TEXAS A&M UNIVERSITY
CORPUS CHRISTI

TRiO

RONALD E. McNAIR
POST-BACCALAUREATE
ACHIEVEMENT PROGRAM

# BIOGRAPHY OF
# DR. RONALD E. McNAIR

## HE OVERCAME OBSTACLES.

Dr. Ronald Erwin McNair, Physicist & Astronaut, dared to dream. As an African-American growing up in a poor community in the South, he encountered discrimination early in his youth. Yet this did not stop him from pursuing his dream of becoming a scientist.

## HE ACHIEVED ACADEMIC EXCELLENCE.

In 1971, he graduated magna cum laude from North Carolina AT&T State University with a B.S. degree in physics. Ronald McNair then enrolled in the Massachusetts Institute of Technology. In 1976, at the age of 26, he earned his Ph.D. degree in laser physics.

## HE BECAME A LEADER IN HIS FIELD.

Dr. McNair soon became a recognized expert in laser physics while working as a staff physicist with Hughes Research Laboratory. He was selected by NASA for the space shuttle program in 1978 and was a mission specialist aboard the 1984 flight of the shuttle Challenger.

## HE WAS RESPECTED AND COMMENDED.

For his achievements, Ronald McNair received three honorary doctorate degrees and many fellowships and commendations. These distinctions include: Presidential Scholar, 1967-71; Ford Foundation Fellow, 1971-74; National Fellowship Fund Fellow, 1974-75, Omega Psi Phi Scholar of the Year, 1975; Distinguished National Scientist, National Society of Black Professional Engineers, 1979; and the Friend of Freedom Award, 1981.



## HE EXCELLED IN MANY ASPECTS OF LIFE.

Ronald McNair also held a fifth degree black belt in karate and was an accomplished jazz saxophonist. He was married and was the dedicated father of a daughter and a son.

After his death in the Challenger explosion in January 1986, members of Congress provided funding for the Ronald E. McNair Post-Baccalaureate Achievement Program to encourage college students with similar backgrounds to Dr. McNair to enroll in graduate studies. Thus, the program targets students of color and low income, first-generation college students. This program is dedicated to the high standards of achievement inspired by Dr. McNair's life.

*Biography courtesy of the University of Nevada, Las Vegas*

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## 2016 McNAIR RESEARCH ARTICLES

# INTERIM PRESIDENT

## DR. KELLY QUINTANILLA

Inspired by the momentous achievements of Ronald E. McNair, the TAMUCC McNair Scholars Program continues to honor his legacy by equipping underrepresented undergraduate students with the tools necessary to realize their highest aspirations.

The ability to conduct scholarly research is central to success in a variety of academic fields and vital to the attainment of a graduate degree. Through faculty mentorship and the assistance of program staff, the McNair Scholars Program is helping students develop these essential skills as evidenced by the work presented in this research journal.

I would like to congratulate the McNair Scholars on their accomplishments and extend my sincerest appreciation to the McNair staff, Faculty Mentors, and the campus community for their continued support of the scholarly growth of our students.

*Kelly M Quintanilla*

Dr. Kelly Quintanilla
Interim President

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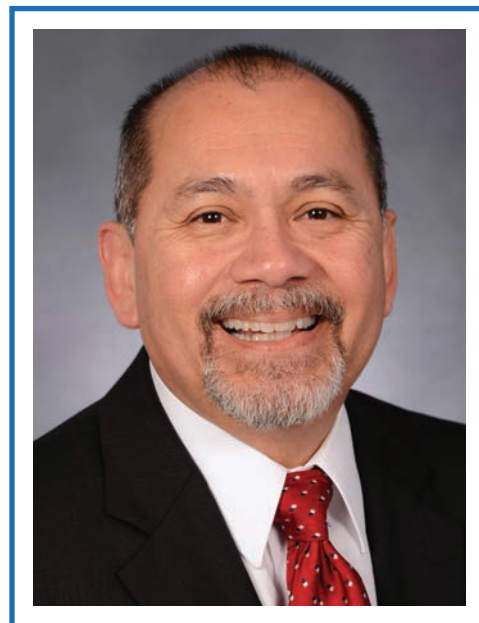
One of the overarching goals of Texas A&M University-Corpus Christi is to help equip underrepresented students in higher education with the skills necessary to succeed in today's society. The TAMUCC McNair Scholars Program continues to exemplify these values. By involving undergraduate students in scholarly research activities, this program is helping to turn the students of today into the professionals of tomorrow.

The excellence of research contained in this research journal represents the tireless efforts of the McNair Scholars, their Faculty Mentors, and the McNair Program staff. Each and every article is a testament to the success of the program in preparing students to undertake scholarly research and enter into graduate-level education.

The university is honored to host these dedicated scholars, faculty, and staff that make the success of this program possible. I commend the McNair Scholars on their achievements and wish them success in all of their future endeavors.

Dr. Gerardo Moreno
Assistant Vice President for Student Success

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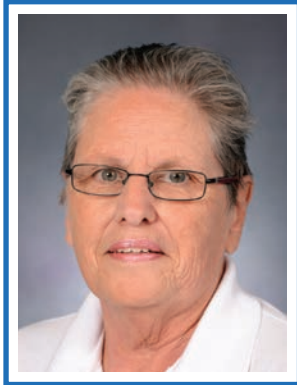
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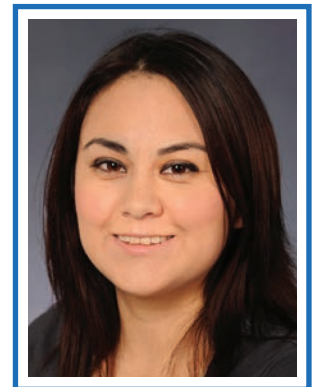
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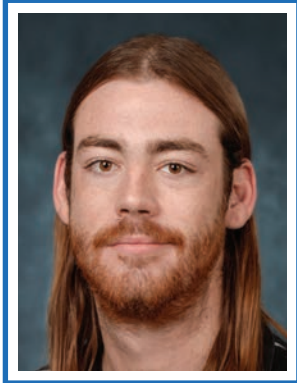
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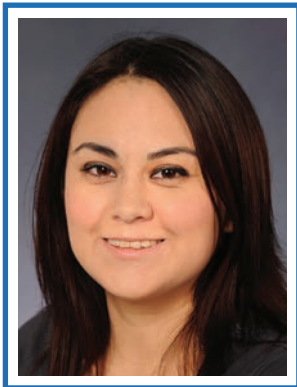
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# 2016 McNAIR RESEARCH ARTICLES

# DEVELOPMENT OF PORTABLE POWER SUPPLY FOR PLASMA ACTUATED UAV'S

by CLYDE AVALOS

## ABSTRACT

*Plasma actuators are devices that create plasma in low temperature and pressure to perform a variety of tasks. As the applications of this technology expand, the requirements needed to operate such devices begin to grow in proportion. With the use of technology ranging from high voltage transformers, a lithium ion battery and custom built plasma actuators, portable plasma formation was sought after to operate an unmanned aerial vehicle (UAV) without the use of moving mechanical parts.*

## LITERATURE REVIEW

Plasma research in the last few years has expanded exponentially in the amount of academic articles, research and technology being published and innovated for different purposes [1-7]. Understanding the basic characteristics and behavior of plasma aids in the variety of applications to which they can be applied. In addition to the common knowledge of the three states of matter, plasma is considered to be the fourth state of matter that makes up about 99 percent of the known universe. This type of matter can be seen in the universe, from auroras and nebulas to flames and solar flares. Plasma is composed of freely floating ions and electrons that have undergone ionization. An atom that has experienced ionization loses valence electrons—electrons from the most outer ring of an atom—causing an atom to have a positive or negative charge. With these free floating electrons, plasma can be manipulated by magnetic and electric fields. Although this type of matter is unique and can be manipulated, the energy required to break the electrons from the atom needs to be sustained. A method to create plasma consists of the use of a plasma actuator. The main components consist of copper electrodes, a dielectric barrier and a power source. Although some configurations of plasma actuators vary, most of the setup is the same.

Understanding plasma at an atomic level has given researchers greater understanding of its applications in many different categories such as ozone generation, fluorescent lamps, X-ray imaging, substance detection, medical applications and aerodynamic purposes [1].

## MENTOR

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One application of utilizing plasma actuated devices, as stated above, regards ozone generation. Ozone consists of a triatomic form of oxygen that is very reactive and is commonly found in the stratosphere. Due to its high reactiveness, ozone is considered a pollutant in the lower atmosphere due to its adverse effects on the environment but has its benefits, such as regulating the amount of radiation entering or reaching the surface of the planet [2]. Other than the natural use of ozone, plasma technologies can be used for industrial purposes such as disinfecting water. Generating ozone at a low temperature can be utilized in disinfecting water by removing odors and pesticides without the use of chlorine [3].

The development of plasma actuated devices has led to applications in the electronics industry. To begin, the electronic industry has benefited greatly from the advancement of plasma technology. As the research in plasma continued, it was discovered that plasma could be utilized to produce computer chips at a far smaller scale than before. Computer chips are created by layering different types of material on one another and removing the unnecessary components through the process of etching and deposition along with other effective means. Plasma is used to create these intricate layers since plasma has certain reactive characteristics [4]. Due to the advancement in plasma research and technology, the ability to utilize these processes with plasma has greatly impacted the size and production of computer chips and other components such as semiconductors.

Plasma can also be utilized for propulsion in applications ranging from space travel to the flight of unmanned aircraft vehicles. Plasma, as we know, is a highly reactive ionized state of matter and the manipulation of certain properties can be utilized to propel objects at high speeds. By controlling the plasma with electric and magnetic fields, the plasma can be directed opposite to which the object is intended to impart, and by doing so has opened the opportunity for much more efficient space travel, flight and satellite operation. Although the low fuel consumption of plasma propulsion is a great benefit in applications, the increase in power requirements due to the high voltage needed to sustain the plasma has lead to complications in applying this newly developing technology [5].

A particularly new research topic involves aerodynamic applications. Since plasma is composed of ions, it can be controlled or manipulated by flow control mechanisms such as plasma actuators. Plasma actuators have been known to aid in improving problems regarding bluff-body wake control, lift enhancement and turbulent transition problems. As research expanded, researchers have attempted to place plasma actuators on aircraft for flight control. Plasma actuators can be a very suitable replacement for mechanical means of operating and maintaining flight of a vehicle [6].

## DESIGN AND DEVELOPMENT

Plasma actuators require certain parameters to enable the formation of low temperature plasma. To create plasma, a frequency of 3-20 kHz and 10kV are needed to operate functioning plasma actuators. Issues that arise from this configuration pertain to the weight requirement. Most power supplies exceed the payload limit to operate an unmanned aerial vehicle (UAV). Some methods that have been considered involved capacitor banks, which store electrical energy temporarily in electric fields to meet the high voltage requirements of small plasma actuated devices [1]. Although this idea can be utilized in some areas, the drawback of the method regards the weight requirement and the amount of space the configuration requires to operate for any consideration of UAV application.

The objective of the current research is to utilize recent innovations in technology to achieve flight while meeting certain parameters. These parameters include the operation of the UAV with specific weight and voltage requirements. The parameters needed to operate a functioning plasma actuator consisted of an output voltage of 10kV and a frequency range of 3-20 kHz. The weight requirements for this study were set at a maximum of a 2kg weight capacity of the power supply components placed on the UAV. The UAV utilized was the HobbyKing Bixler model.

After initial research was conducted, the parameters for the power supply were governed from previous research conducted by Ved Chirayath [6]. From this research, a frequency range of 3-20 kHz and a voltage input of 10 kV were necessary to operate a functioning plasma actuator. The design methods consisted of two designs

FIGURE 1.



