated that the Tonton Macoutes killed over 60,000 of their own countrymen and women (BBC News). This triggered the massive exodus of Haitians, deemed at one point "boat people," into countries north of and in the Caribbean, including the United States, the Bahamas and the Dominican Republic (Haggerty).

At the beginning of the 1990s, it seemed as though Haiti had embarked on the path to democracy with the first democratic elections, when Jean-Bertrand Aristide was elected president. Unfortunately, only one year later, Aristide was ousted in a coup d'état and the decade was marred by political turmoil and an unstable government. Aristide returned in 2000, but he was once again ousted in a popular uprising in 2004. Aristide was unable to deliver promises of economic improvement for the island. Furthermore, he also faced severe



opposition from domestic rebel groups as well as increased international pressure from the U.S. and France. In 2004, he “resigned under pressure” and sought exile in South Africa (BBC News). Aristide returned to Haiti in March 2011, days before run-off presidential elections.

In addition to political instability, Haiti has faced many problems resulting from natural disasters. During the first decade of the new millennium, Haiti saw its land punished by extreme food shortages, unprecedented hurricane seasons, a devastating earthquake that took the lives of over 300,000 in January 2010, and more recently a deadly cholera outbreak that killed more than 2,500 people (BBC News). Haiti’s fight for existence and its journey toward independence have not been easy. In theory, Haiti is effectively “free” from the claws of European power; however, history and the ever-changing world order have not been kind to this Caribbean state. Since the country’s independence, debt, political instability, and poverty have become the new forms of modern slavery.

Yet, despite all the obstacles and difficulties it has had to surmount, this small island and its perseverant people have managed to survive and perpetuate their identity for over two centuries. During the Haitian Revolution that lasted from 1791-1804, they were inspired and led by a courageous general named Toussaint Louverture. He was a freed slave who, after joining the ranks of the French army in 1794, was eventually able to gain command over a large part of the territory then known as Saint-Domingue. A strategic leader inspired by France’s decision to abolish slavery, Louverture stood by the French army, while at the same time going through proper channels to cement the notion of equality under the law between blacks and whites. His patience and moderation were exhausted, however, when he saw that France intended to reestablish slavery in Saint-Domingue. By 1801, along with many of his men, Louverture had gained control of most of the island.

Later that same year, Napoleon ordered General Charles Leclerc and his troops to seize control of the island, but they did not succeed. Despite his inability to gain control of the small but powerful island, Napoleon was indeed able to seize Louverture and exile him to France, where the latter died in prison in 1803 (Biography.com). Despite his deportation, Louverture warned Napoleon not to underestimate the strength of his countrymen and women and famously declared: “In overthrowing me, you have done no more than cut down the trunk of the tree of the black liberty in Saint-Domingue, it will spring back from the roots, for they are numerous and deep.” (Toussaint Louverture Historical Society). Louverture’s principal lieutenant and loyal compatriot during the Revolution, Jean-Jacques Dessalines, was able to see the fruits of the Revolution sparked by his comrade. Saint-Domingue became independent in 1804, just one year after Louverture’s death.

Powerful historical figures, such as Toussaint Louverture and Jean-Jacques Dessalines, were stoic and astute leaders during the struggle for independence from the French empire. They personify the dignified fighting essence of the Haitian nation. The key Haitian values of true independence, a strong sense of community, and their genuine cultural identity, all found within the Haitian collective psyche, are expressed through Haiti’s art and literature. The manifestation of these ideals is especially seen through symbolic characters that are oftentimes considered moral compasses or representations of everything that is good, true, and beautiful in the Haitian consciousness.

In this paper, I argue that the fundamental Haitian values of the struggle for freedom and the prevailing desire for independence are portrayed through the morals and personality

of two child characters found in texts set in Saint-Domingue/Haiti. The first character is a young girl named Adrienne in Alphonse de Lamartine's play *Toussaint Louverture* (1850) and the second is a young boy named Alexis in Marie-Célie Agnant's novel *Alexis d'Haiti* (1999). Through these two characters, Lamartine and Agnant depict Haiti's struggle to achieve freedom and to retain its unique cultural identity that has allowed this nation once called the "pearl of the Caribbean" to survive.

Children are often characters who represent key symbols of freedom, compassion, and a revolutionary spirit. In our consciousness, children represent the future and potential progress of entire nations. Thus, it follows that in the aforementioned texts treating historical and social circumstances in Haiti, child characters take an essential significance and are the principal acting force in the stories' most crucial events.

Before delving deeper into the stories, it is important to clarify certain facts about the authors of each work as well as the period in which they were published. *Toussaint Louverture*, by Alphonse de Lamartine, is a dramatic play that centers upon the life of Toussaint Louverture and his key role in the Haitian Revolution. Lamartine portrays the complex and sometimes strained relationships he had with his sons, the French army, his military comrades and his relationship with his niece Adrienne (a fictional character created by Lamartine). The play is described by Lamartine as "a boulevard play" designed to make historical events accessible to the public, but not necessarily pursuing a high literary regard (Hoffmann).

One important thing to mention about Alphonse de Lamartine is the fact that he is French, despite the fact that he wrote about the hero of the Haitian Revolution. Lamartine was born in Burgundy in 1790 and though he was a writer, he was also a very dedicated politician who was essential in the formation of the Second Republic. While active in the Second Republic, Lamartine led efforts to do away with both the death penalty and slavery in France, experiences which certainly must have influenced his perception and commitment to his play *Toussaint Louverture*.

At the beginning of the play in Act I, Scene I, slaves working in the sugarcane fields actively teach children the "Black Marseillaise." The "Marseillaise" is the French national anthem – its content reflects a violent call to arms to French citizens who must fight to achieve their revolutionary ideals of "freedom, equality and fraternity." In *Toussaint Louverture*, "The Black Marseillaise" is set to the same tune, but its content is different, focusing more on the idea of equality among races. It emphasizes unity and the desire for freedom, and it concludes by affirming that the ideal of equality with liberty will prevail in time: "Let us open our arms, free from chains, to the whites," the anthem concludes. "In the heart of all living blacks in humanity, it is an anthem of love and fraternity. Does blood have only one voice on Earth? Listen! And you, children, learn!"<sup>1</sup> says Samuel, one of the slaves in the story, and right after, he teaches the anthem to the group of children (Lamartine 14). The idea is to transmit not only the traditional tune, but the intrinsic values found within it, onto the children. In turn, the children are fascinated to learn the song.

When compared to the original, "The Black Marseillaise" is different in tone and in essence. The values in its message focus on the idea of humanity and community, especially expressed through the desire to be free but at the same time, being able to offer open arms to

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<sup>1</sup> My translation from the original French, « Au cœur de tous les noirs soufflant l'humanité, c'est un hymne d'amour et de fraternité. Le sang a-t-il donc seule une voix sur la terre ? Écoutez ! et vous, enfants, retenez ! »

the whites: a dignified liberty, free from grudges or retaliation. “The Black Marseillaise” is pacifist and contrastingly less violent than its French counterpart, thus constituting an indication of the kind of values that the adult characters in the play want the children to embrace as their own.

There is a clear assumption that children will be responsible for “retaining” and perpetuating patriotic identity, as well as the notion of true freedom in their incipient nation. In this scene, the mesmerized children are the symbol of collective Haitian national pride, depicted as a completely natural occurrence among the young citizens of a dignified nation. It is also in this scene where the reader is introduced to the character of Adrienne, who is present among the children.

In the ninth scene of Act II, Adrienne’s key role starts to emerge when Toussaint asks her a series of questions concerning her race, her pride, and her willingness to sacrifice herself in the name of her country’s independence. “Do you love your country ? [...] To death ?”<sup>2</sup> asks Toussaint. Adrienne responds, “My uncle and my country, aren’t they the same thing? Aren’t you, for me, what comprises it all? Do I have any country other than the shadow of your steps?”<sup>3</sup> (Lamartine 55). In these lines, Adrienne reveals that her love for her country is as intense and as important as her love for her uncle, her principal father-figure in this play. Yet, when Toussaint says “But if I told you, ‘Go alone, I am sending you to die for all blacks,’”<sup>4</sup> we see Adrienne’s true commitment to her country and to her uncle’s fight for independence. She responds: “I would gladly go! Wherever you would tell me, my uncle, I would go!”<sup>5</sup> (Lamartine 55). Adrienne’s words in this scene are very significant to Toussaint’s actions and leadership role in the play because he regards her as his guide, his inspiration, and his “lamp” on the path towards independence. Her dedication to her uncle’s fight for the liberty of their people is as strong as Toussaint’s devotion to seeing a bright future for his country – a future exemplified in his young niece.

Like Alphonse de Lamartine, Marie-Célie Agnant also portrays the struggle for freedom in many of her works. Agnant is a contemporary Haitian writer who focuses on the condition of women, race, memory, exclusion and exile, among other issues. These themes are personal for Agnant, as she was born in 1953 and grew up during the American occupation and François Duvalier’s regime (Pierre). She emigrated to Québec in the 1970s, and her novel *Alexis d’Haïti* depicts a similar intensity in the pride of being Haitian through the character of Alexis. Agnant’s story portrays a young boy, Alexis, who is faced with the difficult decision of having to leave his country with his mother due to political persecution.

Early in the narrative, the reader finds out that Alexis’s father has “disappeared” –presumably kidnapped by paramilitary militias, due to his political points of view. This is a direct parallel to the reality that many Haitians, including Agnant, had to endure during the era of Duvalier dictatorships in the 20th century. Agnant, coming from an “unequivocally” anti-Duvalier family, was confronted with this experience at the age of 15 and was forced to leave her homeland for a more stable and safer future in Québec. “At that time, it was almost a matter of life and death. We didn’t ask ourselves ‘Should we leave?’ but instead, ‘When are

<sup>2</sup> My translation from the original French, « Aimes-tu ton pays ? [...] Mais jusqu’à la mort ? »

<sup>3</sup> My translation from the original French, « Mon oncle et mon pays, n’est-ce pas la même chose ? N’êtes vous pas pour moi tout ce qui le compose ? Ai-je un autre pays que l’ombre de vos pas ? »

<sup>4</sup> My translation from the original French, « Mais si je te disais, ‘Va, seule, je t’envoie mourir pour tous les noirs ? »

<sup>5</sup> My translation from the original French, « J’irais avec joie ! Partout où vous diriez, oui, mon oncle, j’irais ! »

we leaving?”<sup>6</sup> Agnant said in an interview, retelling of the horror brought on Haiti by these iron-fisted dictatorships, which drove tens of thousands of Haitians into exile (Proulx).

Alexis's mother, obviously worried about the future and safety of her son, makes the decision to brave the 650 miles at sea to try to build a new life in the United States. Though the decision has already been made and is out of his control, Alexis's heart and head are reeling with thoughts concerning the new reality he will face, how he will react to it, as well as how his sense of patriotic pride and his genuine cultural identity may be affected by this life changing event.

Just before traveling to the United States, Alexis talks to his grandmother, Malena, and expresses how he feels regarding the unfortunate circumstances of his forced exile. “When one leaves his or her country, all of a sudden, one can meet others who are gloomy, but they are not ours, one cannot recognize them [...] Those who leave never return and, after some time, they don't know who they are anymore”<sup>7</sup> (Agnant 55). Alexis's patriotic spirit is not as explicit as Adrienne's, yet it is evident in this statement that Alexis has a deep, implicit Haitian pride and he does not want to lose his essence or his identity due to forced exile.

Alexis does not want to become “lost at sea,” as he sails away from his homeland in a boat bound for the United States. He fears that the longer he lives there, the more detached he will become from his own country and identity. As is the case with most first-generation Haitian immigrants who settle in the United States, one of Alexis's greatest fears is losing his national identity or betraying his own roots by assimilating into the new host culture. In her essay *Juggling with Two cultures: Transnationalism and Hybridity as Cultural Outcomes of Immigration for Haitians in the United States*, Flore Zéphir says that many first-generation Haitian immigrants who settle in the United States do not give up their strong sense of nationality as *Haitians* easily. As soon as they realize the racial issues surrounding Black Americans, “who [...] are placed at the bottom of the totem pole in American society”, Haitians typically refuse to accept this discrimination typically associated with being black in the United States. Zéphir explains:

This placement [at the bottom] is in direct conflict with the Haitian definition of Blackness, which is synonymous with pride and unflinching independence. Their race is a symbol of a glorious past, that of a revolution that led to freedom, nationhood and equality with Whites. (Zéphir 67)

Alexis's reluctance to assimilate and his genuine fear of losing his identity during his forced exile reflects the inherent value of national pride that lives on in the Haitian spirit. To him, like the many immigrants in the United States today, retaining his identity intact is a way to carry on the legacy of revolutionary struggle and the conquest of freedom evident in Haiti's remarkable history. These assertions are exemplified in Alexis's character: to come from a past of rebellion, from a nation that literally broke the chains of slavery and colonialism as it became an independent state, in short, to be Haitian, is synonymous with an ever present desire for freedom and equality.

In Agnant's novel, Alexis's friend Jérémie talks about how his uncle who lives in the

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<sup>6</sup> My translation from the original French « A cette époque-la, c'était presque une question de vie ou de mort. On ne disait même pas "est-ce que l'on part?", " mais plutôt "quand est-ce que l'on part?" »

<sup>7</sup> My translation from the original French, « Quand on quitte son pays, dans un débit saccadé, on peut rencontrer d'autres mornes, mais ce ne sont pas les nôtres, on ne sait pas les reconnaître [...] Ceux qui partent ne reviennent jamais et, au bout d'un certain temps, ils ne savent plus qui ils sont vraiment »

United States has become unrecognizable and surly. He is afraid that Alexis will end up the same way. Jérémie's pessimistic tone inherently connects assimilation into a host culture with the betrayal of one's own. Jérémie says: "He spoke a strange language. It wasn't Creole, but instead, a *mélange* that nobody understood [...] he would ask: 'watere, watere'. We had shown him the cabin at the end of the courtyard, I mean, the latrines. He kept asking for 'glass o watere'"<sup>8</sup> (Agnant 39). Jérémie's statement both mocks and laments that situation. Jérémie's judgment regarding his uncle's loss of identity expressed through his inability to retain something as inherently Haitian as the Creole language is one of the most evident manifestations of Haitian cultural value and pride. Zéphir points out this fact when she writes:

[The] fact that Haitian immigrants have their own distinct language, Haitian Creole, unique to them, enables them to maintain their ethnicity and their sense of "peoplehood". Haitian Creole is a marker of Haitian immigrants' ethnolinguistic identity and contributes to their feeling of belonging to a proud cultural and linguistic heritage. (Zéphir 67)

The uncle's loss of identity, as told by Jérémie, centers on the loss of his ability to speak his native tongue. Jérémie is estranged and aggravated, not just by his uncle's loss of the language, but by his pollution of Haitian Creole (*Kreyòl*) when mixed with English, as seen in his request for water. The uncle's use of this mixed language shows a loss of identity in different levels: first, his detachment from the past living conditions in Haiti (where latrines could be called 'water-closets', hence the linguistic confusion reflected in the dialogue), and second, through his inability—or unwillingness—to make a simple request for water in Creole.

Jérémie is unable to comprehend why any Haitian would lose or pollute such an important source of national identity as *Kreyòl*, which is only spoken in Haiti. The loss of language suggests that the recent immigrant has stopped or severely reduced his or her use of *Kreyòl* due to reasons linked to either forced or willing assimilation. In the uncle's case, through his persistence in requesting water in English despite the fact that nobody could understand him, it can be inferred that he is willing to assimilate into the non-Haitian culture. In the eyes of Jérémie and Alexis, this constitutes the ultimate betrayal of identity.

Adrienne and Alexis both express the crucial value of national pride through their willingness to go as far as needed to defend their patriotic essence. It is this patriotism that has allowed their unique country to surmount any obstacles presented to them in the past. Both Alexis and Adrienne personify the desire for freedom and independence of the adults who are responsible for them. These adults must remain discreet and passive about their need to fight against oppression, slavery, exile and injustice either due to the colonial system (as in the case of Lamartine) or their asylum-seeker status (as in the case of Agnant).