FIGURE 2.
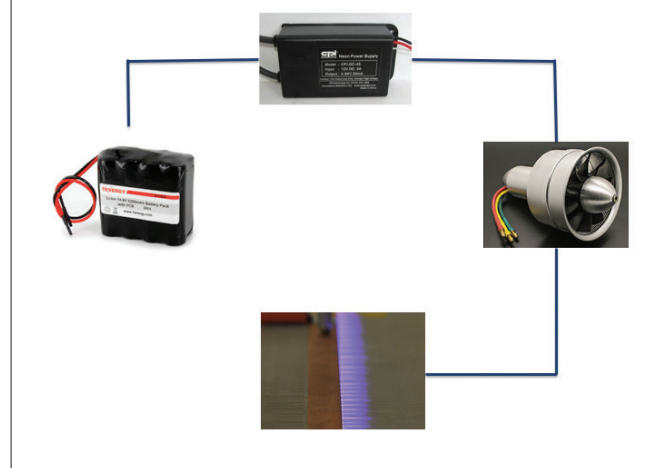
composed of multiple components to meet the goal of operating the UAV to eliminate moving mechanical parts. The first design considered involved a computer hard drive disk that spun creating a customizable AC square wave lined with copper tape with an input from a high voltage DC multiplier. Chirayath mentions that the main issue of the design consists of the mechanical breakdown of the surface electrodes causing arcing. While the first method was successful, the life span of the operation was cut short due to the breakdown of the system. A second design was also proposed by Chirayath that consisted of a high voltage multiplier, EDF (Electric Ducted Fan) and the use of exposed leads and conductive silver coating paint. Similar to design 1, the second design utilized the spinning fan to create the high voltage AC signal from the input of the high voltage multiplier. The task was completed by connecting a voltage source to the high voltage multiplier to which the voltage would increase by multiples of 1000 volts. The voltage would then require a conversion from DC (Direct Current) to AC (Alternating Current) by the use of the ducted fan coated in a silver conductive coating. The output leads from the multiplier are left exposed inside the fan walls and separated with enough distance to not allow arcing. As the fan blades pass over the exposed leads, the circuit is completed for a short period of time and the output is sent into the input of the actuator completing the circuit. To control the needed frequency, the velocity of the fan can be manipulated to control this variable [6].

## EXPERIMENTAL RESULTS AND DISCUSSION

These two methods consist of multiple components that can be utilized in every day applications. Although each method seems promising, utilizing each method has consequences regarding weight and function for the given application. The weight requirement of the chosen UAV model results in a load range of 1.5 kg and 2.0 kg for the power supply components. Due to the restraints of the weight capacity, other methods have been eliminated due to the situation resulting in the two methods explained previously. Preliminary research was conducted to choose the best candidates for the power source and neon transformer used in the research. It was found that lithium ion technology would be the most suitable power source due to the light weight and size of the batteries. Three different models of 14.8-volt batteries were purchased to conduct the testing of the plasma actuator. The models consisted of different amperages ranging from 5.2 Ah, 13 Ah and 6.6 Ah. To meet the high voltage requirements, an auto transformer or voltage multiplier was purchased. The DC multiplier requires an input of 12 V DC and an output of voltage of 7.5 kV. Visual representations of each component can be viewed in the appendix. The first method consisted of a 14.8-volt battery, high voltage neon transformer and the use of a plasma actuator. The circuit is then constructed by connecting the battery to the neon transformer as shown in the circuit below.

FIGURE 3.
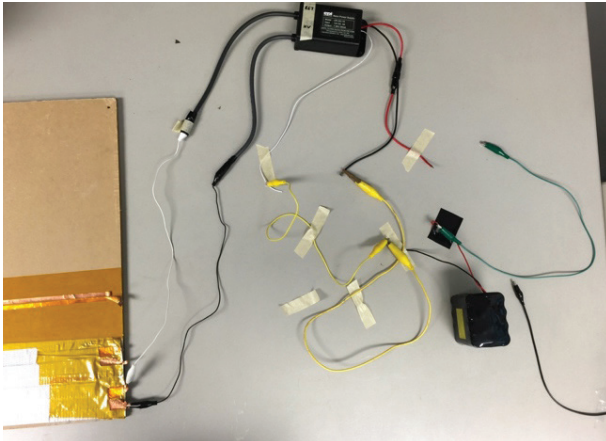


FIGURE 2.



The circuit begins with the battery located on the lower right corner of the figure above. The battery is connected directly to the transformer that steps up the voltage of the battery to 7.5 kV to power the plasma actuator located at the lower left of the figure. The transformer is utilized to step up the voltage as mentioned previously but also to meet the frequency requirements of the plasma actuator.

After testing the circuit, it was found that the high voltage neon-transformer did not meet the needed parameters to sustain a uniform plasma. In the first initial test, a short spark was seen to transfer between the electrodes and can be seen below.

This first test proved that the neon transformer was able to produce the necessary current through the actuator but lacked enough voltage. Two other batteries were utilized in experiments afterward but the circuit did not produce results similar to the initial test and a possible explanation for this could be damage to the neon transformer itself. In conclusion, the circuit configuration constructed had challenges to sustain a uniform plasma with current battery sources used. A possible solution for future studies includes a higher voltage output of a voltage multiplier to withstand and meet the requirements needed to operate a plasma actuated UAV. Transformers of greater voltage and amperage output were found after preliminary testing was conducted. These promising transformers could power and sustain plasma actuated devices that could possibly produce successful results.
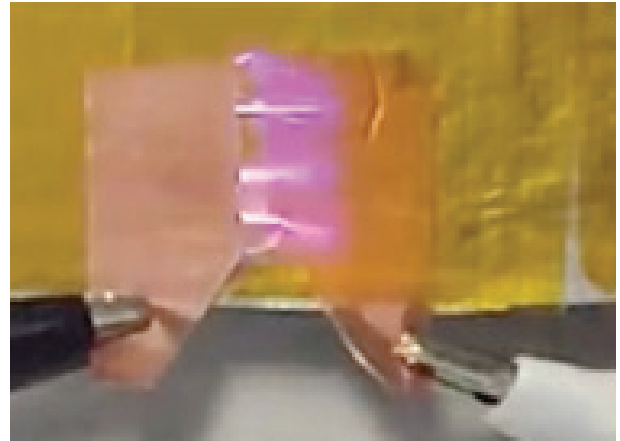
## REFERENCES

[1] Jafari, Hossein, Mortez Habibi, and Hamid Vaneghi. "High-Voltage Pulsed-Power Supply Operating at Repetitive Discharge Mode for Driving Very Small Plasma Focus Devices." Vol. 43. Issue 9 (2015): 3310-319. Business Source Complete. Web. 2 Feb. 2016.

[2] Gleason, Karin. "Science: Ozone Basics." Stratospheric Ozone: Monitoring and Research in NOAA. Web. 4 Apr. 2016. <http://www.ozonelayer.noaa.gov/science/basics.htm>.

[3] ] U. Kogelschatz, B. Eliasson, W. Egli. Dielectric-Barrier Discharges. Principle and Appli-cations. Journal de Physique IV, 1997, 07 (C4), pp.C4-47-C4-66. <10.1051/jp4:1997405>.<jpa-00255561>

[4] Hopwood, J. (2006). Computer Chips and Plasma. Retrieved May 13, 2016, from http://www.plasmacoalition.org/plasma_writeups/computer-chips.pdf

[5] Diaz, F. C. (2007). Plasma Propulsion for Space Flight. Retrieved May 13, 2016, from http://www.plasmacoalition.org/plasma_writeups/plasma-propulsion.pdf

[6] Chirayath, Ved, and Juan J. Alonso, Dr. "Plasma Actuated Unmanned Aerial Vehicle - The First Plasma Controlled Flight in History Single Dielectric Discharge Devices as an Efficient and Novel Means of Aircraft Control." (2011): 1-16. Web.

Diaz, F. C. (2007). Plasma Propulsion for Space Flight. Retrieved May 13, 2016, from http://www.plasmacoalition.org/plasma_writeups/plasma-propulsion.pdf

[7] "Plasma - The First State of Matter." Http://www.plasmacoalition.org. Ed. Paul Rivenberg and Gerald Rogoff. N.p., n.d. Web.

[8] Babij, Michał, Zbigniew W. Kowalski, Karol Nitsch, Jerzy Silberring, and Gotszalk Gotszalk. "Atmospheric Pressure Plasma Jet with High-voltage Power Supply Based on Piezoelectric Transformer." Vol. 85.5 (2014): 1-5. Applied Science & Technology Source. Web. 5 Feb. 2016.

[9] Bhatia, Ankush, Subrata Roy, and Ryan Gosse. "Effect of Dielectric Barrier Discharge Plasma Actuators on Non-equilibrium Hypersonic Flows." 116.16 (2014): 164904-1-64904-16. Applied Science & Technology Source. Web. 5 Feb. 2016.

[10] Neretti, Gabriele, and Andrea Cristofolini. "Experimental Investigation on a Vectorized Aerodynamic Dielectric Barrier Discharge Plasma Actuator Array." 115.16 (2014). Applied Science & Technology Source. Web. 15 Feb. 2016.

[11] Kriegseis, J., S. Grundmann, and C. Tropea. "Power Consumption, Discharge Capacitance and Light Emission as Measures for Thrust Production of Dielectric Barrier Discharge Plasma Actuators." 110.1 (2011). Web. 17 Feb. 2016.

[12] Demir, Kadir Alpaslan, Halil Cicibas, and Nafiz Arica. "Unmanned Aerial Vehicle Domain: Areas of Research." 65.4 (2015): 319-29. Applied Science & Technology Source. Web. 6 Feb. 2016.

[13] Gómez, S., M. P. Buitrago, and F. A. Roldán. "Portable High Voltage Impulse Generator / Generador Portátil De Impulsos De Tensión." (2011). SciELO. Web. 23 Feb. 2016.

[14] Dragonas, Folopimin A., Gabriele Neretti, Padmanaban Sanjeevikumar, and Gabriele Grandi. "High-Voltage High-Frequency Arbitrary Waveform Multilevel Generator for DBD Plasma Actuators." 51.4 (2015): 3334-342. Business Source Complete. Web. 23 Feb. 2016.

[15] Munir, Muhammad Miftahul, Dian Ahmad Hapidin, and Hapidin, Dian Ahmad. "Designing of a High Voltage Power Supply for Electrospinning Apparatus Using a High Voltage Flyback Transformer (HVFBT)." 770 (2015): 145-48. Applied Science & Technology Source. Web. 20 Feb. 2016.

[16] Corke, Thomas C., C. Lon Enloe, and Stephen P. Wilkinson. "Dielectric Barrier Discharge Plasma Actuators for Flow Control." 42 (2009): 505-29. Web. 28 Feb. 2016.

[17] Murphy, J. P., J. Kriegseis, and P. Lavoie. "Scaling of Maximum Velocity, Body Force, and Power Consumption of Dielectric Barrier Discharge Plasma Actuators via Particle Image Velocimetry." 113.24 (2013). Applied Science & Technology Source. Web. 29 Feb. 2016.

[18] Zong, Hao-hua, Yun Wu, Ying-hong Li, Hui-min Song, Zhi-bo Zhang, and Min Jia. "Analytic Model and Frequency Characteristics of Plasma Synthetic Jet Actuator." 27.2 (2015): 1-21. Web. 29 Feb. 2016.

[19] Day, Michael, and Bang S. Lee. "Understanding Piezoelectric Transformers in CCFL Backlight Applications." Texas Instruments Incorporated. Web. 2 Feb. 2016.

# TO GIVE UP OR NOT? DOES LEARNED HELPLESSNESS EFFECT PROBLEM SOLVING BEHAVIORS?

by LORI "JAE" CERDA

## ABSTRACT

*This experiment was designed to investigate the influence of experiencing an uncontrollable and inescapable aversive situation on problem solving behaviors in undergraduate subjects. Previous studies have reported that organisms who are repeatedly exposed to inescapable unpleasant stimuli will learn to inhibit their natural escape or avoidance behavior to future unpleasant stimuli. This learned inhibition of avoidance behavior is referred to as learned helplessness. Prior research has operationalized an uncontrollable aversive situation as the presence of "unpleasant" auditory stimuli (i.e. noise) and physical stimuli (i.e. shock). If learned helplessness relies on experiencing an uncontrollable aversive stimulus and is not limited to an "unpleasant" noise or shock, then other uncontrollable "unpleasant" situations should also induce helplessness. An alternative uncontrollable unpleasant situation may be the inability to successfully remember a set of letters (e.g., GKT) while counting backwards by threes from a random starting point. This situation is aversive because the deceptively simple task of remembering three letters is disrupted by the inability to mentally rehearse the information while counting backwards. The task is made more aversive when the speed control, which should allow the participant to slow the visual dot cue does not function properly. Following the memory task all participants were asked to solve anagrams. The anagram task provides an opportunity to see the effects of the helplessness induced by the memory task, such that participants in the experimental group are expected to terminate or incorrectly complete more anagrams while taking longer to complete the task than compared to the control condition.*

Keywords: *learned helplessness, aversive, uncontrollable, inescapable, helplessness*

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## INTRODUCTION

Naturally, organisms respond to unpleasant or discomforting (i.e., aversive) stimuli by avoiding or escaping behaviors. Dogs naturally demonstrate escape-avoidance behaviors as anxious attempts to get away, relieving themselves uncontrollably, or howling until avoidance is achieved (Seligman & Maier, 1967; Seligman, 1972). However, organisms repeatedly exposed to inescapable aversive stimuli learn to inhibit their natural escape or avoidance behavior to future unpleasant stimuli. This learned inhibition of avoidance

behaviors is referred to as learned helplessness. Overmier and Seligman (1967), exposed dogs to increased inescapable shocks, which induced learned helplessness by interfering with the dog's natural escape or avoidance response to get away from the unpleasant situation (i.e. shocks).