In Lamartine's play, Adrienne is the muse that illuminates Toussaint's revolution. In the last scene of Lamartine's play, we see that for him, Adrienne is "the angel of blacks", an "angel of victory" (Lamartine 146). She is a child that personifies the future of the nation and is Toussaint's reason for fighting and for finally obliterating the chains of French imperialism on his country. Toussaint declares: "Oh, magnanimous child, you will be the warm blanket of my nights, the stick in my hands, the lamp of my path!"<sup>9</sup> (Lamartine 57). As Toussaint's

<sup>8</sup> My translation from the original French, « Il parlait une langue étrange. Ce n'était pas le créole, mais un charabia que personne ne comprenait [...] il s'était mis à demander : 'watere, watere'. Nous lui avions montré la cabane au fond de la cour, je veux dire, les latrines. Il continuait pourtant à réclamer 'glass o watere'" »

“lamp,” Adrienne represents Haiti’s children and the future of Saint-Domingue as an independent nation. The potential of the youth, represented by his niece Adrienne, and the desire for progress and development through them ultimately drives Toussaint to fight against the French empire, colonization, and oppression.

Adrienne is not the only character that serves as inspiration for the desire of freedom and a more prosperous future. Alexis states: “Mom pretends that we are in great danger [...] Mom will not change her mind. Our life is in danger [...] I would like to stay with grandma. But mom refuses. She says that the militias will not hesitate to take even children [...] She is so disheartened, she keeps repeating that anywhere will be better than here!”<sup>10</sup> (Agnant 22). This quotation reveals Alexis’ mother’s final goal of escape to the United States. Although Alexis does not want to leave his country, grandmother, or best friend Jérémie, his mother is determined to flee Haiti at any cost, as long as she is able to protect her child and her child’s future.

These two children, Adrienne and Alexis, symbolize the future, undying hope, and the promise of prosperity for Haiti. For this reason, they are fiercely defended and guarded by their elders. In defending the children as well as their values and morals, the very essence of Haiti is what is being upheld and protected. Alexis and Adrienne are a symbol of birth or rebirth (depending on the case) of the country. As a result, they must be firm, established in their values and convictions, but most of all, they must be proud of all the heritage and history they represent through their existence.

Despite the parallels and similarities between the two child characters, there is a monumental contrast in the destiny of each character within the texts: Adrienne dies while Alexis lives. However, their characters, especially their final and enduring actions, represent and personify the future of the nation at that moment in history. Both Adrienne and Alexis’s actions carry later repercussions because they inspire and drive others to action. Adrienne’s cry to arms and her subsequent death, as she was facing the French army, inspires Toussaint Louverture to take the final plunge into full-on revolution for independence. In the same way, Alexis’s courage and leadership inside the camp motivated his fellow asylum-seekers to stand up against the imprisonment, the abuse and injustice that they felt in the camp. Even more importantly, the children remain eternal symbols of struggle and of revolution. No matter their fate (life or death), the struggle continues through their spirits.

At the end of *Toussaint Louverture*, the jarring image of Adrienne’s death cements the idea of independence and revolution. As she faces the oncoming French army, her last words are: “To arms! [...] May the folds of the flag fly over Haiti! All of you remember the life of those who have died standing against the whites!”<sup>11</sup> (Lamartine 146). After this dramatic scene, Adrienne faces the French soldiers and is subsequently killed as she raised the black distress flag, which had set the patriots’ attack in motion (Cohen 256). She is the child that

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<sup>9</sup> My translation from the original French, « O magnanime enfant, tu seras de mes nuits le manteau réchauffant, le bâton de mes mains, la lampe de ma route ! »

<sup>10</sup> My translation from the original French, « Maman prétend que nous courons de grands dangers [...] Maman ne changera pas d’idée. Notre vie est en danger [...] Je voudrais rester avec grand-mère. Mais maman refuse. Elle dit que les miliciens n’hésitent pas à s’en prendre même aux enfants [...] Elle est si découragée qu’elle répète que n’importe où sera mieux qu’ici ! »

<sup>11</sup> My translation from the original French, « Aux armes ! [...] Que les plis du drapeau sur Haïti s’étendent! Vous, rappelez la vie à ses membres tremblants et qu’il meure du moins debout devant les blancs ! »

symbolizes the incipient nation that is literally facing its occupiers. Toussaint cries: “Angel of victory and freedom!” (Lamartine 147). He is devastated but quickly takes this as fuel for his desire of freedom and finishes the dialogue by yelling “To arms!”<sup>13</sup> – echoing Adrienne’s dying words (Lamartine 147).

Adrienne’s freedom was being threatened by French imperialism and she fought against it until death. She becomes a martyr, but in the play, she is the key source to ignite the powerful ensuing revolution led by Toussaint. In this final scene, Adrienne’s character takes on great significance, especially in the francophone consciousness, as she seems to parallel the French “Marianne”. The symbol of “Marianne” came about in France during the years of the French Revolution, as accounts of a pretty young woman wearing a Phrygian cap rousing the “sans-culottes” (urban laborers, bulk of the Revolutionary army) became legendary. “Marianne” represents the triumph of the French Republic; she can be seen as an allegory for reason and liberty, as well as the personification of the values of the French state (Embassy of France in the United States). A close parallel figure in the United States could be “Lady Liberty”, as it epitomizes the American ideals of freedom and multiculturalism.

Like Adrienne, Alexis’s actions during his escape and later imprisonment inside the walls of an American refugee camp constitute a great example of the notion of the survival of the Haitian revolutionary spirit. Alexis’s freedom is threatened in every way: by his government at the beginning of the novel, and by the oppressive circumstances of the refugee camps at the end. This pressure leads Alexis to develop a ferocious attitude that echoes Toussaint Louverture’s personality. He has seen not only the horrible situation of his country but also the great injustice occurring in this new system, inside the refugee camps. Alexis feels cheated, trapped and this way, the spirit of revolution – much like Toussaint and Adrienne when she raises the flag — exudes from his soul during his final actions in the camp. “You have the semblance of a man now,”<sup>14</sup> Alexis’s mother says.

Agnant’s text illustrates Alexis’s coming of age when he thinks about his father just before fleeing Haiti:

In a history book, they admired the photo of an ancient slave, Jean-Jacques Dessalines, who became emperor of Haiti [...] On another page, a photo of Toussaint Louverture [...] And his father ... made him relive the seizing of Toussaint [...] Alexis then perched on a chair, hand on his chest and yelled Toussaint’s famous phrase: ‘In overthrowing me, you have done no more than cut down the trunk of the tree of black liberty in Saint-Domingue. But it will spring back from the roots, for they are numerous and deep.’ ‘All that is really far away now,’ Alexis thought.<sup>15</sup> (Agnant 84-85).

Even though Alexis was incredibly disappointed by the precarious situation of his

<sup>11</sup> My translation from the original French, « Aux armes ! [...] Que les plis du drapeau sur Haïti s’étendent! Vous, rappelez la vie à ses membres tremblants et qu’il meure du moins debout devant les blancs ! »

<sup>12</sup> My translation from the original French, « Ange de la victoire et de la liberté ! »

<sup>13</sup> My translation from the original French, « Aux armes ! »

<sup>14</sup> My translation from the original French, « Tu as l’air d’un homme maintenant, »

<sup>15</sup> My translation from the original French, « Dans un livre d’histoire, ils admiraient la photo d’un ancien esclave, Jean-Jacques Dessalines, devenu empereur d’Haïti [...] Sur une autre page, une photo de Toussaint Louverture [...] Et son père ... lui faisait revivre la capture de Toussaint [...] Alexis alors se juchait sur une chaise, la main sur la poitrine, et déclamaient cette phrase célèbre de Toussaint : ‘En me renversant, on n’a abattu que le tronc de l’arbre de la liberté des Noirs. Mais il repoussera, car ses racines sont profondes et nombreuses’. ‘Tout cela est bien loin maintenant,’ pensa Alexis. »



country, he knew that was not part of the true Haitian essence. He was convinced that it was the spirit of great leaders like Dessalines and Louverture who comprised the spirit of his country, and not the tyrant dictators who threatened people like his father. Inspired by the images of the revolutionary leaders as well as by the suffering he had endured during his imprisonment in an American refugee camp, Alexis personifies the constant Haitian struggle for independence. Rather than succumb to the awful conditions and deprivations of the camp, he thinks about Louverture and the glory he brought to Haiti. Agnant describes Alexis' progressive spiritual growth and maturity as he realizes his nationalistic roots and his renaissance as a modern combatant who felt compelled to encourage and uphold the dignity of his fellow compatriots in the camp:

[With a] voice of fire, voice of warrior, voice of thunder getting ready to release the tempest, he [Alexis] breathes without hearing all those voices around him, begging him to stop that racket [...] His thinner body bends like a liana, while, with all his might, he breathes on the instrument that once, for the slaves, his ancestors, used to yell out –among the mountains—the battle cry for freedom<sup>16</sup> (Agnant 136, 142)

Alexis knows he has a revolutionary legacy in his blood, for he comes from a proud lineage of warriors that fought with everything they had against slavery and oppression. He reminisces about all those who struggled before him to give Haiti its independence, about those he left behind as he escaped the brutality of the Duvaliers, and about his fellow compatriots who were there in the camp with him dreaming of a brighter future. These memories incite him to become a leader to those in the camp and follow the example of Louverture and Dessalines.

At the end, Alexis turns and talks to Mathurin, another refugee who has helped during the crisis. In a poetic, realistic manner reminiscent of Toussaint Louverture, Alexis tells him: “We have not won the war, Mat, but we have just won a great battle, *Ayabombe!*”<sup>17</sup> (Agnant 142). This last word, “ayabombe”, is derived from the Arawak/Taíno indigenous battle cry “Aji Ayabombe!”, which means that one is better off dead than enslaved (The Taino People).

Today, the question of whether it is better off to be dead than enslaved remains relevant for Haiti. Despite years of political turmoil, social unrest caused by oppressive poverty, and the devastating hurricane season in 2008 that nearly turned Haiti into a wasteland, the situation seemed to be improving by the end of 2009. Food riots in 2008, resulting from the path of destruction left behind by four consecutive Atlantic storms that same year, prompted countries like the United States and Brazil to boost food aid and peacekeeping forces. After evaluating Haiti's progress in economic reform and poverty reduction, the World Bank and the International Monetary Fund forgave 80 percent of the country's debt. Haiti was just beginning to gain stability with the support of the international community, and the country was taking significant steps towards democracy under the presidency of René Préal (BBC News).

Yet, nothing could prepare the small island nation for the catastrophic earthquake that

<sup>16</sup> My translation from the original French, « Voix de feu, voix guerrière, voix de tonnerre qui s'apprête à déchaîner la tempête, il [Alexis] souffle sans entendre toutes ces voix qui, autour de lui, le supplient de cesser ce vacarme [...] Son corps amaigri se plie telle une liane, tandis que toutes ses forces, il souffle dans l'instrument qui jadis, pour les esclaves ses ancêtres, servait à lancer depuis les montagnes le cri de ralliement pour la liberté. »

<sup>17</sup> My translation from the original French, « Nous n'avons pas gagné la guerre, Mat, mais nous venons de remporter une grande bataille, Ayabombe ! »



struck Port-au-Prince on January 12, 2010 and changed its fate forever. The loss of life, estimated at around 250,000, was an unprecedented and devastating blow to Haitian society on all levels: social, economic and psychological. Basic physical and governmental structures, as well as all sense of normalcy were obliterated following the quake, the worst in Haiti's 200 years of history. After the aftershocks passed and endless days of desperate rescue efforts went on, Haiti has had to struggle through unending crises: over a million homeless overcrowded in tent cities and the massive task of physical, political, and psychological recovery.

As if it were not enough, in November 2010, a severe cholera outbreak took the lives of more than 2,000 – a consequence of the precarious living conditions in Haiti after the quake. Cholera, commonly known as “the disease of the poor,” highlighted the daunting amount of rehabilitation that Haiti requires. This intestinal infection is usually caused by the ingestion of bacteria present in water or food contaminated with feces. Symptoms in its more severe form include a sudden onset of acute watery diarrhea that can lead to death from extreme dehydration. The prevalence of cholera is generally linked to inadequate access to proper sanitation and clean water. (World Health Organization)

In the case of Haiti, basic sanitation infrastructures were razed by the earthquake. Since many homeless communities are now agglomerated in tent cities or just under tarps, there is no access to clean water for drinking, cooking, washing hands, or bathing. Under these conditions, the cholera virus thrives and spreads quickly, especially among children, the elderly, and those with depleted immune systems. Cholera can be prevented mostly by providing clean water and proper sanitation to vulnerable communities, as well as through health and food hygiene education (World Health Organization). A lack of hospitals, scarce and underdeveloped sanitation infrastructures, and delays in the arrival of aid began eroding the fortitude of the Haitian people.

Following the outbreak, the streets of Port-au-Prince and other urban areas in Haiti began showing signs of collective psychological distress, through anonymous graffiti stating “Nou bouke,” Creole for “We are tired” (Cardona). Even long-term aid workers who have been committed to Haiti's progress for more than a decade, such as Dr. David Walton of U.S-based health organization “Partners in Health,” echoed the communal sentiment. “It makes me frustrated. I can understand if there was another earthquake that happened. But cholera? You know, it seems like the insults never end,” Walton said during an interview on *60 Minutes*. He repeated: “In Haiti, the insults never end.” (*60 Minutes*). On top of the devastation that still remained 10 months after the quake, the virulent spread of cholera and its lethal consequences was proving to be almost unbearable for Haiti. People began blaming foreign United Nations stabilization troops for the spread of the disease, expressing their frustration in the form of riots and violence (Desvarieux). It seemed that Toussaint Louverture's fighting republic hit rock bottom.

However, despite these disheartening signs of national exhaustion, the actions and willpower of the Haitian people continue to tell another story: one of prevailing spirit, of dignity and pride, a story of hope and everlasting desire to push through again to freedom, as it did two centuries ago when black slaves fought tirelessly for their freedom from Napoleon and the French empire. As Toussaint Louverture declared, even though the trunk of the tree of liberty has been cut, it will grow once more, for its roots are deep and numerous. The

values of courage and struggle that have historically characterized Haitians are pushing the island through its darkest hour.

In their essay “Reckoning in Haiti: The State and Society since the Revolution,” acclaimed Haitian historians Jean Casimir and Laurent Dubois assert that Haitians have remarkably organized and navigated the crisis without the assistance of the Haitian state. Moreover, Casimir and Dubois highlight the fact that Haiti does not need mere aid, but instead actual measures to truly empower its people, consistent with the indomitable spirit that has kept the nation afloat since its inception:

A new kind of state and political order will emerge in Haiti only if the people are empowered. And they need to be empowered as they are. If far too many are poor and illiterate, they are no less ready to think and act for the future, just as their ancestors did during the Haitian Revolution. That revolution began an irreversible process that has constituted the political and social organization of Haiti today, which is the only foundation for the future. (131-133)

In spite of the earthquake, the cholera outbreak, the fragile government infrastructure, and the unfulfilled delivery of foreign aid, Haitians continue showing their determination to prevail. Haitian immigrants living in the United States keep sending remittances to their families, while those who stayed in Haiti keep dreaming of a democratic and stable outlook. While working to save as many Haitians as possible during the cholera outbreak, Dr. Walton remarked: “Look, we’re gonna get through this. However we do it, we’re gonna do it, but there is a way forward. We have to. There is no other way. We’re not gonna lay down and die. It’s gonna be slow. It’s gonna be tough. It’s gonna be agonizing. But we will make it through” (60 Minutes). This determination to persevere reflects the mindset of the Haitian population that has existed for centuries.