Animals have shown passiveness, slower response rates, lack of response, learning deficiencies, and emotional deficiencies with prior exposure to uncontrollable, aversive situations (Seligman, 1972). Effects from uncontrollable aversive situations may elicit motivational, cognitive, or emotional discrepancies within animal and human subjects. Motivational deficits may include failure to naturally escape or learn to escape, or relinquishing response behaviors. Cognitive deficiencies may result in the inability to comprehend what influences behaviors have on outcomes or learning avoidance responses (Abramson, Seligman, & Teasdale, 1978; Maier & Seligman, 1976; Sedek & Kofta, 1990). Emotional deficits such as stress, anxiety, and depression may occur (Abramson et al., 1978; Maier & Seligman, 1976).

A series of experiments were conducted on dogs exposed to several conditions of inescapable shocks. The subjects were tested for interference responses by a two-way shuttlebox, which is a two compartment box separated by a barrier (Overmier & Seligman, 1967; Seligman & Maier, 1967; Seligman & Maier, 1968). Overmier and Seligman (1967) immobilized dogs to ensure instrumental motor responses (i.e. muscle movements) did not influence interference from aversive stimulus. Overmier and Seligman (1967) found that dogs exposed to inescapable shocks showed interference with escape-avoidance and responded with slower response rates even when previously immobilized. Time intervals of two to four days after exposure resulted in the experimental dogs regaining a normal escape-avoidance response. Overmier and Seligman (1967) found that exposure to aversive stimulation with responses that did not remove the aversion lead to helplessness in the experimental dogs. Seligman and Maier (1967) manipulated the degree of control of aversive stimuli to measure its influence of avoidance learning and determine if initial exposure to escapable shocks lessened avoidance learning on behaviors in dogs. Seligman and Maier (1967)

concluded that dogs with prior exposure to inescapable shocks failed to escape and eventually accepted shocks while tested in the shuttlebox. The degree of control modulated the interference of avoidance learning independent of responses. The disruption to avoidance learning was sustained 48 hours after exposure to the uncontrollable aversive stimuli (Seligman & Maier, 1967). Overmier and Seligman (1967) and Seligman and Maier (1967) concluded that interference from exposure to an uncontrollable aversive stimulus was not caused by adaptation or competing motor responses. Rather, learning responses to the aversive, uncontrollable stimulus did not eliminate or reduce the effects of the stimuli (i.e. shock) resulting in the interference by learned helplessness (Overmier & Seligman, 1967; Seligman & Maier, 1967).

Seligman and Maier (1968), questioned if extinction of learned helplessness could occur in dogs who failed to achieve an avoid-escape response. Dogs who displayed acceptance or had no response to inescapable, uncontrollable shock were tested for desensitization seven days following exposure. Dogs were coaxed into the safe zone of the shuttlebox when shocks occurred until naturally responding to the stimulus. Subjects that did not respond to the coaxing were dragged across the barrier into the safe zone until the dogs avoided the shocks willingly. This experiment demonstrated that interference with escape-avoidance learning can be overcome by exposing the learner (by force if necessary) to avoidance responses that ease the aversive stimulus (Seligman & Maier, 1968).

Other animal studies on interference and the learned helplessness phenomena were conducted. Experiments conducted on rats who were inescapably restrained by the use of a holding bag, hand, or a jar filled with water intended for swimming demonstrated extreme stress and overstimulation to uncontrollable aversive stimuli. The inability to escape the restraint lead to hopelessness in rats, which led to instant death or heart failure (Richter, 1957). Although Richter (1957) was able to show extreme responses to inescapable aversion, other studies found it difficult to show interference to avoidance learning in rats (Maier, Albin, & Testa, 1973). Eventually, learned helplessness was achieved with the rats if the time scale of learning was broadened to allow for a more gradual exposure to the inescapable aversive

stimuli. Prior exposure to inescapable shocks with wheel turning escape-avoidance responses resulted in the inability to learn to escape when tested (Maier et al., 1973).

The influence of aversive learning has also been investigated in other species including cats and fish. Using a box similar to the previously described shuttle box, cats were tested to see if exposure to escapable shocks modified learned fear inhibition (Seward & Humphrey, 1967). Cats that were trained to escape the shock were faster to exhibit extinction of fear associated with the box and developed faster avoidance responses when exposed to escapable shock. Whereas the cats were exposed to escapable shock to study fear inhibition, goldfish were exposed to inescapable shock to study avoidance learning. Goldfish where exposed to inescapable shocks in an aquatic shuttlebox to observe if an avoidance response would occur and whether prolonged intervals between the training and testing phases would diminish the learned behavior (Padilla, Padilla, Ketterer, & Giacalone, 1970). After establishing interference of learned avoidance behavior as a consequence of exposure to inescapable shock, Padilla et al. (1970) found that the avoidance response of the goldfish began to improve with a 72-hour interval between exposure and testing with no hindrance.

After exploring the limitations and interference of learned avoidance in animals, researchers turned their attention to learned helplessness in human subjects. Pioneering this extension was the work of Thornton and Jacobs (1971). Similar to the previously mentioned experiments with dogs, cats, rats, and goldfish, the humans were exposed to fixed or variable shocks intended to induce stress. The human participants were provided button panels along with three indicator lights and one warning light. During the training phase, the stimulus light indicated that a shock was imminent and the participant's task was to solve which button would terminate the shock. During the training phase, participants were given either general, informed, or shock-related instructions to their task. In the testing phase, random intensity levels of shock were given with the randomly presented stimulus light and participants were to press a button to terminate the shock. Thornton and Jacobs (1971) concluded that the unpredictability of the amount of shock induced

stress in humans, which promoted the development of learned helplessness. Thornton and Jacobs (1971) discovered different degrees of learned helplessness occurred with subjects exposed to different shocks, and an effect of transferring the learned instructions from one task to another emerged in this experiment.

Once learning helplessness in humans was established, researchers began exploring alternatives to shock. Hiroto (1974) investigated the use of an aversive auditory stimuli to compare how internal vs. external control perceptions influence learned helplessness. Internal perception of control refers to the tendency to perceive events as a consequence of one's personal attributes whereas an external perception of control refers to the tendency to perceive events as due to factors outside or other than one's attributes (Abramson et al., 1978; Hiroto, 1974). Although Hiroto (1974) did not use shock, he did use a human version of the previously described shuttlebox. The human version included a box with horizontally slidable knob. On some trials, contact on the right end would close a hidden switch and stop the aversive stimuli, on the next trial, contact of the other end (i.e., left) would stop the aversive stimuli. Hiroto (1974) reported that participants with external attribute tendencies were slower to terminate the aversive stimuli. Participants who were encouraged through the instructions to have an external attribution perception of the task and less personal control made fewer avoidance responses. This study induced learned helplessness in human subjects without using shock as an aversive stimuli and further emphasized the importance of perceived control of the aversive situation (Hiroto, 1974).

After exploring an alternative aversive stimulus, Hiroto explored the extent of the effects of exposure of uncontrollable aversive stimulation beyond aversion learning. Specifically, Hiroto and Seligman (1975) explored whether the learned helplessness effect would generalize to cognitive and motivational systems in humans. Hiroto once again used an auditory aversive stimulus and the human shuttlebox. A significant modification, however was the use of a triadic design that included control, solvable, and unsolvable conditions (Hiroto & Seligman, 1975). For example, some participants in the solvable and unsolvable conditions were given a discrimination tasks which

utilized four-dimensional patterns presented on index cards. Each of the patterns contained two values: letters (A or T), font color (black or white), font size (large or small), and border shape (square or circle). For those in the solvable condition, one value (e.g., any card with a square) was always correct whereas for those in the unsolvable condition, there was no consistent correct value. This manipulation is designed to influence the amount of perceived control of an aversive stimulus in the participant. To test whether the manipulation of perceived control induced learned helplessness, they followed each condition with a testing phase in which participants were required to either solve anagrams or use the human shuttlebox described above. Participants in the unsolvable conditions showed greater interference of learned avoidance in the shuttlebox and less correctly solved anagrams during the testing phase compared to those in the solvable conditions. Hiroto and Seligman (1975) reported that participants in the unsolvable conditions had higher frustration levels compared to other participants. Other studies using a similar experimental paradigm extended the influence of unpredictable, uncontrollable aversive stimulus to physiological variables as well (Gatchel & Proctor, 1976). Other researchers confirmed the cognitively exhaustive effects of inaccurate versus accurate training feedback and its enhancement of learned helplessness effects (Sedek & Kafta, 1990). Hiroto and Seligman (1975) expanded the possible ways to induce learned helplessness in human subjects with both auditory and cognitive tasks.

In an effort to dissociate uncontrollability and unpredictability, Burger and Arkin (1980) designed a 2 (controllable vs. uncontrollable) X 2 (predicable vs. unpredictable) experiment that utilized the auditory tone as an aversive stimulus and the anagram puzzle as a measure of the learned helpless effect. Additionally, Burger and Arkin (1980) accounted for personal differences by assessing each participant's desire for control using self-report measure to a standardized scale. Participants in the controllable condition were able to reduce or eliminate the aversive stimulus by solving the anagram puzzle whereas those in the uncontrollable condition were unable to change the aversive stimulus. Participants in the controllable-predictable condition and those in the controllable-unpredictable condition

were provided information regarding the consequences of their performance whereas those in the other two conditions (i.e., uncontrollable-predictable and uncontrollable-unpredictable conditions) received no information. Participants in the uncontrollable-unpredictable conditions were more likely to show impaired anagram performance and depression. Moreover, participants in this condition that were also classified as having high desirability for control based on the self-report measure had more errors, higher depression, and a stronger reaction to the aversion. However, this same subgroup of participants reported the tone to be less aversive. Lack of control and unpredictability were both required to successfully induce learned helplessness in humans (Burger & Arkin, 1980).

Whereas the studies describe above focused on varying the aversive stimulus and the measures of the learned helplessness effect, one aspect that has not been discussed is the ability of this learned behavior to generalize to other situations and stimuli. Abramson, Seligman, and Teasdale (1978) concluded that the generalizability of the learned helplessness effect depended on the similarity of a new situation to one previously associated with learned helplessness and the perceived controllability of aversive outcomes. Alloy, Peterson, Abramson, and Seligman (1984), concluded that learners are more likely to generalize the learned helpless to other situations when they perceive outcome causes to reflect more global attributes compared to causes that might be specific only to one situation. After learners were divided based on global versus specific attribution tendencies (based on self-report measures), they were exposed to a pretreatment learned helplessness phase similar to Hiroto and Seligman's (1975) protocol described above. After the pretreatment using a sequence of button presses to terminate or avoid the aversive tone, participants were tested using either a human shuttlebox or anagrams to see if the learned helplessness established during pretreatment would transfer to a testing situation that was either similar or dissimilar, respectively. Participants with global attribute tendencies were more likely to transfer the learned helplessness established during pretreatment to either the similar or dissimilar situations whereas participants with specific attribution tendencies transferred the

learned helplessness to the more similar situation only (Alloy et al., 1984).

The definition of learned helplessness relies on experiencing an uncontrollable aversive situation. If learned helplessness relies on experiencing an uncontrollable aversive stimulus and not limited to "unpleasant" noise or shock, then other uncontrollable "unpleasant" situations should be able to induce helplessness. An alternative uncontrollable unpleasant situation may be the inability to successfully remember a set of letters (e.g., GKT) while counting backwards by threes from a random starting point. A set of three letters appears briefly on the screen followed by a briefly presented three digit starting point. After the three-digit number disappears, a visual cue (a dot on the screen) prompts the participant to subtract three from the starting number held in memory. Each time the dot appears the participant must subtract three. At the end of the trial, the final number or trigram must be typed in. This situation is aversive because the deceptively simple task of remembering three letters is disrupted by the inability to mentally rehearse the information while counting backwards. The task is made even more aversive if the speed control, which should allow the participant to slow the visual dot cue, does not function properly. Following the memory task, all participants were tested with anagrams. The anagram task provides an opportunity to see the effects of the helplessness induced by the memory task such that participants with the nonfunctioning control dial are expected to terminate or complete incorrectly more anagrams with less motivation in a longer time compared to the participants with the functioning control dial.

## METHOD

*Participants*

Texas A&M University-Corpus Christi undergraduates (N = 11) volunteered to participate in this study. The experimenter recruited voluntary participants by meeting with teaching professors and utilizing a recruitment script. SONA-systems was also utilized in the recruitment of participants by providing available dates and times for participation. The SONA system is a cloud-based participant management software, which allows researchers to schedule studies, recruit participants, and manage schedules for participation

(Sona Systems Research Participation System, 1997-2016).

The professors provided extra credit for the participants who volunteered. Participants were randomly assigned to the control or random condition, with five control and six random participants in each condition. Informed consent was obtained from all participants and securely filed away.

*Apparatus*

The display of the stimuli and the recording of participants' performance was controlled by a Dell desktop computer running ePrime 2.0 experimental software. ePrime 2.0 software is a platform utilized to design, generate, run, and collect data from the computerized program created for this experiment (Schneider, Eschman, & Zuccolotto, 2002). The computer program was adapted from the Brown-Peterson Task ("Brown-Peterson Task," 1999-2015). The trigrams (set of three letters) for the memory test included twenty random combinations of consonant letters. The three-digit starting points included twenty random combinations of nine digits. The anagrams used for this study were taken from Adams, Stone, Vincent, and Muncer (2011). The anagram test included eighty five-letter words that were scrambled (e.g., CKRIT – TRICK). The sample of the anagrams are shown in Appendix A. Participants' responses were typed on a standard keyboard.

*Design*

A between-subjects design was used to examine the differences between the control condition and the manipulated random condition. The independent variable was the level of frustration. The dependent variables in this study were the number of correctly answered anagrams and the response time participants took to solve anagram trials.

*Procedure*

Before the arrival of participants, the laboratory computers were arranged for every other computer to run the control or random condition via ePrime 2.0 software. Participants arrived at the laboratory sign-in room, and were then informed of the purpose of the experiment. The purpose of the experiment was to allow investigation of the influence of experiencing

an aversive stimulus on problem-solving behaviors. Voluntary participants signed the consent form, and it was securely filed away. Participants were then escorted to the laboratory where additional instructions were provided before beginning the experiment.

All participants were informed the computers would record how quick and accurate responses were in both tasks. Participants were then informed that the tasks involved 40 short-term memory trials and problem solving trials. The participants were informed that the memory task was to observe how well they held the trigram in their memory until the end of the trial, while counting backwards by three from the given help number. The participants were advised that the alternating green and blue dots indicated when to count backwards by 3 (none of the subjects were aware of the speed control indicator until they observed it in the program). The intention of withholding this information was to allow participants to perceive a sense of control that may influence their frustration levels.

Subjects were also informed that incorrect answers during the memory trials were to be repeated until answered correctly (the participants were not informed that incorrect trials repeated only three times). After the memory test, all participants were asked to complete a short survey. The participants were not informed of the contents of the survey. The survey included a 1-5 scale on the perceived difficulty and technical difficulties with the memory trial task. The technical difficulty survey included a 1-5 list of possible technicalities the program could have displayed.

The participants were told after completion of the memory task and the survey the problem-solving task would begin (they were not informed of the 80 trials). All subjects were asked to unscramble five letters to make a common word. All participants were informed they had an unlimited amount of time to solve the anagrams if needed, and there was an option to terminate at any time. The anagram test was followed by a short survey, which consisted of a 1-5 scale on the difficulty level of the anagram task.

Each trial of the memory test began with a trigram presented for 2000 ms followed by a blank screen for 200 ms. After the presentation of the trigram, a random three-digit number appeared for 2000 ms followed by

a help number indicating the starting number minus three. After the presentation of the help number, a colored dot (alternating between green and blue) appeared cueing the participant to count backwards by three from the second number. The duration of dot speed was controlled to fluctuate between 600 and 3000 ms for half the participants. The duration between dots for the remaining participants randomly fluctuated between 200 and 4000 ms. Half of the forty trials required participants to enter the last number from the counting backwards task. The other twenty trials required participants to enter the trigram.

The independent variable was the level of frustration, which was operationalized as the amount of control over the environment given to the participant. The participants in the control condition had more control over their environment while participants in the random condition had no control over the environment. The environmental manipulation available to the participants was the speed of the alternating green and blue dots. The dependent variables were the number of correctly answered anagrams and the response time spent to solve or abandon the anagram task. Once the experiment was completed the participants were debriefed, informed of the manipulation, and released.

## RESULTS

*Descriptive Statistics*

Figure 1 contains the mean rating for memory test difficulty from the control and random conditions. Figure 2 contains the mean rating for anagram difficulty from the control and random conditions. Figure 3 contains the mean accuracy for completed anagram problems from the control and random conditions. Figure 4 contains the mean response time to complete the problem-solving trials for the control and random conditions.

*T-tests*

Using survey data on the difficulty levels of the memory task for the conditions of the experiment, an independent t-test was conducted. The results showed the average rating for difficulty of the memory trials for the random condition ($M$ = 1.83, $SD$ = 0.752772653) was perceived less difficult than that for the control condition ($M$ = 1.2, $SD$ = 0.447213595). However,

the difference between the two conditions was not statistically significant, $t(9) = -1.65$, $p > .05$ (see Figure 1).

An independent t-test was conducted using survey data on the difficulty of the anagram tasks from the control and random conditions of the experiment. The average rating for difficulty of the anagram trials for the random condition ($M = 3$, $SD = 1.264911064$) was perceived less difficult than that for the control condition ($M = 3.2$, $SD = 1.095445115$). However, the difference between the two conditions was not statistically significant, $t(9) = 0.28$, $p > .05$ (see Figure 2). We expected the anagram task should have been perceived more difficult when exposed to the random condition. However, an opposite effect was shown as the control condition identified the anagram task as more difficult.

An independent t-test was conducted to compare the control and random condition's levels of frustration with the number of correctly answered anagrams. The control condition was expected to be less frustrated and solve more anagrams correctly than the random condition. The average number of correct anagram trials for the random condition ($M = 26.83$, $SD = 23.16$) was more than that for the control condition ($M = 21.8$, $SD = 22.44$). However, the difference between the two conditions was not statistically significant, $t(9) = 0.36$, $p > .05$ (see Figure 3). These results were the opposite of what was expected and suggest that participants who experienced the uncontrollable inescapable aversive stimulus experienced less frustration and had small effects on problem-solving skills.

Another independent t-test was conducted to compare the control condition and the random condition's frustration levels on the response time spent to solve or abandon the anagram task. Participants in the random condition were expected to terminate the task sooner or take longer on the anagram task than the control condition. The average response time for correct anagram trials for the random condition ($M = 17.674$, $SD = 10073.75$) was longer than that for the control condition ($M = 13.131$, $SD = 7511.65$). However, the difference between the two conditions was not statistically significant, $t(9) = 0.83$, $p > .05$ (see Figure 4). These results suggest that subjects who were exposed to the uncontrollable aversive stimulus were affected by their motivational drive when their frustration levels increased. This resulted in the random condition taking

4.5 seconds longer than the control condition to solve or terminate the anagram portion.

## DISCUSSION

The current study was designed to examine how exposure to an uncontrollable aversive stimulus influences cognitive performance as measured by problem solving behaviors. The traditional explanation for learned helplessness predicts that exposure to an uncontrollable aversive situation should diminish motivation and cognitive processing. We hypothesized that participants who were allowed to control the timing of a very difficult memory task would take less time, complete more, and be less likely to lose motivation to complete all problem-solving anagrams compared to participants who could not control the timing of the memory task.

Although the experimental design was successful in developing a cognitively aversive situation and producing frustration in participants, the perceived difficulty between the two conditions was not sufficient to elicit a learned helplessness effect on problem solving behavior. Sample size was also a significant issue which was magnified by the between-subjects design of the independent variable. These limitations surely influenced the muddled outcome of this experiment.

Despite these shortcomings, the trend in response time was congruent with our predictions. Participants who had less control in the memory task took longer to solve the anagram problems compared to participants who had more control. We anticipate that with adjustments to the protocol, we will be able to capitalize on this trend.

The new protocol will consist of a triadic design with an exposure and testing phase. The control group will not be exposed to aversion, while the escapable and inescapable group will be exposed to a version of the aversive stimulus. All participants will be tested using an anagram task. The new protocol should allow observation of the influences an uncontrollable aversive stimulus has on cognitive performance. The new protocol should observe the deficiencies in motivation and cognitive processing and produce perceived difficulty in undergraduate participants to yield significant results.
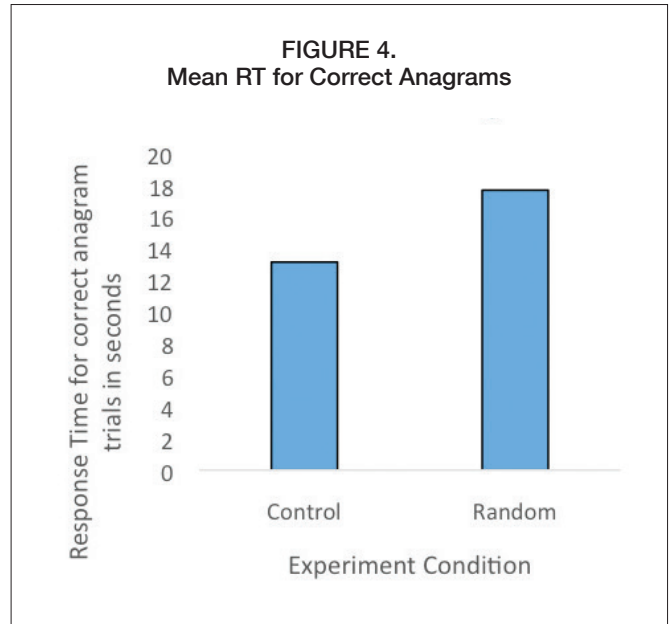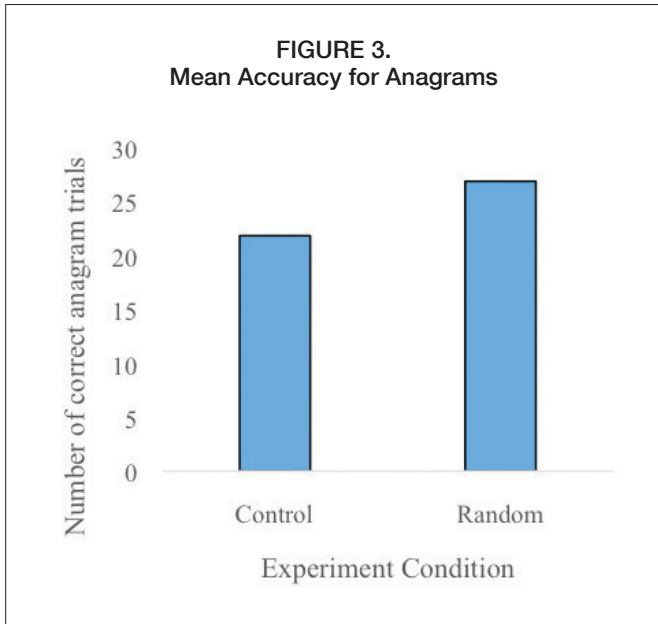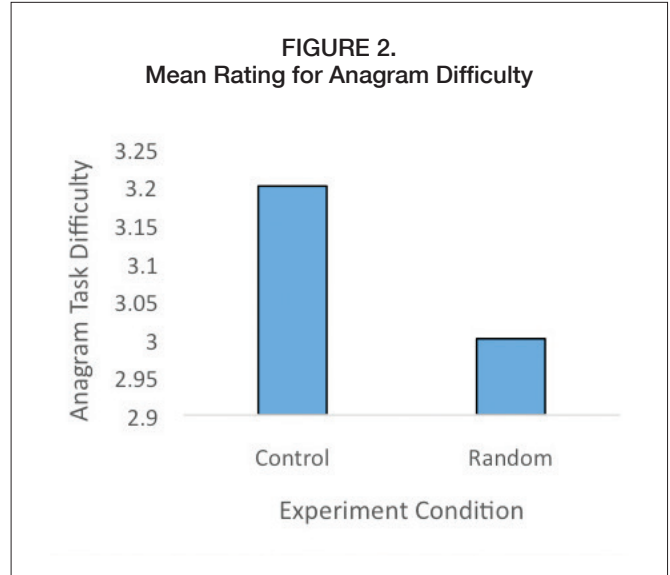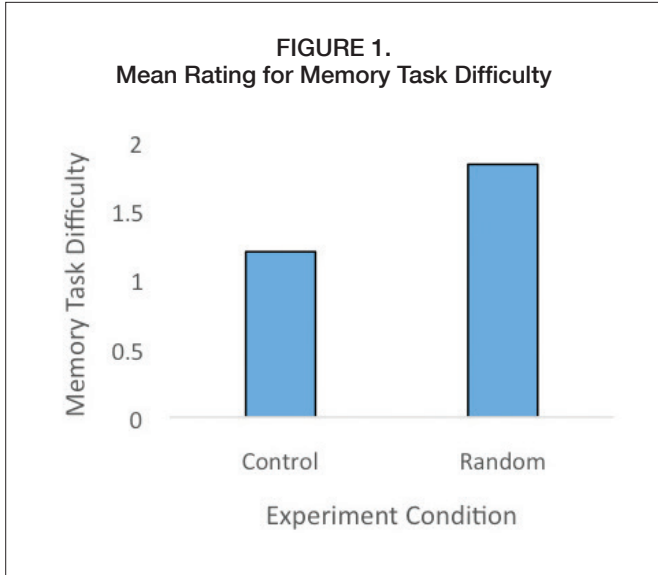
## REFERENCES

Abramson, L. Y., Seligman, M. E. P., & Teasdale, J. D. (1978). Learned helplessness in humans: Critique and reformulation. *Journal of Abnormal Psychology*, 87(1), 49-74.