Despite their trials, the country is undergoing elections for a new president and there is a heightened sense of community in Haiti today. It is evident that Haitians believe in themselves and their ability to construct the bright future they deserve. In his essay “Art in the Time of Catastrophe,” author Madison Smartt Bell discusses the importance of communal thought and action in Haiti’s recovery. He asserts that it is this inherent value of community and collective struggle that will ultimately allow Haiti to rise from its ashes:

The ordinary meaning of ‘tèt ansanm’<sup>18</sup> is comparatively mundane: cooperation of combined intelligence for the common good. In Haiti, it’s an extraordinary force, one with which the First World is no longer familiar; the force which has brought and will bring Haiti back from the worst of disasters. (173)

Bell explains that, even linguistically through the use of an encompassing plural pronoun that can mean either “you” or “we” in *Kreyòl*, the Haitian mindset is rooted in community. During his time in Haiti, he said he experienced “a collective force” or a “shared unconscious” that constitutes a crucial source of strength and identity for the nation, despite the fact that this idea may seem foreign to people from the First World.

This collective force is displayed in Lamartine and Agnant’s characters of Adrienne and Alexis. Although they acted alone, their individual actions began a communal chain reaction that eventually allowed the whole of the collective to overcome and triumph over its obstacles.

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<sup>18</sup> Haitian Creole expression for “the principle of working together”; if roughly translated into French, the expression could turn out as “têtes ensemble” or “heads together”.

Adrienne and Alexis are much like Toussaint Louverture and Jean-Jacques Dessalines, whose actions were the catalyst against oppression and injustice. The Haitian people are like these fictional and historical characters: they will once more dig deep into their historical roots and their revolutionary spirit to surmount obstacles and show the dignity of the first black republic in the world. It is precisely this notion of shared experience, shared efforts, and communal cooperation that allowed Haiti to gain its independence and will continue to ensure the slow yet sure recovery of the Haitian state and its people's spirit. As Bell confirms: "If we are here, it is WE who are here. Not just I"<sup>19</sup> (173).

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<sup>19</sup> My translation from the original Haitian Creole, "Si 'noula', se NOU ki la. Non sèlman 'mwèn'"

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# The Impact of a Fundamentals of Speech Course on Public Speaking Anxiety

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## ABSTRACT

Thirty to forty percent of Americans suffer from Communication Apprehension (CA) to a degree that impairs their ability and willingness to speak publicly (McCroskey, 1984). McCroskey (1984) defines CA as “an individual’s level of fear or anxiety associated with either real or anticipated communication with another person(s)” (p.13). There are many forms of CA, but “the most common [form] is Public Speaking Anxiety” (McCourt, 2007, p.6), which can be defined as the fear of speaking in front of a group of people. Because research has shown that such fears may hinder career aspirations, personal relationships and self-image, scholarly examination of means to reduce CA are merited. Therefore, overcoming CA is a fundamental goal of introductory speech classes. To test the impact of a basic-level speech course on students’ CA, 324 students at a large, Midwestern university took McCroskey’s Personal Report of Public Speaking Anxiety (PRPSA) questionnaire via Questionpro as a pre- and post-test during the first two weeks, and again during the last two weeks of the course, which served as the treatment. Results show a significant decrease in CA after completion of the speech course.

## INTRODUCTION

Communication apprehension (CA) has been defined as “an individual’s level of fear or anxiety associated with either real or anticipated communication with another person or persons” (McCroskey, 1984, p.13). Communication experts gravitate towards scholarly research in this topic area, not only because it is a topic which carries potential to help build confident communicators, but also because there are numerous aspects about CA to study. According to former President of the National Communication Association and internationally-recognized CA scholar and James McCroskey (1984), thirty to forty percent of Americans suffer from Communication Apprehension to a degree that impairs their ability and willingness to speak publicly. His findings further demonstrate that such fears may hinder career aspirations, personal relationships, and self-image. Scholarly examination of means to reduce CA is merited. Previous research has been helpful in designing curricula for university departments of speech to teach students ways to overcome CA and become more confident speakers. Even with all the research that has been completed to develop these curricula, every department can enhance its ability to serve this large apprehensive

population through research to assess whether that school's public speaking education program is effective at reducing CA.

For this reason, the current study (n=161) has set forth and tested a speech program at a mid-size Midwestern university, not only to examine the effectiveness of that program, but to lay the methodological groundwork for other institutions of higher learning to assess their programs, as well. Studying whether the course is effective is vital because there are so many negative consequences for people who struggle with high levels of CA. Some of these symptoms are heart palpitations, dizziness, excessive worry, sweating, confusion (loss of words) (DSM-IV-TR, APA, 2000), (Hunter, 2009). Much of people's communication impacts job success. Public speaking is a task that will be performed during work and school for most people (McCourt, 2007). Many people are asked to give presentations at work and in class or to discuss with a superior how certain projects are going. All of this requires effective communication. No one wants to go into a meeting not knowing what to say or how to say it. Communication apprehension can cause a person to fear these situations making them very difficult and many times causing negative outcomes for those people involved, including the speaker. Therefore, communicating in a confident and effective manner is vital.

The university involved in this study has implemented a "Fundamentals of Speech" class that all students are required to take in order to help each student to overcome CA and enhance potential for career success. The following section discusses the literature which underpinned the PRPSA assessment of students in the "Fundamentals of Speech" class.

## LITERATURE REVIEW

The Diagnostic and Statistical Manual of Mental Disorders 4th edition, text revision, (DSM-IV-TR) (2000) provides the standard definitions for the psychological helping professions. This manual discusses a disorder known as Generalized Social Anxiety Disorder (GSAD), which it defines as facing stimuli in daily social situations that cause a person to feel anxious about that situation(s) (DSM-IV-TR, APA, 2000). McCourt further states that this anxiety can result from public performances as well. "The most common [form] is Public Speaking Anxiety" (2007, p.6), which can be defined as the fear of speaking in front of a group of people.

Despite all of the negative aspects of public speaking anxiety previously listed, one positive aspect of this disorder is that it can be treated. According to Hunter (2009), a number of communication scholars have studied this disorder and have found three main approaches to its treatment: system desensitization, cognitive restructuring, and competence/skill-building approach. These approaches are often combined to maximize their effects and enhance long-term results.

## SYSTEMATIC DESENSITIZATION

The first approach is a type of behavior therapy; "systematic desensitization" aims to reduce anxiety (Pedersen 1980). Systematic desensitization is defined by Hunter (2009) as "the

effort to engage, repeatedly, in the same apprehension-causing exercise or event in order to decrease its novelty and increase comfort with that activity” (p. 1). This approach is designed as a hierarchical system that gradually reduces the persons stress by using relaxation techniques as the person gradually reaches higher and higher levels of exposure to the stressing stimulus without his or her usual level of stress. This type of “exposure” therapy has been utilized by psychotherapists to treat phobias from spiders to fear of flying, and it is also an essential element in building competence as well as confidence in public speaking in the college classroom. While systematic desensitization is vital to helping people overcome their public speaking anxiety, Hunter and other scholars agree that it, alone, is rarely effective in creating longterm change in CA. The second approach discussed is “cognitive restructuring.”

## COGNITIVE RESTRUCTURING

Fremoum and Scott (1979) say that cognitive restructuring is defined as a “systematic technique that alters the cognitive dimension of anxiety” (p. 130). For this technique, those people who have high levels of CA will meet with a trainer to identify the participants’ weaknesses and negative “self-talk” and rebuild and replace them with positive thoughts. Stein and Hollander (2002) assert that cognitive intervention is vital to the patient’s success in overcoming Public Speaking Anxiety Disorder. Cognitive-behavioral theory as discussed by Rodebaugh, Heimberg, and Hallaway (2004) utilizes a balance of both cognitive restructuring and systematic desensitization. Cognitive restructuring occurs when the apprehensive individual is taught new ways of thinking about the apprehensive situation or stimulus, in this case public speaking situations and events. The student or client is taught to rephrase commonly-held negative beliefs and statements such as “I am afraid of public speaking,” or “I hate speaking in front of people,” to say things such as “I am learning techniques that are making me a more competent speaker,” or “I have a lot to teach others about this subject” (Hunter, 2009, p. 2).

Newman and colleagues (1994) further this notion that treating Social Anxiety Disorder using a combination of behavioral techniques and cognitive restructuring. Nutt and Ballenger (2003) explain that social anxiety disorder has three problematic symptom areas which can be targeted by cognitive-behavioral therapies. Those three areas are physical, cognitive, and behavioral. These authors list several of the physiological responses that occur in situations laden with anxiety, including speaking for those with Public Speaking Anxiety Disorder. The symptoms include sweating, shaking, increased heart rate, and tension in the speaker’s muscles—commonly known as the “fight or flight syndrome” because it is the physical response to fear that enables one to “fight or flee from” that which he or she fears (Hunter, 2009). The cognitive aspects are addressed as well; they include irrational beliefs and negative self-evaluations (Nutt and Ballenger, 2003).

The aforementioned techniques of overcoming CA, systematic desensitization and cognitive restructuring, provide a portion of the approach utilized by educators of public speaking. Every time a student gives a speech, or even discusses his or her topic, ideas, or source material with the instructor or with other students, he or she is engaging in systematic desensitization. When an instructor provides encouraging feedback along with critique,



cognitive restructuring is also enhanced. In the department studied, all instructors are required to undergo a one-week-long workshop to “calibrate” their instruction, enabling a truly standardized experience for the more than 1200 students per semester who take the course at that institution, alone. Part of this instruction includes workshop on creating useful and reliable feedback for student speeches. Instructors are advised to make at least 1-2 positive comments about a students’ speech for every negative comment in order to help build confidence.

## SKILLS TRAINING

The third and final approach utilized by the university public speaking program examined in this study also provides a major portion of the instructors’ assistance in helping their students to achieve greater confidence in public speaking. That approach is the competence/ skill-building approach, which consists of building a person’s public speaking knowledge and skillset in order to reduce communication anxiety (Westwick, 2003). It includes the enhanced competency that occurs through the use of studying and being tested on the classroom concepts taught through the reading of the course textbook, participation in class lectures and exercises, and, perhaps most importantly, the incrementally-increasing level of difficulty of the public speaking assignments the students perform.

The fundamentals of speech courses at this large Midwestern University, in which the research was conducted, use this three-pronged approach, melding techniques of systematic desensitization with cognitive restructuring and skill-building in order to help students to reduce public speaking anxiety.

A preponderance of the aforementioned literature leads to the following hypothesis and research question:

## HYPOTHESIS AND RESEARCH QUESTION

**H1:** Fundamentals of Speech students will have significantly lower measurements of Communication Apprehension upon completion of the class than they had upon entering the course.

**RQ1:** How do demographics such as gender, age, and year in school affect the course’s impact on CA?

## METHODOLOGY

This section covers the methodology for the research that was conducted by the research team. The section includes: 1.) the sample group 2.) the procedure 3.) the instrumentation and 4.) the data analysis.

### *Sampling*

A convenience sample was drawn in order to assess the CA of students in the Fundamentals

of Speech course at a large Midwestern University. The sampling frame for the questionnaire included every student in every section of the class, about 1,200 students. Upon university approval of the planned procedures for human subjects research, all fundamentals students were offered 5 points of extra credit for completing the questionnaire once during the first two weeks of the fall semester, as well as a second time (a post-test) during the final week of the semester. The final sample of one hundred sixty-two ( $n=162$ ) students completed the questionnaire during both required timeframes.

### *Procedure*

Although the sample group was relatively small, the team was still able to retrieve usable data that can be generalized to a larger scale. McCourt's (2004) CA research at Eastern Michigan University, despite also having had a small number of participants, obtained useful and instructive results. The current study replicated part of McCourt's methodology in that, like her study, a survey measuring Public Speaking Anxiety was "given on a website to students enrolled in an introductory college speech course at the beginning of a semester and then again at the end of that semester." (p. 3). McCourt's study, like this one "expected that the experimental group, speech students [in her case] ( $N=31$ ), would display significantly lower scores on the Personal Report of Public Speaking Anxiety" (p. 3).

### *Instrumentation*

CA was operationalized for numerical analysis and pre-test/post-test comparison by utilizing Jim McCroskey's (1970) Personal Report of Public Speaking Anxiety (PRPSA) (see Appendix A) and some general demographic background information. The questions on the PRPSA are written on a 5-point Likert type scale, 1 being "strongly agree" and 5 being "strongly disagree" indicating how well each statement applies to the participant. This questionnaire consists of 34 statements that measure levels of anxiety that are solely speech related (see Appendix A). Each statement describes a personal characteristic such as "My thoughts become confused and jumbled when I am giving a speech." The valence of the items is switched so that some items are phrased in such a way as to indicate that an answer of "1" equals the highest level of anxiety ("While giving a speech I get so nervous I forget facts I really know."), while others indicate high anxiety if the answer is "5" ("I have no fear of giving a speech."). The reason for this variation is to avoid a "response-set pattern" in which the respondents simply give a pat answer for every question. The score for the instrument is totaled using a mathematical formula that accounts for these differing valences.

The results indicate whether the person has high, moderate, or low anxiety. Any number above 131 specifies that the participant has a high level of anxiety while scores between 98 and 131 indicate moderate anxiety. Low anxiety is marked by any score below 98. According to McCroskey's survey, the average citizen of the United States has a score of 114.6 which indicates a level of anxiety which lies within the moderate range. In a study by McCroskey, the questionnaire has proven to be highly reliable (McCroskey, 1970).

In addition to the 34-question PRPSA, the remainder of the questionnaire that was used for this research was specifically designed for the study at hand, including questions that assessed the demographic make-up of the sample group. The background information requested included name, identification number, degree, instructor's name and section

number, gender, age, year in college, how many years of speech classes the respondent had before entering college, how many years of speech activities (e.g., debate, oral interpretation, FFA speaking events) the respondent had in high school, how many times the respondents had registered for or attempted to take “Fundamentals of Speech” before the current semester, how many colleges had the respondent attended before attending this university, and why the respondent chose to take the class in the format that he or she did (on campus vs. online). All participants were assured that this information would be used by the researchers only.

### *Data Analysis*

After the questions for the questionnaire were compiled, they were entered into a survey created with QuestionPro (an online site for developing surveys). By using this program the survey could be quickly and easily distributed to all the students. No log-in is required, so the students were not deterred by fearing what they might be signing up for. A link to the survey along with the implied consent letter necessitated for human subjects research was emailed to each “Fundamentals of Speaking” instructor, who then emailed the letter with the link to all of their students and announced the extra credit opportunity in their classes. Instructors were asked to encourage their students to take the survey.

Following the allotted time for the students to take the survey, the results from QuestionPro were exported to a Microsoft Excel file. After deleting the incomplete surveys, the final PRPSA scores of the students were calculated by using the formula given by Jim McCroskey (1984). At the end of the semester, during the final week of class, the students were offered the exact same survey again and reminded that the extra credit required their taking the questionnaire during both timeframes. At the end of that time period, the same procedure was followed to export the completed data from QuestionPro to another Excel file, again necessitating deletion of any incomplete surveys followed by calculation of the final scores. The data were grouped by participant, so that only the students who completed the PRPSA both times would be included in the sample. The files were sorted by identification number in numerical order in one Excel file and by names in alphabetical order in another and then assessed by hand to ensure that students who reported their names differently on each PRPSA were not inadvertently deleted from the dataset. Finally, data were entered into SPSS© for data analysis and table configuration. The next section will discuss the results and discussion of this analysis.

## **RESULTS**

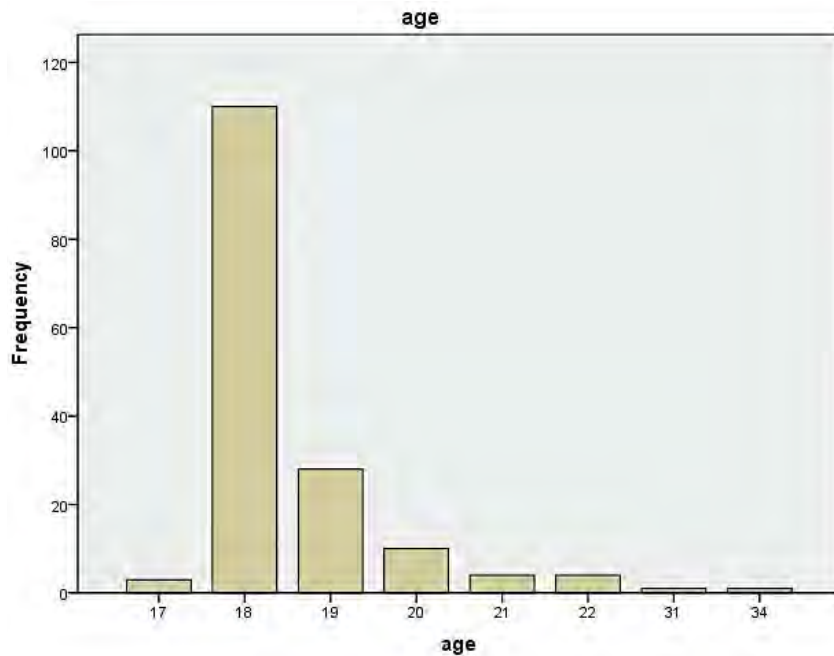
### *Demographic Information*

Demographic information including gender, age, and year in school was assessed for the sample. A relatively equal number of males (n=65) and females (n=96) took part in this study, although females did make up a higher percentage of the students taking the survey (see Table 1 and Figure 1 below). Perhaps there were more females registered for the class, or the females may have been more worried about their grades or class performance, males may have had other priorities. In future studies, the team may look into some of these reasons to find out why more women took the survey than men.

**Table 1:** Gender representation in the sample.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	males	65	40.1	40.4	40.4
	females	96	59.3	59.6	100.0
	Total	161	99.4	100.0	
Missing	System	1	.6		
Total		162	100.0		

Figure 1 shows a graphic representation to demonstrate the difference in the number of males versus the number of females who engaged in this study. (See Figure 1 below)



**Figure 1:** Histogram showing gender representation in sample.

There were a wide range of ages of the students that participated in this survey. The majority of the students (n=110) were 18 years old (see Tables 2 and 3 and Figure 2 below). The Fundamentals of Speech course at this institution is a freshman level course and it is encouraged that students take it as a freshman. The encouragement from faculty and advisors

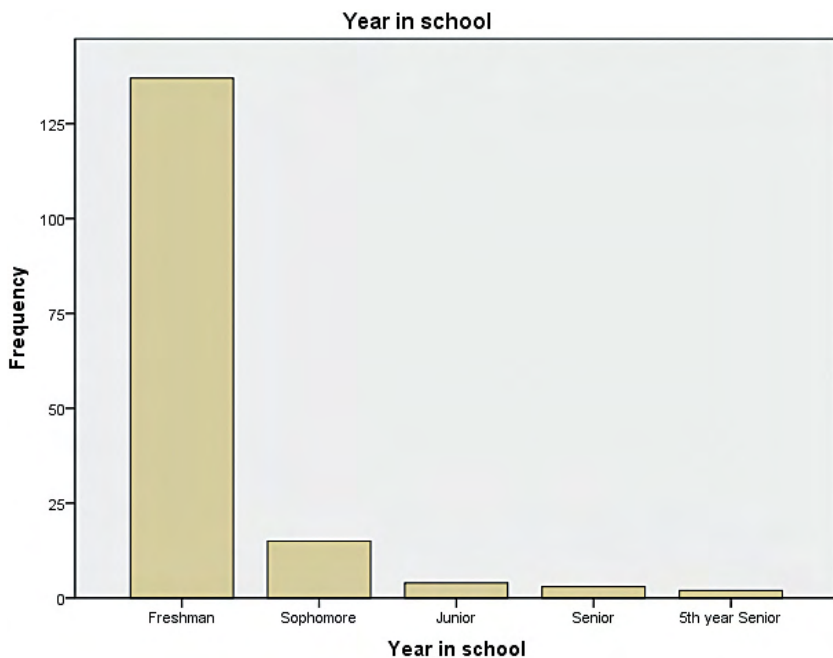
as well as the level of the class is one reason why the majority of the people in the class are 18 when taking it as they took it upon completion of their high school degree. Some of the students were older, the oldest being 34 years old. The explanation for the older students in the class are those people who may have dropped out of high school and later went back to get a GED and a college degree or maybe some reason prevented them from attending college straight out of high school and so they have decided to return several years later. It would be very interesting to study the difference in CA between those younger and older students.

**Table 2:** Age statistics in sample.

age		
N	Valid	161
	Missing	1
Mean		18.63
Median		18.00
Mode		18
Std. Deviation		1.822
Variance		3.321
Range		17
Minimum		17

**Table 3:** Age representation in sample.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	17	3	1.9	1.9	1.9
	18	110	67.9	68.3	70.2
	19	28	17.3	17.4	87.6
	20	10	6.2	6.2	93.8
	21	4	2.5	2.5	96.3
	22	4	2.5	2.5	98.8
	31	1	.6	.6	99.4
	34	1	.6	.6	100.0
	Total	161	99.4	100.0	
Missing	System	1	.6		
Total		162	100.0		



**Figure 2:** Histogram showing age representation in sample.

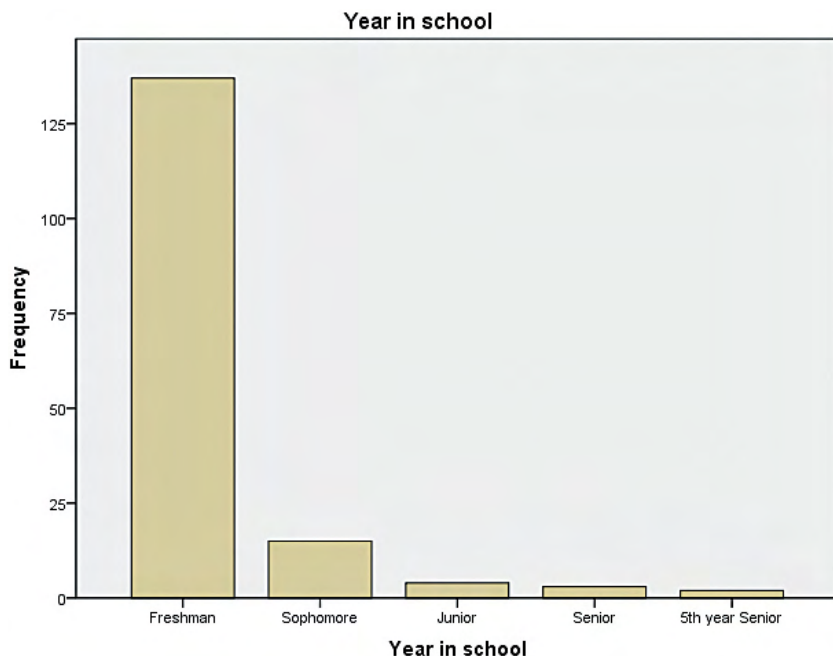
Over eighty four percent of the students were freshmen at the time of taking this survey (n=137) (see Tables 4 and 5 and Figure 3 below). As discussed earlier in regards to age, many of the students were just beginning college following graduation of high school. Because this class is required for graduation from this university, every student must take it. For this reason some of the students took it during a year other than their freshman year. The reasons are multiple as to why they would have waited: maybe some had a high level of CA, maybe others wanted an easy class later in their degree plan, or possibly the course had not fit into their plans of study during their first year. It would be interesting to study how the levels of CA in those who waited to take the class differ from those who took it right away their first year.

**Table 4:** Year in School.

N	Valid	161
	Missing	1
Mean		1.2484
Median		1.0000
Mode		1.00
Std. Deviation		.70738
Variance		.500
Range		4.00
Minimum		1.00

**Table 5:** Year in school representation in sample.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Freshman	137	84.6	85.1	85.1
	Sophomore	15	9.3	9.3	94.4
	Junior	4	2.5	2.5	96.9
	Senior	3	1.9	1.9	98.8
	5th year Senior	2	1.2	1.2	100.0
	Total	161	99.4	100.0	
Missing	System	1	.6		
Total		162	100.0		



**Figure 3:** Histogram showing year in school representation in sample.

### *Hypothesis Testing and Research Question findings*

This study's Research Hypothesis stated that "Fundamentals of Speaking students will have significantly lower measurements of Communication Apprehension upon completion of the class than they had upon entering the course." The hypothesis was supported. In order to analyze results to test this hypothesis, means were computed for the pre-test PRPSA scores for the 162 students in the sample, and then for the post-test PRPSA scores for the same students. These means were then compared by performing a t-test. A t-test computes the difference of means from separate groups within the study. For example in this study, the t-test compares the means from the pre – and post- test results. The means for this study are as follows: pre-test=113.1700 and post-test=99.9600. The mean of the pre-test minus the mean of the post-test is 13.2100. A significant difference was found for this sample of students between their mean PRPSA scores in the pre-test versus that on the post-test ( $t(322) = 5.5908, p < 0.0001$ ). The post-test mean of 99.9600 ( $sd=21.3400$ ) was significantly less than the pre-test mean of 113.1700 ( $sd=21.1900$ ). In the Social Sciences, an alpha level (p-value) of .05 or less is considered statistically significant.

In addition to the hypothesis tested, a research question was posed regarding whether demographics such as gender, age, and year in school affected the "Fundamentals of Speaking" class's impact on CA in any way. While no significant differences were found for students of different ages or years in college, findings indicated that the females who took the



PRPSA had significantly higher levels of CA in the beginning than did the males. However, after comparing the results of the second survey, both the males and females tested on average more similarly, lacking significance in the difference between their PRPSA means.

Males had an average pre-test score of 105.1700 and females has a pre-test score of 118.6900 (see Table 6 below). A t-test was showed these means to be significantly different, ( $t(159) = 4.16, p < 0.0001$ ). As mentioned previously, in the Social Sciences, an alpha level (p-value) of .05 is considered statistically significant. The two-tailed P-value is less than 0.0001. By conventional criteria, this difference is considered to be extremely statistically significant.

**Table 6:** PRPSA pre-test men vs. women.

Gender	Mean	N	Std. Deviation	Minimum	Maximum
Males	105.1692	65	21.53309	54.00	156.00
Females	118.6875	96	19.31420	72.00	159.00
Total	113.2298	161	21.24213	54.00	159.00

The post-test averages, however, did not significantly differ between males and females (male mean= 96.0500 and female mean=102.4400) (see Table 7 below). The post-test scores were calculated in the same way.  $T=1.8800$  and  $df=158$  ( $t(158)=1.8800, p=.06$ ). This p-value of .06 is not considered to be statistically significant.

**Table 7:** PRPSA post-test men vs. women.

Gender	Mean	N	Std. Deviation
Male	96.0455	66	18.58323
Female	102.4362	94	22.91525
Total	99.8000	160	21.40734

## DISCUSSION

Because the comparison of pre-test to post-test means showed a statistically-significant decrease in PRPSA scores upon completion of the course compared to scores upon first entering the course, the Research Hypothesis is confirmed. Hence, the researcher can conclude that the tested system of teaching the Fundamentals of Speaking course is successful at lowering Communication Apprehension by an average of 13.2100 points.

In addition, the research question data shows that women had higher levels of communication apprehension before learning techniques to cope with that anxiety, but that after training and guidance, they were at the same levels as men who had had the same training and guidance. Friedrich (1970) had obtained similar findings, that females tested higher for CA than did males.

Many causes would likely be found for why women have an initial level of CA that is significantly higher than their male counterparts. These causes could range from the

difference in the way that males and females are raised to men possibly being less worried about judgment from people than women are. Finding out these reasons would be a whole separate study. While this study did not address this topic it is an area of interest for future studies. Being as how women have higher levels of CA initially makes their education much more vital and important. This is not to discount the benefit for the males taking the fundamentals of speech course, but women statistically benefit more than men do from speech training.

In looking forward to the future of how this study can be used again, some limitations and future directions are addressed. Future research might involve giving the survey three times instead of two, testing the students before coming to campus, at the beginning of class, and a third time at the end of the semester. This will allow for assessment regarding whether the initial anxiety results from actual CA, or if it stems from being new to the college environment, or from hearing the challenging requirements of the course syllabus for the first time. This approach would test all incoming freshman, thus increasing the study's sample size. With university administrative permission, making the survey mandatory rather than optional would give the team a much larger sample group.

Limitations of this study include the absence of a control group; the study being limited to the Midwest; the relatively small participant group; the self-reporting nature of the PRPSA data, and the fact that the researcher does not know the causes of the subjects' reported CA. The absence of a control group limits the study in that it cannot be ascertained that the treatment (the "Fundamentals of Speaking" course) is the only factor decreasing significantly the students' levels of public speaking anxiety. Since nearly all of the participants were first-semester freshman, the research may also be measuring the confidence that is likely to accompany the college experience, rather than the effects of the course, itself, alone. In further studies, all incoming freshman will be tested before they even arrive on campus, once they have been in classes for a few weeks and finally at the end of the semester. This process will eliminate the questions that have developed. In the future, this research could be performed on a large scale in different parts of the country. Some skeptics may say that the results are only typical of the Midwest but giving the survey in several areas of the country would allow the research to reflect the general population of the United States. Of course, increasing the participant group would strengthen the predictive power of the results, making them more meaningful.

Another potential limitation regards the question of whether the online test was the best way to gather the necessary information. Perhaps a richer analysis could be derived through in depth interviews, or a triangulation of these two methods. Additionally, adding qualitative measures for data gathering and analysis would aid the researcher in ascertaining the causes of the CA, as well as, perhaps, offering a way to validate the PRPSA's findings. A potential explanation for the fact that females' scores were initially higher than males' could lie in one licensed social worker's assessment (Denise Hunter, personal communication, May 29, 20011) that men perceive weakness in reporting phenomena such as apprehension and fear, while women are more likely to be not only comfortable reporting these feelings and reactions, but actually more likely to want to report them so that they can work through them.

A final concern regards what happened to the people who have extremely high communication apprehension. It is possible that those people either dropped the class,

dropped out of college completely, or may even “self-select” to avoid college altogether, making availability for assessment of these extreme cases of CA challenging, at best. The current study did not track this because the only cases that were analyzed were students who took the survey twice. Had any of these possibilities occurred the results may have been skewed. Future research might attempt to gather a sample of such highly apprehensive subjects in order to test the treatment’s effects given that demographic.

## CONCLUSION

Public speaking anxiety is a highly common disorder that impacts the life satisfaction and career success of many of its sufferers. However, through treatment that involves a three-pronged approach of systematic desensitization, cognitive restructuring, and skills-training, much of the negative impact of this dilemma can be lessened. The findings of this study supported the true importance of the fundamentals of speech course at the university level, as well as the particular methods utilized by the institution studied.

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## APPENDIX A – PERSONAL REPORT OF PUBLIC SPEAKING ANXIETY (PRPSA)\*

**Directions:** This instrument is composed of thirty four statements concerning feelings about communicating with other people. Indicate the degree to which the statements apply to you by marking whether you (1) strongly agree, (2) agree, (3) are undecided, (4) disagree, or (S) strongly disagree with each statement. Work quickly; just record your first impression.

1. \_\_\_\_ While preparing for giving a speech I feel tense and nervous.
2. \_\_\_\_ I feel tense when I see the words speech and public speech on a course outline when studying.
3. \_\_\_\_ My thoughts become confused and jumbled when I am giving a speech.
4. \_\_\_\_ Right after giving a speech I feel that I have had a pleasant experience.
5. \_\_\_\_ I get anxious when I think about a speech coming up.
6. \_\_\_\_ I have no fear of giving a speech.
7. \_\_\_\_ Although I am nervous just before starting a speech, I soon settle down after starting and feel calm and comfortable.
8. \_\_\_\_ I look forward to giving a speech.
9. \_\_\_\_ When the instructor announces a speaking assignment in class I can feel myself getting tense.
10. \_\_\_\_ My hands tremble when I am giving a speech.
11. \_\_\_\_ I feel relaxed while giving a speech.
12. \_\_\_\_ I enjoy preparing for a speech.
13. \_\_\_\_ I am in constant fear of forgetting what I prepared to say.
14. \_\_\_\_ I get anxious if someone asks me something about my topic that I do not know.
15. \_\_\_\_ I face the prospect of giving a speech with confidence.
16. \_\_\_\_ I feel that I am in complete possession of myself while giving a speech.
17. \_\_\_\_ My mind is clear when giving a speech.
18. \_\_\_\_ I do not dread giving a speech.
19. \_\_\_\_ I perspire just before starting a speech.
20. \_\_\_\_ My heart beats very fast just as I start a speech.
21. \_\_\_\_ I experience considerable anxiety sitting in the room just before my speech starts.
22. \_\_\_\_ Certain parts of my body feel very tense and rigid while giving a speech.
23. \_\_\_\_ Realizing that only a little time remains in a speech makes me very tense and anxious.
24. \_\_\_\_ While giving a speech I know I can control my feelings of tension and stress.
25. \_\_\_\_ I breathe faster just before starting a speech.
26. \_\_\_\_ I feel comfortable and relaxed in the hour or so just before giving a speech.
27. \_\_\_\_ I do poorer on speeches because I am anxious.
28. \_\_\_\_ I feel anxious when the teacher announces the date of a speaking assignment.
29. \_\_\_\_ When I make a mistake while giving a speech, I find it hard to concentrate on the parts that follow.
30. \_\_\_\_ During an important speech I experience a feeling of helplessness building up inside me.