Adams, J. W., Stone, M., Vincent, R. D., & Muncer, S. J. (2011). The role of syllables in anagram solution: A rasch analysis. *The Journal of General Psychology*, 138(2), 94-109.

Alloy, L. B., Peterson, C., Abramson, L. Y., & Seligman, M. E. P. (1984). Attributional style and the generality of learned helplessness. *Journal of Personality and Social Psychology*, 46(3), 681-687.

Brown-Peterson Task [Program documentation]. (1999-2015). Retrieved August 8, 2016, from https://coglab.cengage.com/labs/brown_peterson_task.shtml

Burger, J. M., & Arkin, R. M. (1980). Prediction, control, and learned helplessness. *Journal of Personality and Social Psychology*, 38(3), 482-491.

Gatchel, R. J., & Proctor, J. D. (1976). Physiological correlates of learned helplessness in man. *Journal of Abnormal Psychology*, 85(1), 27-34.

Hiroto, D. S. (1974). Locus of control and learned helplessness. *Journal of Experimental Psychology*, 102(2), 187-193).

Hiroto, D. S., & Seligman, M. E. P. (1975). Generality of learned helplessness in man. *Journal of Personality and Social Psychology*, 31(2), 311-327.

Maier, S. F., Albin, R. W., & Testa, T. J. (1973). Failure to learn to escape in rats previously exposed to inescapable shock depends on nature of escape response. *Journal of Comparative and Physiological Psychology*, 85(3), 581-592.

Maier, S. F., & Seligman, M. E. P. (1976). Learned helplessness: Theory and evidence. *Journal of Experimental Psychology: General*, 105(1), 3-46.

Overmier, J. B., & Seligman, M. E. P. (1967). Effects of inescapable shock upon subsequent escape and avoidance responding. *Journal of Comparative and Physiological Psychology*, 63(1), 28-33.

Padilla, A. M., Padilla, C., Ketterer, T., & Giacalone, D. (1970). Inescapable shocks and subsequent escape/avoidance conditioning in goldfish. Carassius auratus. *Psychonomic Science*, 20(5), 295-296.

Richter, C. P. (1957). On the phenomenon of sudden death in animals and man. *Psychosomatic Medicine*, 19(3), 191-198.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). E-Prime User's Guide. Pittsburgh: Psychology Software Tools, Inc.

Sedek, G., & Kofta, M. (1990). When cognitive exertion does not yield cognitive gain: Toward an informational explanation of learned helplessness. *Journal of Personality and Social Psychology*, 58(4), 729-743.

Seligman, M. E. P. (1972). Learned helplessness. *Annual Review of Medicine*, 23(1), 407-412.

Seligman, M. E. P., & Maier, S. F. (1967). Failure to escape traumatic shock. *Journal of Experimental Psychology*, 74(1), 1-9.

Seligman, M. E. P., & Maier, S. F. (1968). Alleviation of learned helplessness in the dog. *Journal of Abnormal Psychology*, 73(3), 256-262.

Seward, J. P., & Humphrey, G. L. (1967). Avoidance learning as a function of pretraining in the cat. *Journal of Comparative and Physiological Psychology*, 63(2), 338-341.

Sona Systems Research Participation System [Computer software]. (1997-2016). Retrieved June 25, 2016, from http://www.sona-systems.com/default.aspx

Thornton, J. W., & Jacobs, P. D. (1971). Learned helplessness in human subjects. *Journal of Experimental Psychology*, 87(3), 367-372.

## APPENDIX A

List of Words Used and Their Anagrams

| Word | Anagram | Word | Anagram | Word | Anagram |
|------|---------|------|---------|------|---------|
| ALBUM | AULMB | FORCE | ROEFC | ORBIT | TRIBO |
| ANKLE | LAEKN | FRAUD | DFRUA | PANIC | CNAPI |
| BATON | TOBAN | FROWN | OFNRW | PORCH | ORPHC |
| BIGOT | TBOIG | FRUIT | ITRFU | PRIZE | ZPREI |
| BIRCH | ICHBR | GAUZE | ZAEGU | QUERY | QRUYE |
| BRAWL | BLRWA | GLORY | YLGOR | QUILT | IQUTL |
| BRINE | NIERB | GNOME | MGOEN | SCARF | RASCF |
| CABIN | BIACN | GROUP | OPRUG | SCYTH | TYSCH |
| CHIMP | PHMCI | GUARD | GADRU | STYLE | YLTSE |
| CLERK | RLEKC | HONEY | OYNHE | TEMPO | EMOTP |
| CLOAK | LCKOA | HOUND | DHNUO | TOKEN | NOETK |
| CLOWN | COLNW | HOVEL | VEHLO | TRAMP | APRMT |
| COUNT | OUTCN | INDEX | NDXEI | TRICK | CKRIT |
| COUGH | OGUHC | INPUT | UTPIN | TRUCK | UCTKR |
| COVER | EROVC | JOINT | JNTOI | TRUMP | RMUTP |
| CRAMP | ARPCM | KNIFE | NKEIF | VALET | ALTEV |
| CRANK | CARKN | LIGHT | HGTLI | VICAR | CRVIA |
| CRYPT | PYTCR | LIMBO | OLIBM | VIPER | ERPVI |
| DEMON | ODNME | MAJOR | AOJMR | VIRUS | VSRUI |
| DRAWL | LWDRA | MATCH | HACMT | VISOR | OSIRV |
| FAITH | IFHAT | MERCY | CREMY | VISTA | VTSIA |
| FANCY | FNYAC | MIDGE | DGEMI | VODKA | AODVK |
| FILTH | LHTIF | MINER | IRMEN | WATCH | HWTCA |
| FINCH | CFHIN | MOUTH | MHUOT | WHARF | FRHAW |
| FLASH | LHSFA | NYMPH | YMHPN | WITCH | WCIHT |
| FLIRT | IRFTL | OPERA | PAEOR | WOUND | UDNWO |
| FLUKE | FEUKL | OPIUM | OMUPI | | |

## FIGURE 1.
## Mean Rating for Memory Task Difficulty



## FIGURE 2.
## Mean Rating for Anagram Difficulty



## FIGURE 3.
## Mean Accuracy for Anagrams



## FIGURE 4.
## Mean RT for Correct Anagrams

# CONDITION FACTORS OF FISH IN RESPONSE TO HYPOXIA EXPOSURE

by ALFONSO COHUO

## ABSTRACT

Hypoxia (low dissolved oxygen concentrations) in coastal waters is a growing issue worldwide. In recent years, new hypoxic regions have begun to emerge and this may pose problems for marine wildlife ranging from direct mortality to sublethal effects on metabolism, growth, reproduction or behavior. This study aims to test the effects of hypoxia on growth performance by comparing relative body masses (Fulton's K index) of Atlantic croaker (*Micropogonias undulatus*) collected in the northern Gulf of Mexico. Fish that experienced hypoxic exposure were hypothesized to have a lower condition index than fish that were always normoxic. This pattern was also hypothesized to be consistent across two sampling years. Hypoxic fishes' diet should reveal a higher number of pelagic prey, rather than prey common in the benthos. All fish had their standard length, total length, and mass recorded. Fish otoliths, liver, and muscles samples were removed and stomachs were weighed when full and empty. No significant difference was found between hypoxic and normoxic condition indices, but a significant difference in condition was observed between 2014 and 2015 fish. The slopes of the relationship between length and weight were significantly different between 2015 normoxic and hypoxic fish, but length-weight slopes were otherwise statistically similar for all other pairwise comparisons. A majority of stomachs were empty or had organisms that we could not identify. Multiple factors may have affected the lack of an effect of hypoxia on condition indices, including the potential for fish movement and mixing after hypoxia exposure but prior to capture. Stomach emptiness might have been the result of collection methods. Being in the nets for an extended time may have caused some fish to regurgitate. Otolith chemistry will be used in the future

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to determine hypoxia exposure of individual fish to more directly link hypoxia with growth performance.

## INTRODUCTION

Hypoxia is a worldwide phenomenon in which dissolved oxygen concentrations in water fall below 2mg/L. Nutrient loading, stratification, fossil fuels, and any source of organic carbons are factors that can drive formation of hypoxic waters (Rabalais et al. 2010). Hypoxic regions can manifest naturally or have human causes. In coastal regions hypoxia is commonly observed in the summer when there is stratification of the water column, which lowers the amount of oxygen that can be cycled between layers (Diaz and Rosenberg 2008). The low dissolved oxygen content is made even lower by inhabitants respiring (Grantham et al. 2004). Global warming could increase stratification and increase the area of hypoxia due to temperature differences (Rabalais et al. 2010). Human-caused hypoxia can occur from nutrient offloading from the land and mostly affects coastal areas rather than open ocean. Fertilizer use is a large contributor in increasing nutrient offloading. This nutrient input gives rise to algae blooms, which die and feed microbes in the benthos. Since benthic microbial respiration drives the majority of oxygen depletion, the hypoxic portion of the water column normally begins at the benthos, but can spread up to the bottom half of the water column (Rabalais et al. 2007). The Chesapeake Bay, Gulf of Mexico and the Baltic Sea have a positive relationship with nutrient inputs and hypoxia (Hagy et al. 2004, Carstensen et al. 2014). Anthropogenic nutrient loading coupled with halocline creation drive the hypoxia that occurs in the Baltic Sea. The salinity of the Baltic Sea is a large factor of hypoxia as shown by Cartensen et al. (2014). Salinity fell during 1983 to 1992 in both basins which resulted in a lower area of hypoxia. The halocline created from salt water inputs in the Baltic Sea is a form of stratification, limiting the nutrient mixing that could deter hypoxia creation. The hypoxic zones that have been present in the Baltic Sea have worsened due to eutrophication (Conley et al. 2009). Eutrophication is a result of nutrient loading that may originate from fertilizer use around the basins. Stratification of the water column due to temperature and low salinity river outflow couples with nutrient loading to cause hypoxia in the Chesapeake Bay and Gulf of Mexico. The Mississippi River is a large contributor of nitrogen deposits into the Gulf of Mexico system. The human caused hypoxia is the result of multiple human and non-human factors. Most systems are different and have different reasons why they are hypoxic.

The effects of hypoxia on marine fauna can vary depending on the duration and intensity of the event as well as organisms' tolerances to low dissolved oxygen levels. The focus of numerous studies on the effects of hypoxia on mobile fish has been on Atlantic croaker (*Micropogonias undulatus*; hereafter referred to as croaker), which are an abundant species of demersal fish that inhabit much of the Atlantic coast as well as the Gulf of Mexico (Whitaker 2005). The species is subject to high fishing pressure both recreational and commercial as well as subjectivity to hypoxic waters (Hales and Reitz 1992). Hypoxia in the Gulf of Mexico shifted the populations of brown shrimp and croaker to the edge of the area of hypoxia (Craig and Crowder 2005). The croaker and shrimp were displaced into environments with suboptimal temperature and DO levels. A decrease in weight was observed in the croaker and lower sizes for the shrimp were observed. It is believed suboptimal habitats caused by hypoxia are responsible for these declines. Croaker were also recorded moving from long term hypoxic areas, but not having as much avoidance for episodic hypoxia (Bell and Eggleston 2005). The relocation of croaker to pelagic habitats may also be an avoidance of benthic hypoxia. Movement of croaker into pelagic habitats could also result in diet shifts from benthic to pelagic prey items. If croaker are not displaced laterally or vertically due to hypoxia, their reproductive systems may begin to suffer as a result of hypoxia exposure. The gonads of male and female croaker that experience mild to intense hypoxia are smaller compared to normoxic fish (Thomas et al. 2007). Female croaker also develop male gamete cells in the ovaries under hypoxic conditions in field observations and lab studies. Females under normoxic conditions do not develop these cells (Thomas and Rahman 2012). Croaker that relocated in the Gulf of Mexico due to hypoxia still encountered levels low enough to have their reproductive systems affected. These reproductive effects could lead to lower fecundity and change population sizes. Thus, the potential sublethal effects of hypoxia on mobile fish species are

diverse and could have wide-ranging effects on fisheries and trophic interactions.