31. \_\_\_\_\_ I have trouble falling asleep the night before a speech.  
 32. \_\_\_\_\_ My heart beats very fast while I present a speech.  
 33. \_\_\_\_\_ I feel anxious while waiting to give my speech.  
 34. \_\_\_\_\_ While giving a speech I get so nervous I forget facts I really know.

To determine your score on the PRPSA, complete the following steps:

1. Add the scores for items 1, 2, 3, 5, 9, 10, 13, 14, 19, 20, 21, 22, 23, 25, 27, 28, 29, 30, 31, 32, 33, and 34.

2. Add the scores for items 4, 6, 7, 8, 11, 12, 15, 16, 17, 18, 24, & 26.

3. Complete the following formula:  $PRPSA = 132 - (\text{total from step 1}) + (\text{total from step 2})$ .

4. Your score on the PRPSA can range between 34 and 170:

**34-84** indicate a very low anxiety about public speaking.

**85-92** indicate a moderately low level of anxiety about public speaking.

**93-110** suggests moderate anxiety in most public speaking situations but not so severe that the individual cannot cope and be a successful speaker.

**111-119** suggest a moderately high anxiety about public speaking. People with such scores will tend to avoid public speaking.

**120-170** indicate a very high anxiety about public speaking. People with these scores will go to considerable lengths to avoid all types of public speaking situations.

Your score: \_\_\_\_\_

\*The PRPSA was taken from McCroskey and Virginia P. Richmond, *Communication: Apprehension, Avoidance, and Effectiveness*, Third Edition (Scottsdale, AZ: Gorsuch Scarisbrick, Publishers, 1992) pp. 127-128.

# Residual Stress Analysis of Composite Cannon Barrel

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Department: Mechanical Engineering Department

## ABSTRACT

The objective of this paper is to describe the process and results of a residual stress analysis done on a composite cannon barrel. A cross section of a full cannon barrel was cut off to be used in the analysis. The barrel cross section was composed of an inner steel layer that was wrapped in an outer composite layer.

The residual stress analysis was done using x-ray diffraction (XRD). The XRD machine uses different types of x-ray tubes based on what material it is analyzing. For this reason, the first portion of the experiment dealt with finding the exact material of the inner steel layer of the barrel. It was concluded that the majority of the barrel was composed of iron. This meant that a chromium x-ray tube had to be used in the XRD machine. Once the material composition was found, the next step was to determine how much the barrel needed to be polished down before accurate readings could be obtained. The reason this is necessary is because the cutting of the barrel would introduce stress into the system through the friction from the blade. By chemically eating away the metal, a depth in the material could be obtained where the residual stress level was not affected by the cutting. The results showed that at a depth of 200 microns or greater, accurate results were obtained. It was also observed that the inner portion of the barrel was in compression while the outer was in tension. Once the barrel was analyzed, the outer composite layer was cut off. It was predicted that the material in the inner steel layer would relax if the outer layer was removed. When placed in the XRD machine, the hypothesis was confirmed. The inner ring of the steel layer went from -396 MPa to -300 MPa, but the residual stress in the outer layer did not change.

## INTRODUCTION

Residual stress is stress that remains in a material after the original cause of the stress has been removed. Common forms of this initial stress are usually from the manufacturing process-e.g. forging, extruding, plating, bending, and welding. Stress can also be introduced into a material from outside forces. It can be generated after plastic deformation caused by applied mechanical loads, thermal loads, or phase changes such as the material expanding or contracting due to exposure to extreme heat or cold [1,2].

When a material has a positive residual stress, it means that it has a tensile residual stress. This means that the material is pulling apart. This could help to open a crack and increase crack propagation. When a material has a negative residual stress, it means that it

has a compressive residual stress. The material is pressed together which in turn will help to close a crack and slow crack propagation.

It is important to monitor residual stress because it may help predict life expectancy of a part. By controlling the amount of residual stress in a material during the manufacturing process, it can help extend the part's life. This is why it is beneficial not only to control the amount of residual stress, but also to attempt to obtain a negative residual stress value during the manufacturing process [2].

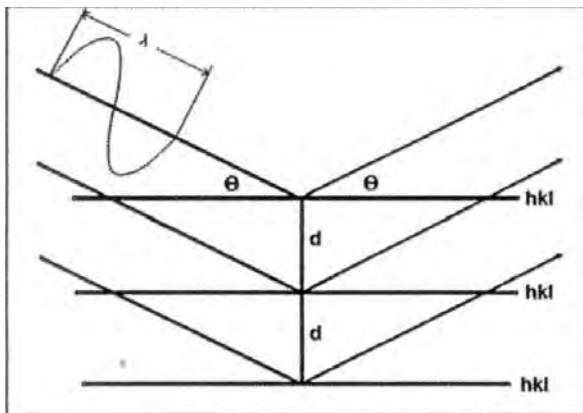
Cannon barrels are subjected to extreme heat and pressure changes due to the rounds being fired through them. With each round, more stress is placed on the barrel and increases the amount of residual stress in the barrel material. Eventually, enough stress will cause surface defects or cracks along the inner surface of the barrel. This could potentially set off a round traveling through the cannon which could cause severe equipment damage and/or loss of life. Currently, the Department of Defense is replacing the barrels after a set number of rounds have been fired. By comparing the residual stress in a barrel to the amount of rounds that have been fired through it, the life expectancy can be more accurately predicted.

A cross section of a cannon barrel was analyzed for this project. The barrel consists of an inner steel layer that is wrapped in an outer carbon fiber composite outer layer. The goal of this project is to analyze the residual stress content of the barrel, and how the composite layer affects the inner steel layer.

## DEVELOPMENT OF THEORY

### *Bragg's Law*

Bragg's law explains why crystal lattices will reflect x-ray beams at certain angles of incidence. It is used to measure the distance between atomic layers in a crystal plane. This is called the d-spacing. Figure 1 shows an example of an x-ray hitting a crystal plane. The x-ray strikes the plane at a certain angle  $\theta$  and reflects back at an angle of  $2\theta$  from the path that it was traveling [3]. Equation 1 relates the wavelength of an x-ray ( $\lambda$ ) and the angle at which the x-ray hits the surface plane ( $\theta$ ) to the distance between the atomic layers [4].



**Figure 1.** Complete Figure Definition of Bragg's Law [4].

$$\lambda = 2d_{hkl} \sin\theta \quad (1)$$

Where:

$\lambda$  = Wavelength of incident x-rays

$d_{hkl}$  = distance between crystal plane

$\theta$  = angle of incidence

### *X-Ray Diffraction (XRD) for Residual Stress Evaluation*

X-ray diffraction was used to measure the residual stress in the cannon barrel. X-ray diffraction works by first bombarding a part's surface with an x-ray source. The x-rays are diffracted by the atoms arranged periodically in the crystal lattice of the material. The angles of the diffracted x-ray beams are related to the spacing of the atoms in the crystal structure through Bragg's Law. The lattice spacing is calculated from the diffraction angle. The larger change of the d-spacing means a larger strain component and therefore a larger residual stress value. If the d-spacing of a material is greater than the equilibrium spacing, the material is in tension. The same is vice versa. If the d-spacing is less than equilibrium, the atoms in the material are closer. This means that the material is in a state of compression [2,5].

As stated in the introduction, residual stress is stress that remains in a material after the original cause of the stress has been removed. Figure 2 shows a surface plane of a given material. X-ray penetration is very shallow, less than 10 microns. Equation 2 calculates the strain in the material by using the changes in the distance between crystalline planes.  $d_0$  in equation 2 is the d-spacing that is assumed to have no residual stress. When the x-rays are bombarded perpendicular to the surface of the plane, the results obtained are assumed to be the original d-spacing of the material. This means this value is  $d_0$ .  $d_{\phi\psi}$  is the d-spacing in relation to the angle that the x-rays hit the surface. The angled x-rays will hit the grain of the



material differently and cause the strain readings to change. Equation 2 shows how the strain in the material is calculated using  $d_0$  and  $d_{\psi\phi}$ . The strain component is directly related to the residual stress as a result of Poisson's ratio and the modulus of elasticity seen in equation 3 [5].

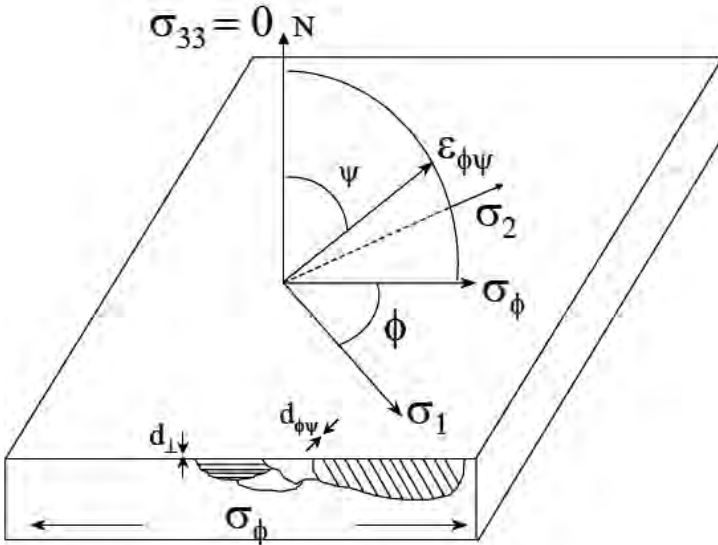


Figure 2. Plane Stresses Description for XRD Evaluation [5].

$$\epsilon_{\psi} = \frac{d_{\psi\phi} - d_0}{d_0} \tag{2}$$

Where:

- $\epsilon_{\psi}$  = Strain in the material
- $d_{\psi\phi}$  = Distance between crystal planes at a particular angle
- $d_0$  = Distance between crystal planes at 0 degree bombardment

$$\sigma_{\phi} = \frac{E}{(1+\nu)\sin^2(\psi)} \left( \frac{d_{\psi\phi} - d_0}{d_0} \right) \tag{3}$$

Where:

- $\sigma_{\phi}$  = Residual Stress in the material
- $E$  = Modulus of elasticity
- $\nu$  = Poisson's Ratio
- $d_{\psi\phi}$  = Distance between crystal planes at a particular angle
- $d_0$  = Distance between crystal planes at 0 degree bombardment

It is very beneficial to optimize the residual stress to some level. It is even better to manufacture the material so that it is in a state of compression. This is due to the fact that the

total stress experienced on a material is the sum of the residual stress and any applied stresses. This means that if an outside force (applied mechanical load, heating, etc.) was placed on the material, the total stress could be high enough that if additional stress was added, it could cause the part to break if it is past the yielding stress. If the residual stress is negative, it could allow the part to withstand more loading placed on it [2].

## EXPERIMENTAL APPARATUS AND PROCEDURE

### *Determining Material Composition*

The first step was to determine what material the inner steel layer of the barrel was. A Niton Alloy Analyzer from Thermo Scientific was used. This tool utilizes an x-ray fluorescence technique (XRF) to determine the element composition of what it is testing. It was predicted that the inner diameter of the barrel may have had some type of plating treatment done to it. For this reason, the inner diameter surface and the cross section of the barrel will both be tested.

### *Determining Proper Depth for Accurate Residual Stress Readings*

A cross-section of the barrel had to be cut off for the piece to be able to fit into the XRD machine. During the cutting process, heat was introduced into the part. Due to the friction, the residual stress readings could be affected. If the part was heated, it could cause a compressive force to release slightly. If there was a tensile residual stress, the additional heat could cause it to increase. To ensure accurate readings, a depth in the material would have to be found where the cutting had no effect. The barrel would have to be chemically eaten away through the use of a micro-polisher. A micro-polisher uses an electrolyte solution with a current running through it to chemically eat away the metal. This process would not introduce any stress into the system that could throw off the readings from the XRD machine. Accurate readings were determined when the amount of polishing had no effect on the residual stress. This means that once the data became consistent regardless of depth, the polishing was complete. The readings taken were the residual stresses at the inner and outer rings of the inner steel layer with the composite layer on the barrel.

### *Residual Stress Analysis of Cross Section without the Composite Layer*

Once the proper depth had been determined, the residual stress at the inner and outer rings on the cross section was recorded. The next step was to determine how the outer composite layer was affecting the inner steel layer. The outer layer had to be removed and the barrel had to be analyzed again.

## EXPERIMENTAL RESULTS AND INTERPRETATION

### *Determining Material Composition*

The results from the Niton Alloy Analyzer from the inner diameter of the barrel can be seen in table 1.

**Table 1:** Inner Diameter Material Composition

Fe (%)	Fe % Error	Cr (%)	Cr % Error	V (%)	V % Error	Ni (%)	Ni % Error	Pb (%)	Pb % Error	Mo (%)	Mo % Error
0.17 6	0.025	99.51 9	0.078	< LOD	0.04 6	< LOD	0.02 1	0.00 4	0.002	0.01 7	0.001
0.31 6	0.032	99.40 6	0.088	< LOD	0.05 1	< LOD	0.02 6	0.00 4	0.002	0.02 9	0.002
0.74 3	0.045	98.90 1	0.097	< LOD	0.05 4	< LOD	0.02 8	0.00 5	0.002	0.03 7	0.002
0.36 3	0.029	99.31 4	0.076	< LOD	0.04 4	< LOD	0.01 9	0.00 3	0.002	0.03 2	0.001
0.27 6	0.028	99.46 9	0.081	< LOD	0.04 7	< LOD	0.02 3	0.00 4	0.002	0.01 9	0.001

The results show that the material at the inner diameter of the barrel is almost entirely composed of chromium at 99.5%. It can be concluded from this that the barrel has a coating on it to eliminate corrosion. The barrel needed to be cut so the cross section side wall could be analyzed.

Table 2 shows the results from the Niton Alloy Analyzer when the barrel's cross section side wall was analyzed. It shows that the material in the barrel is comprised of about 92.5% Iron, 3.75% Nickel, 1.5% Chromium, 1% Mo, and 1.25% other. From this data, it was concluded that a Chromium x-ray tube was needed in the LXR machine since the majority of the barrel material was Iron.

**Table 2:** Barrel Cross Section Material Composition

Fe (%)	Fe % Error	Cr (%)	Cr % Error	V (%)	V % Error	Ni (%)	Ni % Error	Pb (%)	Pb % Error	Mo (%)	Mo % Error
92.85 7	0.37	1.62 9	0.035	0.27 2	0.01 9	3.68 5	0.11 7	< LOD	0.032	0.95 5	0.017
92.41 6	0.429	1.64 4	0.036	0.26 5	0.01 9	3.68 9	0.13 3	< LOD	0.038	0.94 4	0.02
92.26 6	0.41	1.70 3	0.036	0.26 5	0.01 8	3.72 8	0.13 1	< LOD	0.035	0.93 8	0.019
92.71 6	0.425	1.77 4	0.034	0.26 5	0.01 7	3.81 9	0.13 9	< LOD	0.036	0.94 4	0.02
92.90 2	0.419	1.62 4	0.021	0.25 5	0.01 5	3.70 5	0.13 7	< LOD	0.037	0.96 4	0.02

### *Residual Stress Measurement (Machine Calibration)*

When the powder sample (0 MPa residual stress) was placed in the LXR machine for calibration, the results showed that it had a residual stress level of 11.7 Mpa. Figure 3 shows the linear dependence of the d-spacing vs.  $\sin^2\psi$ . A horizontal line was produced because the d-spacing did not change in relation to the incident x-rays. This means that there was little to no residual stress in the calibration sample. A residual stress of 11.7 MPa was recorded, but this was within the standard deviation of the machine so it is an acceptable value for the 0 MPa stress sample.

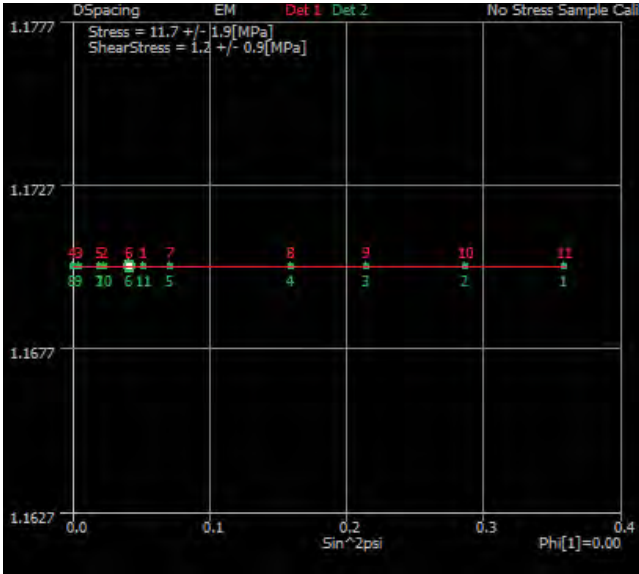


Figure 3. Calibration Results from Powder Sample

Figure 4 shows the linear dependence of the d-spacing vs.  $\sin^2\psi$  in the -526 MPa calibration sample. The graph shows that as the orientation of the grain change increases, the d-spacing in the crystal lattice of the material decreases. This is accurate since it is known that this sample is in compression. The results of the test showed that it had a residual stress of -510.1 MPa. This was within an acceptable range of deviation for the sample so it was determined that the machine was calibrated.

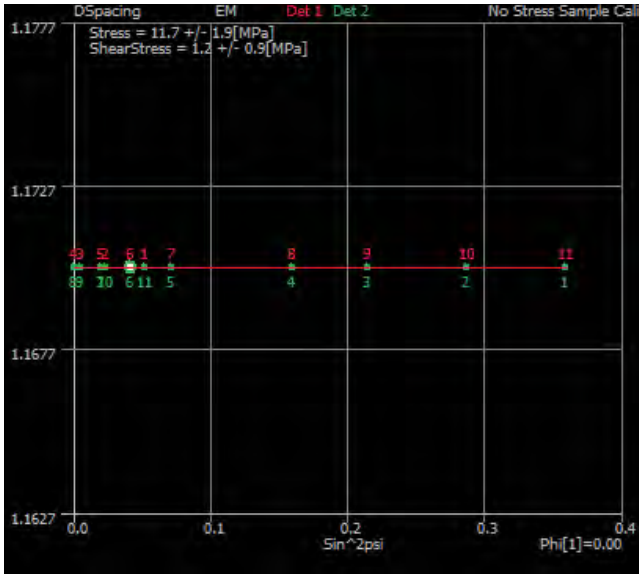


Figure 4. Calibration Results -526 MPa Sample

*Determining Proper Depth for Accurate Residual Stress Readings*

The locations on the outer and inner rings were done simultaneously. Figure 5 shows the location of the outer and inner holes that were polished.

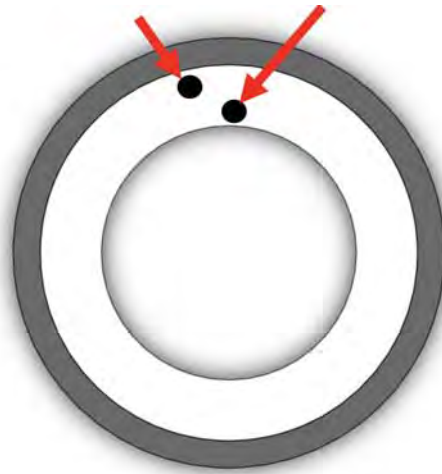


Figure 5. Schematic of Polished Locations

Figure 6 shows how the hoop residual stress readings changed as the depth in the material increased. At a depth of 0 microns, there is virtually no residual stress. This is due to the cutting of the cross section relaxing the material. As the depth increased, so did the amount of residual stress. At 200 microns, the residual stress starts to even out. A depth of 220 microns was attained and the results at this depth were similar to the results that were obtained at 200 microns. This shows that the outer ring on the barrel has a residual stress of 200 MPa, which means that the outer portion of the steel layer is in a state of tension.

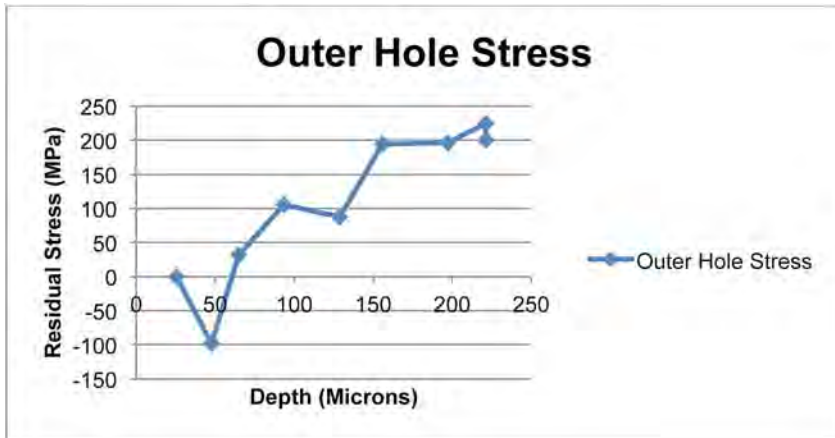


Figure 6. Outer Ring Hoop Residual Stress vs. Depth

Figure 7 shows the hoop shear stress on the outer ring of the steel layer. It initially has a shear stress of -60 MPa. As the depth increases, the shear stress begins to increase. At the 200 micron depth, the average shear stress is -2 MPa. This is a very small value which means there is no hoop shear stress in the barrel.

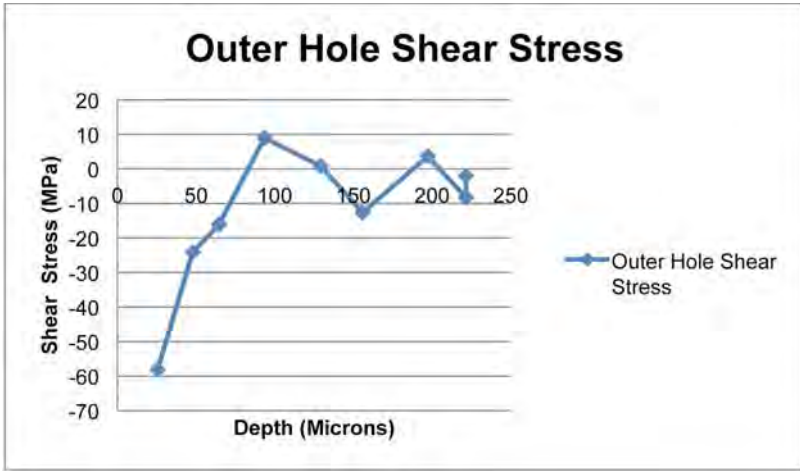


Figure 7. Outer Ring Hoop Shear Stress vs. Depth

Figure 8 shows how the hoop residual stress readings changed as the depth in the material increased on the hole in the inner ring of the steel layer. Before any material was polished away, the residual stress was about 0 MPa. As the barrel was polished down, the residual stress decreased. The residual stress values for this portion of the barrel were all negative. This means that the inner portion of the barrel was in a state of compression. Around 200 microns, the residual stress values began to level off. The residual stress level after this depth was about -396.64 MPa.

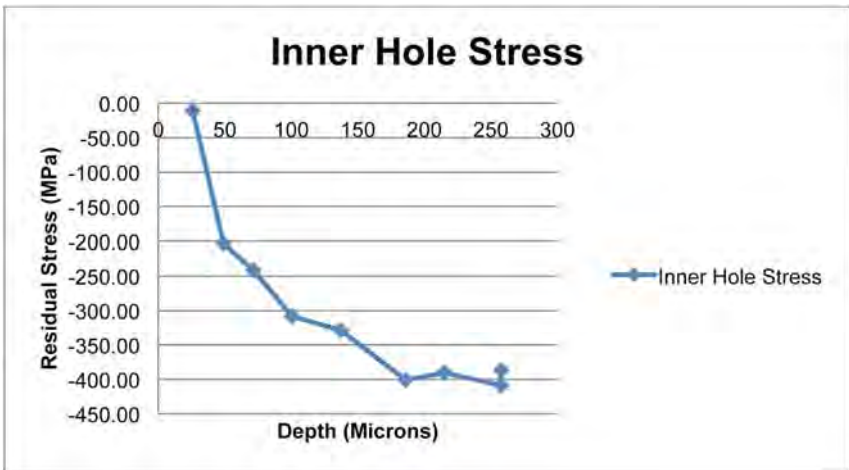


Figure 8. Inner Ring Hoop Residual Stress vs. Depth

Figure 9 shows the shear stress on the inner ring of the steel layer. It initially has a shear stress of -70 MPa. As the depth increases, the shear stress begins to increase. At the 200 micron depth, the average shear stress is -14 MPa. This is a very small value which means that there is no hoop shear stress in the barrel.

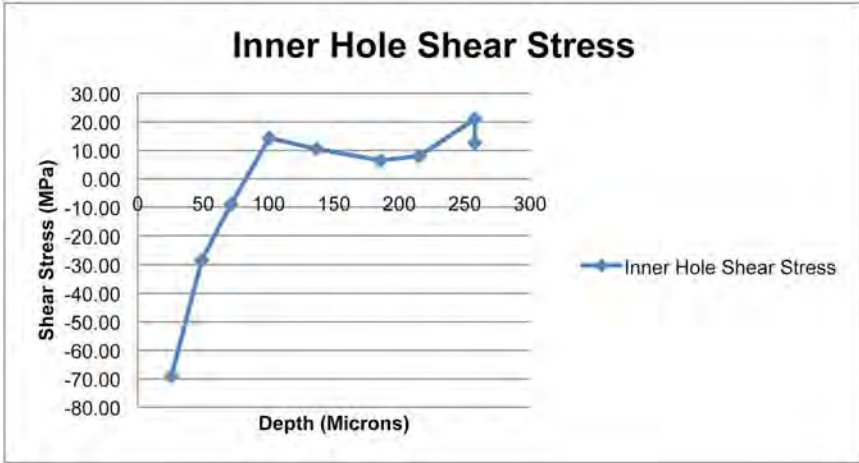


Figure 9. Inner Ring Hoop Shear Stress vs. Depth

Figure 10 shows a schematic of the vector stress distribution in the barrel. As shown by these results, the inner portion of the barrel was in compression with the maximum value being at the inner diameter of the bore. The stress increased with a larger radius until it hit its peak value at the outer diameter of the barrel.

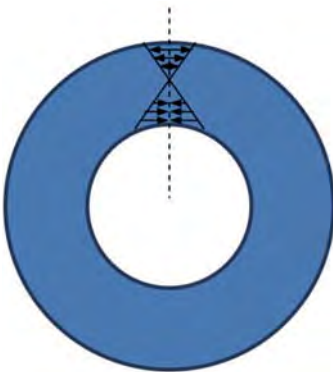


Figure 10. Schematic of Barrel Stress Vectors



*Residual Stress Analysis of Cross Section without the Composite Layer*

Once the residual stress was taken on the cross section, the outer composite layer was removed. Table 3 shows the data taken on the inner ring of the barrel with the composite layer removed.

**Table 3.** Inner Hole with No Composite Layer

Inner Hole	Normal Stress (MPa)	Standard Deviation	Shear Stress (MPa)	Standard Deviation
Hoop 1	-321.36	±8.95	8.51	±4.03
Hoop 2	-301.11	±12.92	-1.91	±5.82
Average	-311.24	Average	3.3	
Radial 1	103.65	±9.55	2.72	±4.30
Radial 2	84.16	±10.13	7.53	±4.56
Average	93.905	Average	5.125	

The average residual stress in the hoop direction is -311.24 MPa. The inner portion of the barrel is still in compression, but the material relaxed about 85 MPa from when the composite layer was on. The shear stress is about 3 MPa. With the standard deviation of the machine, anything within the range of positive or negative 14 MPa is considered to have no residual stress. Table 4 shows the data taken on the outer ring of the cannon barrel with the composite layer removed.

**Table 4:** Outer Hole with No Composite Layer

Outer Hole	Normal Stress (MPa)	Standard Deviation	Shear Stress (MPa)	Standard Deviation
Hoop 1	221.75	±13.94	12.26	±6.28
Hoop 2	223.61	±10.44	15.6	±4.70
Average	222.68	Average	13.93	
Radial 1	-47.54	±16.36	13.18	±7.37
Radial 2	-48.04	±14.65	8.95	±6.60
Average	-47.79	Average	11.065	

The outer layer is still in tension. It had an average residual stress of 222.68 MPa. This only increased by about 20 MPa. The results show that there is still no shear stress in the material.

Since the composite layer was removed, the surface on the outer diameter of the steel layer could be analyzed. A hole polished down to almost 400 microns. Table 5 shows the results of the top hole.

**Table 5:** Outer Surface Results

Top Hole	Normal Stress (MPa)	Standard Deviation	Shear Stress (MPa)	Standard Deviation
Hoop Deeper	222.16	±12.75	7.64	±5.74
Hoop 1	244.23	±18.25	-8.26	8.22
Hoop 2	215.42	±12.41	-3.57	±5.59
Average	229.825	Average	-5.915	

The results from this surface were very similar to the ones from the outer ring on the cross sectional side wall. The outer surface is in a state of tension with an average residual stress of 229.825 MPa and an average shear stress of -5.915 MPa, which means that there is still no shear stress.

## CONCLUSION

It can be seen from the alloy analyzer results that the composition of the barrel is primarily iron with a bit of nickel, chromium, and some other miscellaneous metals. It was also observed that the inner diameter of the barrel has chromium plating on it to help reduce corrosion and wear.

Once the machine was calibrated, the first step in measuring the residual stress on the barrel was to determine at what depth the machine would yield accurate results. Eight different depths were scanned and it was determined that at 200 microns, the residual stress measurement that was produced was not affected by the stress induced by the cutting of the barrel. This depth was to be used for all future residual stress measurements on this barrel cross section.

Once an accurate depth was determined and results were recorded for the inner and outer rings on the cross section, the outer composite layer was removed. The results showed that the material in the inner steel layer “relaxed” slightly. This means that the stress in the material became more positive due to it being in compression. The inner ring of the barrel increased its residual stress level by about 85 MPa while the outer layer does not change much.

From all of this, it can be seen that the barrel was manufactured to be in a state of compression to help combat the extreme pressure and temperatures it would experience during the firing of a shell. This would ultimately help to increase barrel life. The inner most portion of the barrel had a compressive residual stress. As you move outward on the barrel, the material starts moving toward a higher value of tensile residual stress. The results showed that the carbon fiber composite layer was helping to hold the entire barrel in a state of compression.

## ACKNOWLEDGEMENTS

Research was sponsored by Benet Laboratories on behalf of the US Army Contracting Command Joint Munitions & Lethality Contracting Center - and was accomplished under

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# VIBRATIONAL ANALYSIS OF AN ELECTROMECHANICAL TOOTHBRUSH

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Department: Mechanical Engineering

## ABSTRACT

The effectiveness of an electromechanical toothbrush is based entirely on its ability to remove plaque through vibrations. This paper contests that the three-dimensional motion of more inexpensive models of electromechanical toothbrushes can be accurately modeled in one-dimension so as to predict the motion of future toothbrush designs using simply the material properties, motor specifications, and grip design. Vibrational modeling, mathematical modeling, and experimentation were used in the analysis to confirm the outcome of the study and the assumptions of the model. *Keywords:* vibration analysis, electromechanical toothbrush.