It is important to know the biological effects of hypoxia because the number of hypoxic regions worldwide is increasing (Rabalais et al. 2010) (Rabalais 2002). Occupying suboptimal habitats could affect growth because more energy has to be allocated for maintaining healthiness rather than growth. Weight is the characteristic that was affected by hypoxia indirectly through change in habitat (Craig and Crowder 2005). The condition indices should be lower for Atlantic croaker that were subject to hypoxic waters when compared to normoxic fish. The possible impacts of movement in the water column due to hypoxia may also change relationships in the pelagic food web (Nye et al. 2011). The stomach contents of the Atlantic croaker affected by hypoxia should include less demersal food items than normoxic fish. This reflects avoidance of the benthic area due to hypoxia. Vertical movement of croaker to avoid hypoxia has yet to be proven and stomach contents could be used as a proxy for this movement. Knowing how hypoxia affects the mass and length could change how conservation could be managed due to croaker being a frequently fished species. Information gathered could also be utilized to give insight on how new hypoxic areas are affecting demersal fish species.

## METHODS

Atlantic croaker from the Gulf of Mexico were collected in 2014 and 2015 between October and November. Collections took place on the NOAA ship Oregon II during SEAMAP Groundfish surveys between Galveston, Texas and Pascagoula, Mississippi. Fish were collected with benthic trawls at stations selected through a stratified random sampling design to include stations at various distances from the shore across the continental shelf. A 20' net was used along the Texas coast and a 40' net was used the remaining part of the voyage. Fish were organized into plastic bags by the station in which they were caught in. Each bag contained 20-50 fish and were put into a freezer until needed.

The thawing process would start two hours before dissection. All bags that were planned to be dissected that day were placed in a sink with warm water to help thawing. Once fish started to unfreeze from each other,

dissection could begin. One fish was processed at a time. Total length and standard length were recorded to the nearest 0.1 millimeter. A paper towel was used to dry the carcass after which it was weighed to the nearest 0.1 gram. The fish was then dissected to remove the head at a point right behind the gills. The sagittal otoliths of the fish were rinsed in distilled water to remove adhering tissue and placed in 0.5 ml vial to dry. Scissors were used to cut from the anterior end of the belly to the anal opening. The liver was located, removed, and rinsed in distilled water. It was placed into a vial and frozen at -20ºC.

The stomach was dissected on a cutting board and weighed to .001 of a gram to obtain a total mass of stomach tissue and any contents. The stomach was then placed on the cutting board again and the contents were carefully removed. The emptied stomach was weighed again to obtain the mass of the stomach tissue alone. The difference between the two masses provided the mass of any stomach contents, if present.

The fish was placed on its right side and a dorsal muscle sample was cut out from the top end of the fish. Skin and scales were removed from the muscle and discarded, and the remaining muscle sample was rinsed with distilled water and frozen at -20ºC.

Fulton's K Index was used to calculate relative condition. The equation used was with m representing mass (g) and L representing standard length (mm).

$$k = \frac{10^6 m}{L^3}$$

Determination of hypoxic and normoxic fish was done by identifying fish stations on a map, acquired from GulfHypoxia.net, of the hypoxic region in the prior summer for each year. If a station fell into a region under 2.0 mg/L it was marked hypoxic. Any station above that threshold was marked normoxic. Fish were assigned the exposure type corresponding to their station.

A 2-way ANOVA statistical test was used to compare the condition indices of normoxic and hypoxic fish in 2014 and 2015. Exposure levels were referred to as categories. An ANCOVA test was used to determine the difference of slope and y-intercept between each category. Log 10 mass was compared to the covariant, log 10 standard length. Two categories were tested each time to best determine the location of difference.

TABLE 1.
Affect year and exposure had on
condition of collected specimens.

| Source of Variation | Df | MS | P |
|---|---|---|---|
| Year | 1 | 9.978 | <0.001 |
| Exposure | 1 | 0.0108 | 0.634 |
| Year x Exposure | 1 | 0.0023 | 0.823 |
| Residuals | 902 | 0.0476 | |

FIGURE 1.
Map of the Gulf of Mexico.
All stations utilized in the data have been marked.
2014 stations are shown by open circles and
2015 stations are marked by filled circles.



TABLE 2.
Slope differences between different assigned exposure
types and years. Y-intercept comparisons were
unnecessary between 2015 normoxic and hypoxic
groups due to the slopes being significantly different.

| | Df | MS | F | P |
|---|---|---|---|---|
| Environment Normoxic 2014 vs 2015 | | | | |
| Slope | 1 | 0.006 | 3.839 | 0.0506 |
| Y-intercept | 1 | 0.288 | 152.6 | <0.001 |
| Hypoxic 2014 vs 2015 | | | | |
| Slope | 1 | 0.005 | 3.448 | 0.0642 |
| Y-intercept | 1 | 0.122 | 79.17 | <0.001 |
| Year 2014 Normoxic vs Hypoxic | | | | |
| Slope | 1 | 0.001 | 0.923 | .337 |
| Y-intercept | 1 | 0.000 | 0.096 | 0.757 |
| 2015 Normoxic vs Hypoxic | | | | |
| Slope | 1 | 0.016 | 10.076 | 0.00161 |
| Y-intercept | | | | |

FIGURE 2.
The Fulton's K boxplot of normoxic and hypoxic fish as well as 2014 and 2015 fish.
Significant differences were found between 2014 and 2015 fish (p<.001).
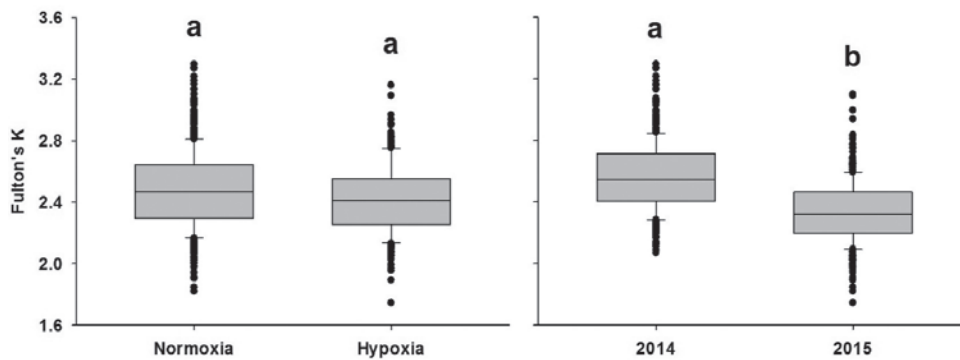
FIGURE 3.
The length distribution of 2014 and 2015 fish to visually show the similarity in sizes of the samples. The x axis are mm ranges and the y axis is the frequency the ranges occurred. Ranges are based on standard length.
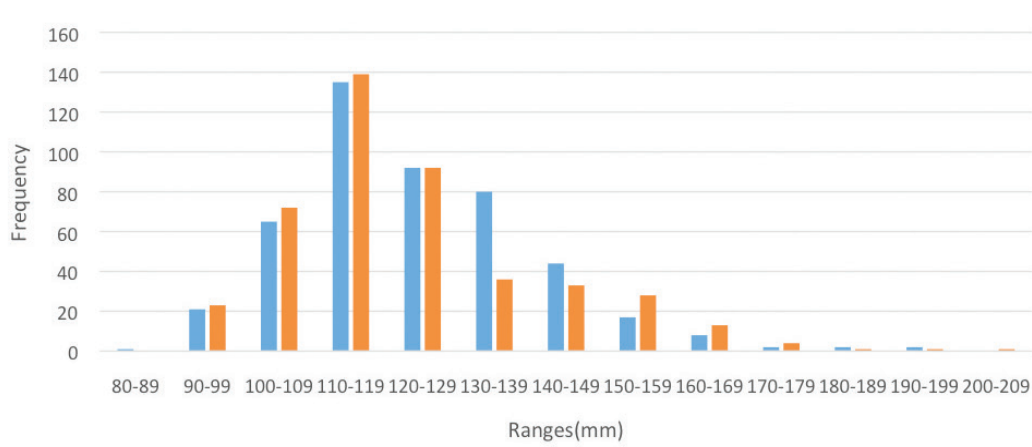


FIGURE 4.
The data points of 2014 and 2015 normoxic and hypoxic areas (Left). The regressions for each data set are shown in the right panel. Scale is transformed to log base 10 of length on the x axis and log base 10 of mass on the y axis for both graphs.
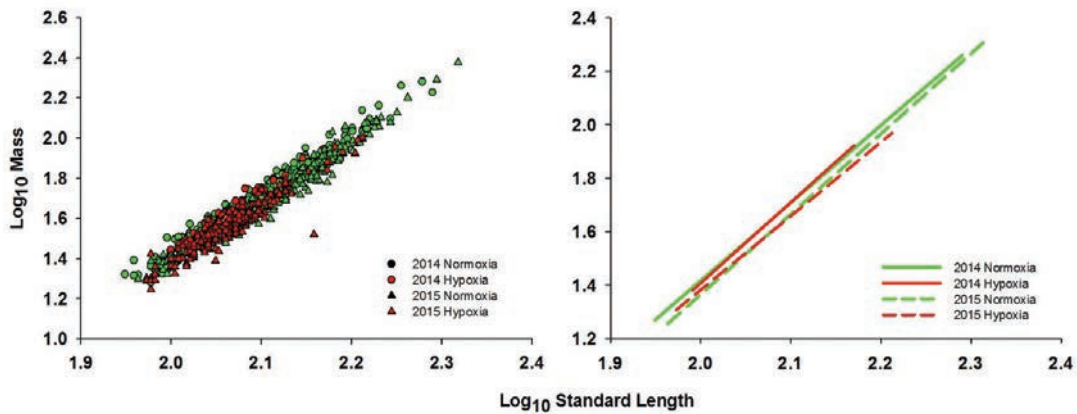


## RESULTS

The locations of all stations used for the data set are shown in Figure 1. The data set contained 23 stations from 2014 and 14 from 2015. The total amount of fish in this project were 463 and 443 for 2014 and 2015 respectively. The two-way ANOVA found no significant difference in the exposure type over the years 2014 and 2015 (p=.634). A visual representation of normoxic, hypoxic, 2014 and 2015 Fulton's K is shown in Figure 2. The condition of fish differed only in years and not exposure (p<.001, Table 1), with Fulton's K higher in 2014. Length sizes were similar between years 2014 and 2015 (Figure 3) and were tested with a two-tailed t-test (p=.74811). The regressions comparing log10 length and log10 weight for 2014 and 2015 hypoxic and normoxic groups had slightly differing slopes (Figure 4). Initially, significant difference between slopes using an ANCOVA (p=.0075) was found among the data set of 2014 and 2015. When tested in pairs, a significant difference in slope appeared between normoxia and hypoxia in 2015 (p=.00161, refer to Table 2). Y-intercept significance was found between 2014 and 2015 normoxia (p<.001) and 2014 and 2015 hypoxia (p<.001, Table 2).

Most stomachs were empty or contained small benthic prey while 6.3% of stomachs contained larger contents. Remnants of shell pieces were normally present within a large number of the unidentifiable digested remains in most of the croaker. Two fish were recovered fairly intact and a large shrimp. All other contents were larger benthic prey or unidentifiable.

## DISCUSSION

In this experiment we did not find any significant difference in condition index between normoxic and hypoxic groups either between or within years. Lab results from other studies have shown changes in condition index in response to hypoxia exposure. For instance, Mohan et al. (2014) shows significant decrease in size between a four week and ten-week exposure time compared to the control. For this study, the only difference in condition index was found between years regardless of hypoxia category. The observed annual difference in condition index between years may have been caused if one sample pool had a different length distribution. The lengths of 2014 and 2015 fish had to be tested against one another to eliminate that as a confounding factor. Since length distributions were shown to be similar between years, we can conclude that the 2014 fish had larger masses relative to length overall. This could be explained by the differences in station locations used in the data set. The dispersion of 2014 stations covers more area than 2015 stations. Different areas may contain different size and aged fish. This causes some inconsistency in the data set. The slope differences between 2015 normoxic and hypoxic fish suggest the mass of hypoxic 2015 fish was affected differently than normoxic fish. This difference may be biologically significant. The y-intercept difference was .49, which falls above the difference seen in an experimental study between normoxic and hypoxia exposed fish (Mohan et al. 2014). More research still needs to be done to verify what constitutes biological difference in regards to Fulton's K for croaker.