## INTRODUCTION

Mechanical toothbrushes are becoming a common sight among household bathroom items. Closely following expensive models of any invention are more affordable versions which sometimes lack in quality. Colgate has developed many models of electromechanical toothbrushes which fit into the second category; however, using the science of vibrations and mathematical modeling it may be possible to design a toothbrush which is similar in cost, but opposite in quality.

To accomplish the design of an electromechanical toothbrush improved in quality, but without the increased price tag, a diagram must be constructed of the physical system. Once a diagram has been assembled, it may be decomposed and mathematical models can be constructed of the components. These mathematical models can be reconstructed allowing for a prediction of the vibrational motion of any toothbrush of similar design based solely on the materials on the toothbrush, the motor inside, and the design of the grip.

Standard engineering practice is to make certain accurate assumptions on a complex physical situation and to model that system according to those assumptions. Going a step further, a standard vibration principle is to take the developed model and simplify it until it can be solved through the most basic analysis. Once a model has been developed, it becomes necessary to confirm all assumptions through empirical data and observation.

## METHODS

In an electromechanical toothbrush there occur three-dimensional vibrations due to the use of a single, unbalanced motor to force the vibrations. The removal of plaque, on the other hand,

is dependent only on one-dimensional motion parallel with the surface of a tooth. As such, this analysis assumed that the three-dimensional motion of a mechanical toothbrush could be accurately modeled as one-dimensional motion.

Figure 1 shows the breakdown of the physical toothbrush into its correlating diagram. To arrange the diagram in such a way that basic vibration mathematical models can be applied, the neck and head must be modeled together followed by the user's hand and then the impact of the user's hand and handle on the upper portions of the toothbrush.

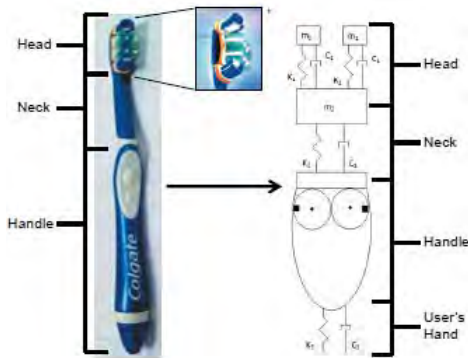


Figure 1. Diagram of Physical System [1]

*Neck and Head*

Beginning with the head and neck, the model is simplified through the process in Figure 2. The result of the supporting mathematical reduction of the head and neck are as follows:

$$m_{eq} = 2m_1 + m_2 \tag{1}$$

$$k_{eq} = \left( \frac{1}{2k_1} + \frac{1}{k_2} \right)^{-1} = \frac{2k_1k_2}{2k_1+k_2} \tag{2}$$

$$c_{eq} = \left( \frac{1}{2c_1} + \frac{1}{c_2} \right)^{-1} = \frac{2c_1c_2}{2c_1+c_2} \tag{3}$$

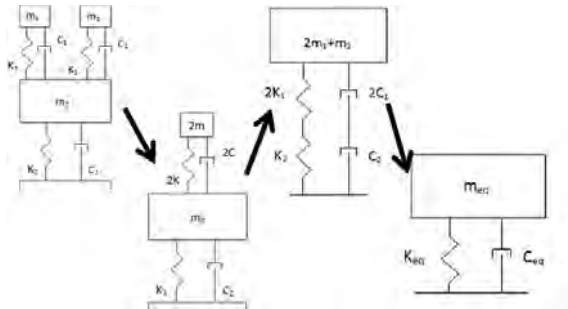


Figure 2. Head and Neck Diagram Reduction

In equation (1),  $m_1$  and  $m_2$  are mass of the head and the neck respectively;  $m_{eq}$  is equivalent mass of the head and the neck. In equation (2),  $k_1$  and  $k_2$  are the spring constants of the head and neck respectively while  $k_{eq}$  is the equivalent spring constant of the combined head a neck spring constants. Equation (3) is similar to the previous two equations where  $c_1$  and  $c_2$  are the damping coefficients of the head and neck respectively and  $c_{eq}$  is the equivalent damping coefficient of the head and neck.

Throughout the analysis in the paper, the use of terminology in the models will remain the same. The letter  $m$  represents a mass of some mechanical component, in this case, two small masses representing the multiple components on the toothbrush head seen in Figure 1 and the larger mass,  $m_{eq}$ , representing entirety of the mass from the hand grip to the head of the toothbrush. The letter  $k$  represents the vibrational property known as a spring constant. Springs are known for having a specific spring constant, but all materials have a spring constant value associated with them. The letter  $c$  represents the vibrational property known as the damping coefficient. This, like the spring constant, is both present in dampers as well as being a material property.

*User’s Hand and Handle*

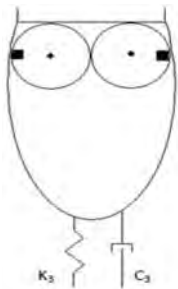
The vibration of the toothbrush is caused by an unbalanced motor near the grip of the toothbrush. This motor cannot, however, cause vibrations in free space. For vibrations to occur, the motor must be anchored to some fixed point. As the components of a toothbrush cannot be fixed to one another, the hand must act as the anchor. It is uncommon to consider the human body as a material, but for this analysis such a case must be examined. The spring constant and damping coefficient of the hand,  $k_3$  and  $c_3$  respectively, can be seen in Figure 3. The mathematical equations representing the unbalanced motor are seen below [4]:

$$M\ddot{y} + c_3\dot{y} + k_3y = me\omega^2 \sin(\omega t) \tag{4}$$

Resulting in

$$Y = \frac{me\omega^2}{[(k_3 - M\omega^2)^2 + (c_3\omega)^2]^{\frac{1}{2}}} \tag{5}$$

$$y(t) = Y \sin(\omega t - \phi) \tag{6}$$



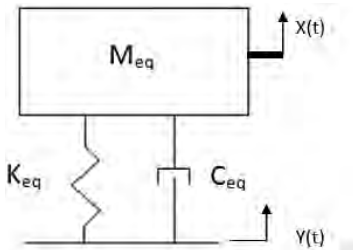
**Figure 3.** User’s Hand and Handle

In equation (4),  $M$  represents the mass of the toothbrush while  $m$  represents the mass of the unbalanced mass. Eccentricity, or  $e$ , refers to the distance which the unbalanced mass's center of gravity is rotating from the shaft of the motor. The  $\ddot{y}$ ,  $\dot{y}$ , and  $y$  terms refer to the acceleration, velocity, and displacement of the motor in a single plane of motion respectively. Finally,  $t$  represents time and the Greek letter  $\omega$  refers to the angular velocity of the motor and toothbrush.

In equations (5) and (6),  $Y$  represents the amplitude of the vibration caused by the rotation of the unbalanced motor,  $\varphi$  the phase shift of the vibration (negligible for these considerations), and  $y(t)$ , the resulting function for the unbalanced motor vibration.

### Final Equation

With the unbalanced motor interacting with the user's hand and the handle of the brush, an equation exists to model the motion of the lower portion of the brush. This harmonic motion in the base of the toothbrush must now be applied to the upper portion of the toothbrush as though the base is a simple plane experiencing a harmonic vibration. Figure 4 illustrates the harmonic motion and the resulting force in the upper portion of the brush.



**Figure 4.** Base Vibration Forcing Upper Toothbrush

The following are equations describing this base vibration [4]:

$$m_{eq}\ddot{x} + c_{eq}(\dot{x} - \dot{y}) + k_{eq}(x - y) = 0 \quad (7)$$

$$m_{eq}\ddot{x} + c_{eq}\dot{x} + k_{eq}x = k_{eq}y + c_{eq}\dot{y} = k_{eq}Y\sin(\omega t) + c_{eq}\omega Y\cos(\omega t) \quad (8)$$

$$k_{eq}Y\sin(\omega t) + c_{eq}\omega Y\cos(\omega t) = A\sin(\omega t - \alpha) \quad (9)$$

$$A = Y\sqrt{k_{eq}^2 + (c_{eq}\omega)^2} \quad (10)$$

$$\alpha = \tan^{-1}\left[-\frac{c_{eq}\omega}{k_{eq}}\right] \quad (11)$$

$$x(t) = A\sin(\omega t - \alpha) \quad (12)$$

In equations (7) through (12),  $\ddot{x}$  is the acceleration of the upper portion of the toothbrush,  $\dot{x}$  is the velocity of the same, and  $x$  is the displacement also of the upper portion

of the toothbrush. Also included is  $\dot{y}$  the velocity of the lower portion of the toothbrush, and  $y$  the displacement of the same.

Combining equations (1), (2), (3), (5), (6), (10), (11), and (12) yield the final solution,  $x(t)$ , which predicts the motion of a toothbrush from the masses, spring constants, and damping coefficients of the different components of an electromechanical toothbrush.

$$x(t) = \left[ \left( \frac{me\omega^2}{[(k_3 - M\omega^2) + (c_3\omega)^2]^{\frac{1}{2}}} \right) \sqrt{k_{eq}^2 + (c_{eq}\omega)^2} \right] \sin \left[ \omega t - \left( \tan^{-1} \left[ -\frac{c_{eq}\omega}{k_{eq}} \right] \right) \right] \quad (13)$$

## ANALYSIS AND EXPERIMENTATION

Experimentation was performed to validate the mathematical model after its development. First, it was necessary to establish the spring constant,  $k_3$ , and the damping coefficient,  $c_3$ , of the hand. The measurement of such properties was beyond the capabilities of available equipment so the research of three professors from Johns Hopkins University was relied upon for those values. Normal values were chosen to represent the largest portion of the population through design. The measurement of hand properties using the testing apparatus shown in Figure 5, produced values of 0.9 N/mm for the spring constant and 0.006N-s/mm for the damping coefficient [3].



**Figure 5.** Hand Vibrational Properties Measuring Apparatus [3]

With hand values determined, the toothbrush was weighed using a precision scale finding the mass,  $M$ , of the toothbrush to be 35.81g. Also, the toothbrush was destructed and the eccentric motor weight removed for measurement using the same scale. This value proved to be 1.2g, much smaller than that of the toothbrush.

Next, the angular velocity at which the end of the toothbrush was traveling needed to be determined. This was accomplished using an Olympus i-Speed 3 high speed camera to observe the toothbrush's linear displacement in frames per second. A video frame can be seen in Figure 6.





**Figure 6.** High Speed Video Clip

In order to calculate the spring constant,  $k_{eq}$  of the toothbrush, it was held in a test fixture. Specific loads were applied to the end of the brush while recording the displacement of the brush using a Jeweled dial indicator with 0.005 inch precision as seen in Figure 7.



**Figure 7.** Measuring Spring Constant of Head and Neck

Although it is not often associated with vibrational analysis, the Young's Modulus,  $E$ , of the head and neck of the toothbrush may be used as another method for calculating the spring constant,  $k_{eq}$ . Available through the Materials Evaluation and Testing Laboratory, METLAB, at South Dakota State University was an MTS machine. This machine, as seen in Figure 8, allows for material samples to be stretched under increasing loads to plot the stress versus strain curve of the material. The beginning, linear, portion of the stress/strain curve is directly correlated with the Young's Modulus of that material. Figure 9 shows a plot of a sample toothbrush's stress/strain curve which yielded a Young's Modulus value of  $4.077\text{N/mm}^2$ .

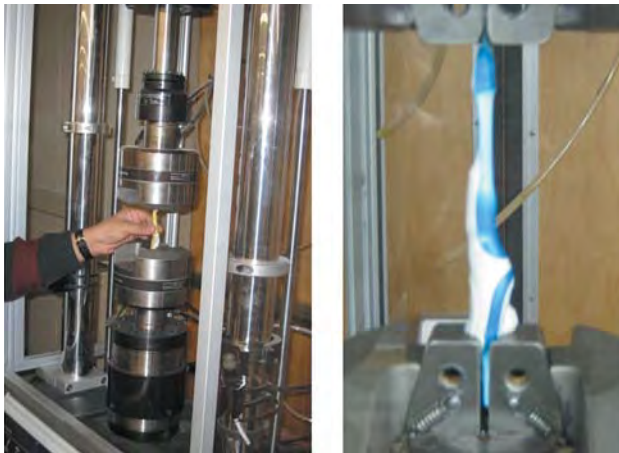


Figure 8. MTS Machine and Toothbrush Sample

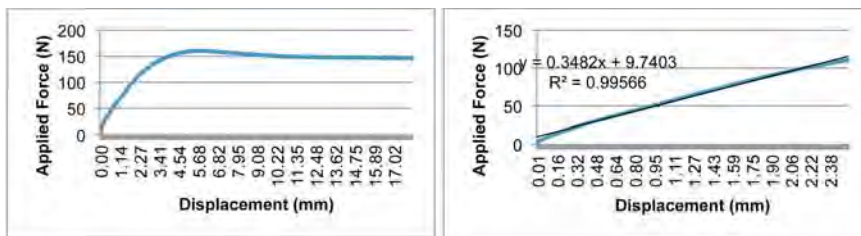


Figure 9. Head and Neck Stress/Strain Curve

With the final forcing function measured in the high speed video and all material values calculated except the damping constant of the head and neck,  $c_{eq}$ , the value for the damping constant could be solved from the equation. However, multiple data points needed to be produced in order to measure the error in the one-dimensional model and to verify the resulting value for the damping constant. To do this, the battery from the toothbrush was removed and a variable voltage power supply was supplemented in its place. Varying the voltage supplied to the motor would yield different angular velocities and resultant functions, both seen in the high speed video, but the value for the damping constant should remain the same. Figure 10 shows the result of a few sample tests in Engineering Equation Solver.

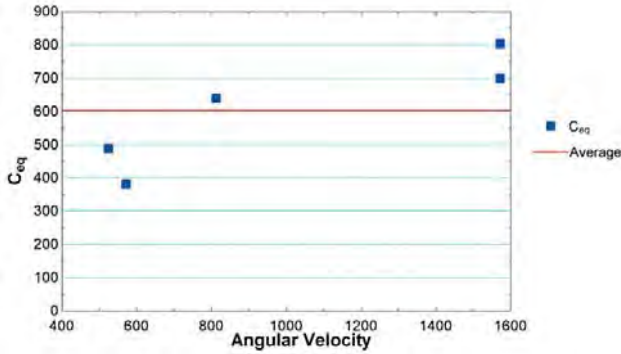


Figure 10. Damping Coefficient Test Results

## RESULTS

The results of the values that were calculated from the equations of motion, high speed videos, and measured physical properties are seen in Table 1, but referring back to the data shown in Figure 10, there appears to be a large amount of error as the standard deviation is 169 N-s/m. However, three factors should be considered. First, damping coefficients are notorious for their difficulty to be measured. Geometry, material age, and sometimes even temperature change the damping coefficient. Second, all the errors occurring in the model show in the graph in Figure 10. Third, the neck of the toothbrush is a composite of both rubber and plastic, further complicating accurate material tests due to varying composite percentages.

Table 1. Property Test Results

Symbol	Property	Value
$k_3$	Hand spring constant	0.9 N/mm
$c_3$	Hand damping coefficient	0.006 N-/mm
$M$	Mass of toothbrush	0.03581 kg
$m$	Mass of eccentric weight	0.0012 kg
$\omega$	Angular velocity	7758.62 rpm
$e$	Eccentricity of unbalanced motor	3 mm
$k_{eq}$	Head and neck spring constant	1.765 N/mm
$c_{eq}$	Head and neck damping coefficient	0.603 N-s/mm

Considering all of these factors as well as the fact that the rubber/ plastic composite is expected to yield results below the 1,000 N-s/m range, the results seem to confirm the

assumption that a one-dimensional model can accurately predict the motion of a three-dimensional situation [2].

Further confirming this data was an observation made during the filming of the high speed videos. As a force is applied to the bristles of the brush in a similar fashion to that experienced when brushing teeth, the obvious three-dimensional motion that was present in earlier videos disappears and all motion is converted to a linear motion that is the most conducive to plaque removal.

## DISCUSSION

As a result of the extent to which experimentation was performed on multiple toothbrush samples, it can be concluded that the one-dimensional mathematical vibration model is a valid approximation of the actual three-dimensional situation. The experimental data confirmed this finding, allowing for reasonable error, and a visual observation of the resulting motion under force applied to the bristles yielded confirmation as well.

The American Dental Association suggests that for optimal plaque removal, a toothbrush should vibrate to a peak of 30,000 strokes per minute [5]. Using this information for toothbrush redesign would suggest that more money should be spent in specifying better motors while limiting the prices spend on other materials. Careful consideration of the mathematical model also suggests that grip design is a critical part of toothbrush design impacting not only the spring constant and damping coefficient of the hand, but also the resulting spring constant and damping coefficient of the head and neck.

## LIMITATIONS

As previously discussed, extensive testing should be done when calculating the damping coefficient of the neck of a toothbrush. May issues can lead to complications in its measurement such as changes in geometry and component composition. Also, the creation of the vibrational model in this paper is only valid for design of toothbrushes of similar geometry which utilize an unbalanced motor as a means of creating mechanical vibrations through the structure of the brush. The model is invalid for all other electromechanical toothbrushes whose vibrations are powered by any other means.

## ACKNOWLEDGEMENTS

Nathanael Rehn, Tara Jeatran, and Darin Waldner – Collaborators  
Materials Evaluation and Testing Laboratory (METLAB) – Testing Equipment

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# Xenakis' Combination of Music and Mathematics

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Faculty Advisor: Professor Walsh  
Department: Music Literature and History III

## ABSTRACT

My interest in using mathematics in music composition stems from the works of the contemporary composer Iannis Xenakis. As a physics and music education major I am able to combine both fields of study for this topic. Although Xenakis wrote many orchestral compositions it is his vocal music that I have concentrated on as I too am a singer. Graphic representation and new music notation are among the methods used to analyze his music.

I found that his first choral work was called "Nuits," which I proceeded to analyze. I also found myself interested in the analysis of a more recent piece "Sea Nymphs" as another example of his style. I found Xenakis' graphical and musical notation intriguing especially related to the evolution of music and mathematics throughout history. I found enough sources and his works in books, websites, song tracts, and documents. I have concluded that Xenakis' style of writing vocal works may not thrive, but his instrumental works and composing methods will surely withstand the test of time.

## XENAKIS' COMBINATION OF MUSIC AND MATHEMATICS

Since the beginning of life, evolution has evoked change in various species throughout generations on planet Earth that advance life on this planet. I believe Homo sapiens have made the most notable advancement of all, especially in intellect. The heterogeneous content that humans have become familiar with in the intellectual field are numerous, therefore, one person cannot be a master of all subjects, but the interlay of content is most interesting, specifically, in mathematics and music. Iannis Xenakis has explored these subjects in connection with his music compositions. Specifically, his vocal compositions are creative combination of mathematics and music that have evolved from the demand for advancement in vocal performance and in musical notation.

According to A.S. Barthel-Calvet's biography of Iannis Xenakis, this famous composer, was born May 24, 1922 in Braila Rumania. His mother was Photini Pavlou, his father was Clearchos Xenakis, and he had two brothers. Xenakis was introduced to world music because his mother was trilingual; therefore, she knew of other places, and she was a pianist/flutist which brought music into his life from a very young age. In 1932 he moved to Greece. In 1941 Xenakis joined the communist Greek resistance. January 1, 1945 shrapnel hit Xenakis in the face, and he was left for dead by his comrades, but his father found him

and brought him to the hospital. In 1949 Xenakis begins composing music, and he continued with music and architecture until his death February 4, 2001. (Barthel-Calvet)

## HISTORIES IN TANDEM

Music and mathematics have evolved together throughout time. According to Oliver Messiaen, in five hundred BC there is evidence of the beginning of both subjects; music began with creation of music theory using geometry and incomplete scales; math discovered natural numbers and fractions (Messiaen, 1994). In other words, humans were beginning development in higher thinking academic subjects, but these subjects relate so closely that when humans begin development of one, the other follows.

Similarly, according to A. Helden, Galileo Galilei's father, Vincenzo Galilei, was a musician, and he conducted experiments during the 1500s by hanging double bass strings from the ceiling connecting weights to the end, then plucking the string and counting the number of revolutions per period of time (Helden 2005). Today musicians do not use science like this, but today there are scientists with emphases in mathematics and not music. It is also interesting that Galileo Galilei, a musician's son, became one of the best-known scientists of his time; this contributes to the connection of the subjects of math and music in history.

Messiaen also connects the subjects in 1700AD-1800AD; musical forms such as the fugue and sonata appeared while mathematicians invented complex numbers and group structures as well as defined continuity (Messiaen 1994). Both of these developments involve groupings, structures, and inventions that are almost identical, yet in different subjects. Continuity was most intriguing to Xenakis, so much so, that he graphically represented continuity with the musical glissando. A glissando is a continuous slide between two notes. Trombones are known for performing glissandos well.

## GRAPHICAL REPRESENTATION OF MUSIC

Xenakis makes the content of math and music belong together with graphic representation, and Xenakis points out the development throughout time of music and mathematics in his book *Formalized Music*. This book discusses many of his various discoveries and experiments, including graphs involving the glissandi. There are graphs of the song *Metastaseis*'s glissandi in many books including Barbara Hanning's text book *Concise History of Western Music* (p. 644). *Metastaseis* is of great importance due to its graphical shape being based off of the architectural structure of Philips Pavilion's surfaces creating structured glissandos (Messiaen, p. 62). Another popular Xenakis graph is the *Free Stochastic*. It is my opinion that many articles do not thoroughly explain what these graphs mean; Xenakis breaks the graphs down in *Formalized Music*. The best way to explain what is happening in these graphs is to break it down into smaller graphs. The smallest part of a graph is a point, and points are described using the axes. The axis that is used for the glissandi graph is pitch vs. time.

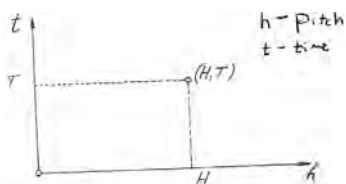


Figure 1. Graph information found in *Formalized Music* p. 212

This concept seems simple enough, but what if we look at a bigger piece such as straight lines. The graph below is a small complete section of a diagram for music in time.

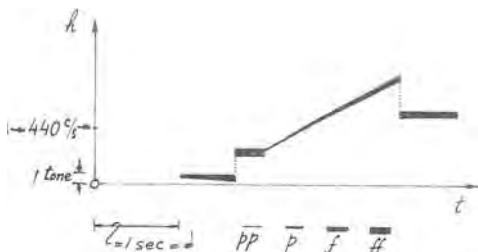


Figure 2. From *Formalized Music* p. 213

N	T	H	V	D	I
1	1.00	1	0	0.66	3
2	1.66	6	0	0.33	5
3	2.00	6	+17.5	0.80	6
4	2.80	13	0	?	5

N = note number

H = pitch in half tones with + 1 0 ~ A ~ 440 Hz

V = slope of glissando (if it exists) in semitones/sec, positive if ascending, negative if descending

D = duration in seconds

/ = number corresponding to a list of intensity forms

The pitch is on the y-axis with a reference frequency of 440Hz, and there is an indication of intervals. The x-axis is simply time with a quarter note tempo of 60. The graph shows a key at the bottom with line width matched to dynamic marking. Obviously every line with a slope of zero is a particular pitch, and there is no connection between pitch one and two. The dotted line represents discontinuity. Then the third line with a slope of +17 represents a glissando, continuity is present between all of these notes. This glissando is in a positive direction meaning that the pitch is getting higher and the thickness of the line increases suggesting a slight crescendo. Then discontinuity appears again in the fourth note and there is no end; therefore, no final time can be determined of the fourth note. (Figure 2 Graph is from *Formalized Music* p. 213)

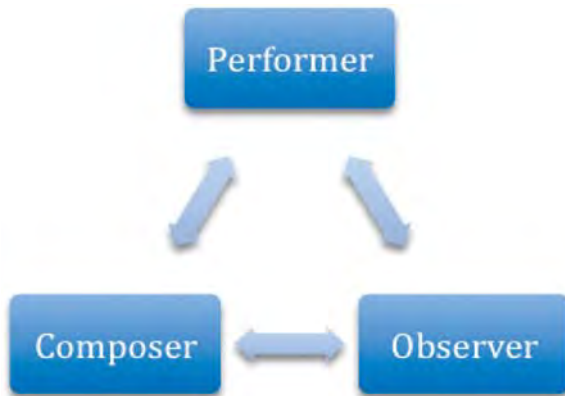


## THE HUMAN VOICE

Xenakis views the human voice differently than many other composers because he searches for pure vowels, he feels that the composer is at the mercy of the performer, and he believes the voice is an instrument and should be treated as such.

Many composers of vocal pieces search for the purest vowel, which is difficult to do since singers have to modify vowels depending on the register they are using (Ware, 1998). Xenakis used sounds without meaning, *Anemoessa*; he decided to do this because he felt that Germans are the only people who pronounce consonants strong enough to understand the words and the meaning of the words (Varga, p.105). While analyzing the English song *Sea Nymphs*, an a cappella piece with 24 voice parts, an English speaking person would notice that the phrases are not particularly coherent. Xenakis accomplishes this by using phonemes from Shakespeare's *The Tempest*. He creates a scattered affect by placing the phonemes randomly. Obviously, he was not interested in storytelling as other vocal composers such as Benjamin Britten are (Groves, 2001).

Xenakis believes that the composer is at the mercy of the performers, and that new music usually is misinterpreted at first (Varga, p.106). There is a great deal of dependence that the composer has on the performer, but the performer also has a dependence on the composer as can be seen in Figure 3 from *Basics of Vocal Pedagogy* p. 234. Without the composer, the performer, and the audience members, there would be no performance art. Ware shows all pieces of this phenomenon are crucial to maintain and advance musical in a society in Figure 3.



**Figure 3.** Recreated from *Basics of Vocal Pedagogy* p. 234

Xenakis also believes that in order for performers to interpret his music correctly they need a better understanding of science (Varga, p.126); musicians need to be more rounded and intelligent. Public education in industrialized countries is getting better, and students are becoming more well-rounded with many subjects through high school. There are no longer people who are only trained in one craft. For Example, a blacksmith would not know how to

read, just as a scholar would not know how to make swords. Industrialized countries have not only higher literacy rates, but also mathematical, scientific, and political understanding. Though somehow there is not crossing between analytical and creative thoughts according to Xenakis, "Even in the United States, with all its technological advantages, scientists simply lack imagination in a field which lies outside of mathematics or physics." (Varga p.76) Performers and composer should be able to do more than just perform and compose just as mathematicians and physicists need to be able to do more than math and problem solving. Hopefully, this combination of fields can be achieved without too much pain from either analytical or creative thinkers.

It is rare that the human voice is expected to do strenuous music that could injure the performer such as pizzicato. If a vocalist does not use vibrato, there is stress on the vocal mechanism, and pizzicato is hard for a vocalist to do due to the glottal approach necessary to create the sound. These practices are not healthy, but Xenakis uses both of these in his works. Xenakis believes that the human voice is an instrument and should be treated as such (Varga p.105). The reason the human voice requires fewer articulation markings is that feeling is expressed with interpretation and acting. Singers have to visually show expression with acting (Ware, p. 233). Instruments require more rigorous articulations and expressions because there is not as much acting/facial expression possible with most instruments. A clarinetist is not able to give a big toothy smile while sustaining a note to express mischievousness, but the clarinetist can play the note in a more playful manner perhaps with a trill, or another articulation that vocalists do not usually execute.

Xenakis also specifies in his work *Nuits* that the performer is "absolutely without vibrato." Disregarding vocal ability and health with vibrato is a common mistake for old-school choral enthusiasts. According to Ware:


Voices lacking vibrato are usually described as breathy, dull, straight, spread, or yell-like. One explanation of the vibrato-less (straight) tone is that intrinsic laryngeal muscular tension causes the mechanism to be rigid or static instead of the relaxed and flexible condition necessary for proper vibrato functioning...excessive straight-tone singing can retard the vocal development of young singers, studio voice teachers are often in conflict with choral director over this practice... vibrato actually results in an improved choral sound that is characterized by truer intonation, balanced coral tone, and more variable dynamic contrasts. (Ware, p. 182)

However, Xenakis does not use vibrato to successfully emulate his mathematical idealism. If the pitch is altering a quartertone on either side of the core pitch the frequency numbers do not add up to his graphical representations or the mathematical equations. This could prove to be a problem in popularity if his musical style leads performers to hurt themselves while performing the work.

## NEW NOTATION IN *NUITS*

Due to the new exploration/definition of vocal ability Xenakis created new notation to aid his compositional combination of music and mathematics as can be seen in *Nuits*. When

a person listens to the piece *Nuits* it could easily be interpreted as Halloween music, not high level art, even Xenakis himself understands this, "I realized that probabilities used wrongly could be boring..." (Varga p.79) Xenakis also mentions his scientific friends not understanding his work aurally, only visually or mathematically. (Varga, 1996) It is my opinion that with time and intelligence people may one day understand the works of s idea on both levels, aural and visual, without a book explaining the equations.

*Nuits* is a most intriguing piece today, and it requires new notation that Xenakis created. There are many instructions at the beginning of the piece as well as International Phonetic Alphabet (IPA) symbols to explain the particular sounds he wants to be made. There is a key with symbols for the quarter steps because western music only writes the smallest interval as a half step. Many parts of the score are obviously hand written because music notation software does not have these symbols. The piece is in cut time with the half note equal to 60, and there are three vocal parts inside each part adding up to twelve different voices, while most vocal scores only go up to eight voices. Glissandos and quartertones dominate the first twelve pages of the music. Page twelve becomes very rhythmic, utilizing triplets, pentalets, and staccatos. Not all of the rests are written in, and Xenakis starts introducing non-traditional musical elements to the piece. Vocal shouts are written with percussion note-heads with an x. In measure 124 vocal tremolos are introduced. The next new symbol Xenakis uses in the piece is circles with little stems shooting out the side. According to the score, these "raise the pitch sufficiently in order that this voice produces  $\frac{0}{3}$  beats (interferences) with the other one as many per second as indicated by numerals." (Nuit, 1965) Candy cane shaped hooks are introduced later some pointing positively and others pointing negatively  meaning ascending/descending glissandi with extinction (very short, of an octave range approximately) respectively. A nasal pizzicato/glissando occurs in measure 136 for the women followed by the men whistling. The time of glissandos are indicated with numbers and arrows. In measure 160 all of these elements seem to be moving together and die out by measure 169. The beginning feeling and notation returns with tremolos until measure 179 when the score states, "Ataxic clouds on the syllable Tsi very sharp and dry" emerges. This is notated with dots all over the staves. The soprano "cloud" becomes a whisper then the men have "Ataxic clouds of the syllable Tsi whispering (voiceless even when varying the nuances and the timbre (sharp))" while the altos continue the quarter-tone glissandos. These concepts continue until the final three pages when there is little movement and a huge contrast from the rest of the piece is introduced. The singers all sing whole notes on varying quartertones. The very last sound you hear in the song is from the basses giving a single cough.

## CONCLUSION

In conclusion, it is my opinion that Iannis Xanakis will have a place in the history books; however, I do not foresee his vocal compositions ever becoming popular because of his disregard for vocal health and his lack of story and expression in these compositions. After all evolution involves natural selection, and his vocal works will die and his instrumental works will live on. Even though his vocal compositions do creatively combine mathematics and music to demand an evolved intelligent vocal performance, he disregards the delicacy of

the singers' instrument. Also, amateur listeners love stories; especially, when the vocal performers can act out the story. Expression with the human voice is not as aurally noticeable as it is with instruments. Vocalists express through acting and feeling, not mathematics. The reason I feel he will be in the history books is that his mind is in the right place combining music and mathematics. I see his instrumental works different from his vocal works because these pieces will last through the ages, because of the concepts and difficult meter and creative notation. The factor preventing his vocal pieces from extending to the future is his lack of respect for vocal health.

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