Diet was used as a proxy of movement along the water column. The contents of the croaker stomachs were found to reflect a benthic diet. Croaker tend to have a high percentage of decapods, echinoderms and polychaetes in their diet (Willis et al. 2015, Overstreet and Heard 1978, Nye et al. 2011). Based on observation of dissections, our data coincided with this trend. This may be the result of only the benthic trawl being utilized for collection. Stomach analysis was not the primary objective during collection so the type of capturing could affect what was seen during dissection. Many fish had everted their stomachs, possibly from the amount of stress caused from being trapped in a net and pulled from deep water as noted by Overstreet and Heard (1978). Access to a microscope could improve identification of contents by making it easier to find body parts in more digested prey.

The data gathered may not have fully reflected hypoxia exposure histories due to time of capture and the categorization of fish. The fish were gathered in the fall at least one month after hypoxia ended in the Gulf of Mexico. The start of collection allowed abundant time for fish to move throughout the Gulf. Our method of categorizing was more suited for a stationary organism rather than an organism with high mobility. Fish identified as hypoxic may have never been exposed to hypoxia, only caught in a station deemed hypoxic in the summer and vice-versa.

To improve categorization of fish, otolith chemistry will be utilized to determine the levels of DO exposure in the fish as we further this project. Laser ablation will be used to examine otoliths and determine the levels of Mn, Ca, and Ba. The manganese to calcium ratio is used to determine the level of hypoxic exposure fish may endure. Higher levels of Mn 2+ are found in hypoxic regions due to the diminished oxic top soil. (Limburg et al. 2015). High barium levels will be used to eliminate any high manganese readings since they both naturally occur at high quantities in estuarine environments (Elsdon and Gillanders 2006). Estuaries may have a larger barium concentration due to fresh water mixing.

## CONCLUSION

We conclude our hypoxic fish did not have a lower condition than our normoxic fish for either year. This may have resulted from the categorization method being unfit for a mobile species as it increased the room for error when assigning exposure type. Diet analysis did not yield many identifiable contents. Many benthic organisms were found with a small amount of pelagic fish. This project demonstrates the need of direct approaches in determining hypoxic history and diet. Otolith chemistry will be used in the future to obtain the hypoxic history of each individual fish, providing a direct approach to categorizing fish. Stable

isotope analysis of the liver and muscle will be used to record any diet alterations in response to hypoxia. Direct methods will decrease error and uncertainty of the results.

## REFERENCES

Bell G.W. and D.B. Eggleston. 2005. Species-specific avoidance responses by blue crabs and fish to chronic and episodic hypoxia. *Marine Biology*, 146, 761-770.

Carstensen, J., J.H. Anderson, B.G. Gustafsson and D.J. Conley. 2014. Deoxygenation of the Baltic Sea during the last century. *Proceedings of the National Academy of Sciences*, 111, 5628-5633.

Conley D.J., E. Bonsdorff, J. Carstensen, G. Destouni, B.G. Gustafsson, L.A. Hansson, N.N. Rabalais, M. Voss, and L. Zillen. 2009. Tackling Hypoxia in the Baltic Sea: Is engineering a solution? *Environmental Science and Technology*, 43, 2407-3411.

Craig K.J. and L.B. Crowder. 2005. Hypoxia-induced habitat shifts and energetic consequences in Atlantic croaker and brown shrimp on the Gulf of Mexico shelf. *Marine Ecology Progress Series*, 294, 79-94.

Diaz R.J. and R. Rosenberg. 2008. Spreading Dead Zones and Consequences for Marine Ecosystems. *Science,* 321, 926-929.

Elsdon, T.S., and B.M. Gillanders. 2006. Temporal variability in strontium, calcium, barium and manganese in estuaries: Implications for reconstructing environmental histories of fish from chemicals in calcified structures. *Estuarine, Coastal and Shelf Science,* 66, 147-156.

Grantham, B.A., F. Chan, K.J. Nielsen, D.S. Fox, J.A. Barth, A. Huyer, J. Lubchenco and B.A. Menge. 2004. Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific. *Nature,* 429, 749-754.

Hagy, J.D., W.R. Boynton, C.W. Keefe and K.V. Wood. 2004. Hypoxia in Chesapeake Bay, 1950-2001: Long-term change in relation to nutrient loading and river flow. *Estuaries,* 27, 634-658.

Hales, L.S. Jr. and E.J. Reitz. 1992 Historical changes in age and growth of Atlantic croaker, Micropogonias undulatus (Perciformes: Sciaenidae). *Journal of Archaeological Science,* 19, 73-99.

LIMBURG, K.E., B.D. Walther, Z. Lu, G. Jackman, J. Mohan, Y. Walther, A. Nissling, P.K. Weber, and A.K. Schmitt. 2015. In search of the dead zone: Use of otoliths for tracking fish exposure to hypoxia. *Journal of Marine Systems*, 141, 167-178.

Mohan, J., S. Rahman, P. Thomas, and B. Walther. 2014. Influence of constant and periodic experimental hypoxic stress on Atlantic croaker otolith chemistry. *Aquatic Biology,* 20, 1-11.

Nye J.A., D.A. Loewensteiner, T.J. Miller. 2011. Annual, seasonal, and regional variability in diet of atlantic croaker (Micropogonias undulatus) in Chesapeake Bay. *Estuaries and Coasts,* 34, 691-700.

Overstreet R.M., R.W. Heard. 1978. Food of the Atlantic Croaker, Micropogonias undulatus, from Mississippi sound and the Gulf of Mexico. *Gulf Research Reports,* 6, 145-152.

Rabalais, N.N., R.E. Turner, B.K. Sen Gupta, D.F. Boesch, P. Chapman, and M.C. Murrell. 2007. Hypoxia in the Northern Gulf of Mexico: Does Science Support the Plan to Reduce, Mitigate, and Control Hypoxia? *Estuaries and Coasts,* 30, 753-772.

Rabalais, N.N., R.J. Diaz, L.A. Levin, R.E. Turner, D. Gilbert and J. Zhang. 2010. Dynamics and distribution of natural and human-caused hypoxia. *Biogeosciences*. 7, 585–619.

Thomas, P. and S. Rahman. 2012. Extensive reproductive disruption, ovarian masculinization and aromatase suppression in Atlantic croaker in the northern Gulf of Mexico hypoxic zone. *Proceedings of the Royal Society of London*, 279, 28-38.

Thomas, P., S. Rahman, I.A. Khan, J.A. Kummer. 2007. Widespread endocrine disruption and reproductive impairment in an estuarine fish population exposed to seasonal hypoxia. *Proceedings of the Royal Society of London,* 274, 2693-2701.

Whitaker, J.D. 2005. South Carolina – Atlantic croaker. South Carolina Department of Natural Resources. Accessed on: 15 June 2016. Online at: http://www.dnr.sc.gov/cwcs/pdf/Croaker.pdf

Willis M.C., J. Richardson, T. Smart, J. Cowan and P. Biondo. 2015. Diet composition, feeding strategy, and diet overlap of 3 sciaenids along the southeastern United States. *Fish Bulletin*, 113, 290-301.

# HEALTH INSURANCE STATUS: IS THERE A DIFFERENCE IN PATIENT HEALTH OUTCOMES: A SYSTEMATIC REVIEW OF LITERATURE

by LAUREN DAVILA BSN, SN

## ABSTRACT

Background: *Patients who are uninsured or who have public health insurance have been associated with increased adverse health outcomes such as hospital readmissions, infection and higher levels of disability and mortality when compared with commercially insured patients. As of 2014, 33 million Americans remain uninsured and continue to be at risk for undesirable healthcare outcomes. Americans with either Medicare or Medicaid also make up a significant amount of the population at 35%.*

Methods and Findings: *A systematic review of literature comprising a search of Medline, PubMed, and CINAHL was conducted. Included were articles reporting patient outcomes based on insurance status. Fifteen articles were identified that met selection criteria.*

Conclusion: *Evidence suggests that insurance status is a significant predictor of patient health outcomes as well as mortality. Patients with Medicare, Medicaid, or no insurance consistently had worse health outcomes than patients privately or commercially insured. More studies should be conducted to assess the effects of insurance status on overall health care and patient outcomes. Further studies should be conducted to understand these findings and perhaps reduce adverse patient outcomes and mortality.*

Keywords: *Insurance status, uninsured, underinsured, and patient outcomes*

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## INTRODUCTION

An individual's health insurance status has a significant influence on their overall access to care, quality of care, and subsequently their overall health status (Moskovitz, 2014; Chikani, 2015; Jimenez, 2016; Spencer, 2015). Studies have shown patients who are uninsured or underinsured (such as those with Medicare and Medicaid) are at risk for more adverse health outcomes than those individuals with commercial insurance (Spencer, 2015; Jimenez, 2016; Bittoni, 2015; Saunders, 2016; Sutton, 2015). Fargen et al. (2015) reported insurance status as an independent predictor of patient safety events after stroke. The multi-variable analysis demonstrated Medicaid, self-pay, or no charge patients had statistically significant (p<0.001) longer length of
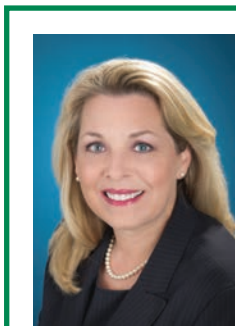
stays, higher mortality, and worse health outcomes than those with private insurance. Furthermore, Fargen et al. (2015) reported Medicaid, self-pay, and no-charge patients had a 1.5 times greater odds of having poorer health outcomes and 1.2 times the odds of dying during the initial hospitalization than patients with private insurance. Spencer et al. (2015) examined the rate of adverse patient safety events differing by insurance status concluding that Medicare and Medicaid patients experienced statistically significantly (p<0.05) more adverse safety events than private pay patients.

Examples of the hazardous safety events include but are not limited to: Central Venous Catheter-Related blood stream infections, postoperative hemorrhage, postoperative respiratory failure, and postoperative sepsis (Spencer et al., 2015). Prior research and statistics are important on this issue since many of our most vulnerable and disadvantaged populations (infants, migrants, refugees, the poor, children, adults, and elderly) fall under the category of uninsured, public insurance, or not having private insurance. The percentage of people without health insurance coverage the entire calendar year was 9.1 percent, or 29 million people in 2015 (U. S. Census Bureau, 2015). In the United States, 19.6% of people have Medicaid and 16.3% utilize Medicare for their healthcare necessities (U.S. Census Bureau 2015). The uninsured and underinsured population in the United States (US) totals approximately 45%. This systematic review aims to find the insurance status effects on mortality, patient health outcomes, access to care and quality of care.

## METHODS

### Selection Criteria

Studies were eligible for inclusion if they: (1) included participants who were uninsured, underinsured, commercially or privately insured, private pay, and self-pay. (2) Presented the results of the results of peer–reviewed research based on experimental study with measures for the outcomes of interest; (3) identified patient outcomes influenced by insurance status. Restrictions were limited to publications in the United States. Studies were excluded if they: (1) were not published in a book, report or other non-peer-reviewed publication; (2) were not published in the last six years; (3) not in the English language.

### Search Strategy

A systematic review of literature comprising searches of Medline, PubMed and CIANHL were conducted. Included were peer-reviewed, published literature reporting on the health outcomes of uninsured and under-insured patients. Keywords insurance status, uninsured, underinsured, health outcomes, and quality of care were utilized. The search identified 19 articles that reflected insurance status impact on patient health outcomes.

### Data Extraction

Authors LD and LG independently screened papers for eligibility and appraised the quality of the involved studies. The articles' titles and abstracts were screened and were omitted if they did not meet the inclusion criteria. When it was uncertain whether the article was appropriate, it was included for review. Authors then evaluated the full text of potential articles against the inclusion criteria. Data from the comprised papers were extracted by LD; LG independently extracted data from a random sample of 14 of the papers as a check for interrater reliability; no differences were noted.

### Data Analysis

Information about the study design, study sample, definition and method of assessing health outcomes based on insurance status was summarized. Insurance status impacting patient health outcomes was reported across the US using different study designs over a significant amount of years. The four primary outcomes of interest consistently expressed in the articles are (a) mortality, (b) availability and access, (c) quality and (d) adverse outcomes.
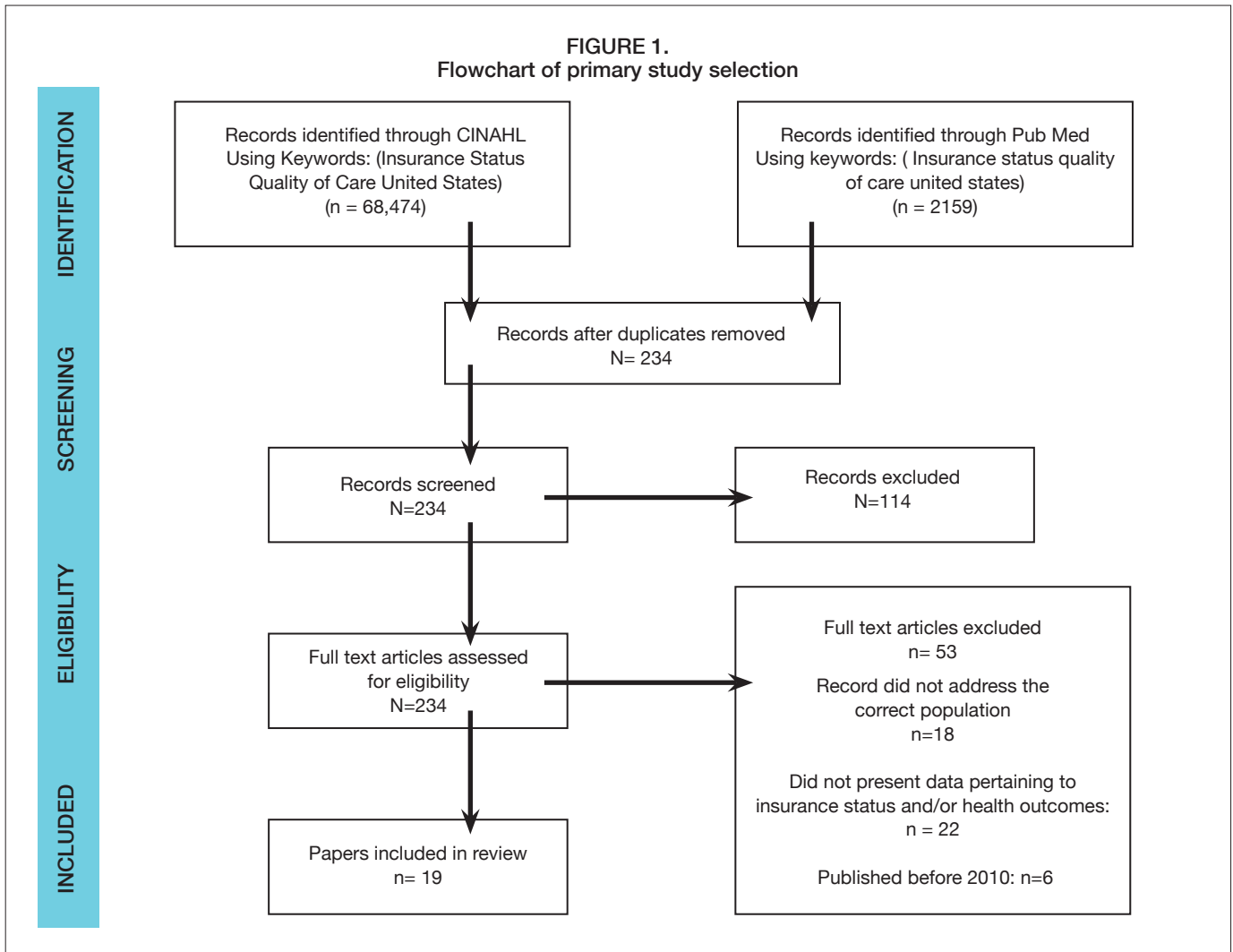
TABLE 1.
Characteristics of included studies (n = 19)

| Author and Year | Study Design | Sample | Outcomes of Interest | Level of Evidence |
|---|---|---|---|---|
| Jimenez, 2016 | Retrospective Cohort | n= 9361 children hospitalized for TBI between 2007-2012 , from a national Medicaid claims database | Access, Availability, Adverse Outcomes | Level 3 |
| Thorburn, 2010 | Cohort Study | n = 5,762 women from 1999-2001 who responded to surveys via telephone or mail. | Availability, Quality, Patient Views | Level 3 |
| Klimmek, 2010 | Cohort Study | n = 14 women in treatment or scheduled for treatment for breast cancer. | Quality, Access, Patient Views | Level 3 |
| Hossler, 2010 | Cohort Study | n = 899 people who received diabetes care | Access, Availability, Quality | Level 3 |
| Cook, 2009 | Retrospective Cohort | n = 9,761 adults with coronary artery disease or congestive heart failure receiving primary care at practices affiliated with 2 academic medical centers during 2000-2005. | Access, Adverse Outcomes | Level 3 |
| Berdahl, 2010 | Cross- Sectional Study | n = 20, 707 children. | Quality | Level 3 |
| Gardizi, 2014 | Cohort Study | n = 70 Adults with mild-complicated to severe TBI | Adverse Outcomes, Access | Level 2 |
| Moskovitz, 2014 | Prospective, Cohort Study | n = 1084 surveys from adult ED patients at a teaching hospital. | Access | Level 2 |
| Kuhlthau, 2016 | Cross-Sectional Study | n = 123,854 sample of all CCS ages 21-65 years old and a 1:3 matched sample of controls without a history of cancer. | Access, Affordability | Level 3 |
| Saunders, 2016 | Observational Cohort Study | n = 934 non-pregnant adults (18-64 years old) with albuminuria | Mortality, Access | Level 2 |
| Bittoni, 2015 | Cohort Study | n = 8950 participants (ages >40, and cancer free at baseline) | Mortality, Access, Adverse Outcomes | Level 2 |
| Ward, 2016 | Cohort Study | n = (1,377,827) patient age >18 years old, emergency department visits from 2006-2011 with an NEDS diagnosis of STEMI and a disposition of interfacility transfer or hospitalization at the same institution. | Adverse Outcomes, Mortality, Quality | Level 2 |
| Fargen, 2015 | Multivariable Analyses of Covariance | (n = 1,507,336) information on both primary payer and hospital teaching status. Ischemic stroke hospitalizations based on payer status (2002-2011). | Adverse Outcomes, Mortality, Access, Quality | Level 3 |
| Slatore, 2010 | Systematic Review | n = 23 eligibility criteria. | Adverse Outcomes, Mortality, Access | Level 1 |
| Chikani, 2015 | Retrospective Cohort | n = 80,435 cases analyzed based on primary payer, sex, race, zip code of residence, injury severity score, and alcohol or drug use. | Mortality, Access/Availability | Level 2 |

## TABLE 1. (continued)

| Author and Year | Study Design | Sample | Outcomes of Interest | Level of Evidence |
|---|---|---|---|---|
| Sutton, 2015 | Cohort Study | n = (118, 378) Patients with AA were identified by International Classification of Diseases, ninth edition, codes using the Agency for Health Care Administration Florida Hospital inpatient discharge data sets for (2002-2011) | Quality, Access, Adverse Outcomes | Level 2 |
| Antwi, 2015 | Pre and post ACA using a control group | N = 17,296,381, Treatment group=12,309,003 ages 12-25, Control group= 4,987,378 ages 27-29 | Availability, Quality | Level 2 |
| Golberstein, 2015 | Single Non-Randomized Trial | N = 430,583 with primary behavioral health diagnosis in 2005-2011 NIS data | Availability, Access, Quality | Level 2 |
| Spencer, 2015 | Cohort Study | 1,434 acute-care general hospitals that treat broad range of conditions. | Quality, Adverse Outcomes | Level 2 |

## FIGURE 1.
## Flowchart of primary study selection



**IDENTIFICATION**

Records identified through CINAHL Using Keywords: (Insurance Status Quality of Care United States) (n = 68,474)

Records identified through Pub Med Using keywords: ( Insurance status quality of care united states) (n = 2159)

Records after duplicates removed N= 234

**SCREENING**

Records screened N=234

Records excluded N=114

**ELIGIBILITY**

Full text articles assessed for eligibility N=234

Full text articles excluded n= 53

Record did not address the correct population n=18

Did not present data pertaining to insurance status and/or health outcomes: n = 22

Published before 2010: n=6

**INCLUDED**

Papers included in review n= 19

## RESULTS

The study selection process is presented in Figure 1. The literature search resulted in 70,633 unique records, of which 114 were included following abstract and title screening. The two hundred and forty-four articles that possibly met the inclusion criteria were retrieved. After additional screening, 19 of the papers were reserved for inclusion.

*Key Features of Included Papers*

Table 1 reviews the key features of the 19 included papers. Each of the 19 studies were conducted in the US. All of the articles discussed one or more of the primary outcomes of interest. Five studies examined mortality rates and their relationship with insurance status. Twelve studies examined the impact of availability and access of health insurance. Eight of the papers examined the impact of patient insurance status on patients' view of their quality of care. Five of the studies exposed more adverse events such as patient safety events and hospital acquired infections being more likely in patients that are underinsured or uninsured than those with private insurance.

*Mortality*

Insurance status has been proven to be associated with mortality risks and rates. Slatore et al. (2010) determined that patients with Medicaid or no insurance had increased mortality rates secondary to lung cancer. This population were more likely to be diagnosed at a more advanced stage of the disease and had increased rates of dying within the same month of their diagnosis, concluding that patients that were insured and Medicaid patients had higher overall mortality rates. Chikani et al. (2015) discovered self-pay patients had a significantly greater risk of mortality after a traumatic injury compared to any other insurance type groups. Self-pay patients had significantly higher fall-related mortality (OR = 2.06, 95% CI [ 1.17-3.61]) firearm-related mortality (OR= 2.72, 95%, CI [ 1.59-4.64]), MVT-related mortality (OR=3.11, 95%, [2.34-4.14]) and morality related to all other causes of injury (OR=2.59, 95%, CI [1.62-4.15]), with the exception of cut-pierce (Chikani et al., 2015). Saunders et al. (2016) specifically analyzed the morality risk for patients with albuminuria in relation to their insurance status. The study discovered increased mortality risk for those uninsured even after controlling for sociodemographic, health status, and health care variables. Compared to those with private insurance, being uninsured and publicly insured was associated with increased risk for all-cause mortality. In full adjusted models, compared to individuals with private insurance, being uninsured was associated with increased risk for all-cause mortality (HR 2.97, 95%, CI 1.29-6.85) (Saunders et al., 2016). Uninsured individuals with albuminuria had nearly a three-fold higher risk for all-cause mortality than their privately insured counterparts. Bittoni et al. (2015) assessed the impact of health insurance status on cancer and chronic disease mortality. The results proved that insurance status was related to the risk of mortality from cancer, cardiovascular disease (CVD) and diabetes, both in unadjusted and adjusted models as she hypothesized. After controlling for demographic and lifestyle risk factors, the increase in mortality risk for public/uninsured patients was still evident at 1.4 times greater for cancer (HR=1.35; 95% CI=1.09, 1.66; P<0.001) compared to 2.5 times greater (HR= 2.45, 95% CI=1.45, 4.14; P <0.001) for diabetes. This research specifically supported the hypothesis that those with public or no insurance showed the greatest increase of risk of diabetes mortality (245%) compared to (35-62%) for other types of possibly mortality (Bittoni et al., 2015).

*Adverse Health Outcomes*

Insurance status alone, specifically lack of insurance, is a risk factor for suboptimal clinical outcomes. The introduction of additional delays of care as an effect of interfacility transfer may further jeopardize outcomes for this susceptible population (Wang, et al., 2011; Ward et al., 2016). Sutton et al. (2015) wanted to define the relationship between patient presentation, management, outcomes, and costs in acute appendicitis. The study found that the uninsured were statistically more likely to present with complicated appendicitis (p<0.01) and Medicare patients were more likely to experience postoperative complications (p<0.01). The overall findings show patients without commercial insurance are more likely to present with complicated appendicitis, are less likely to receive a laparoscopic appendectomy, have longer lengths of stay, and a higher total cost of care (Sutton et al., 2015). Slatore et al. (2010) chose to study patient insurance status and outcomes in patients

with lung cancer. The study found that when compared to private or Medicare insurance groups, patients with Medicaid or no health insurance had higher lung cancer incidence rates, a more advanced stage at diagnosis, and higher stage-specific and overall mortality rates (Slatore et al., 2015). Gardizi et al. (2014) found that individuals with government-funded insurance had higher levels of disability relative to individuals with commercial insurance. This relation persisted even when controlling for level of education, race, and cause of injury. Spencer et al. (2016) examined the rate of adverse patient safety events differing by insurance status in the same hospital, concluding that Medicare and Medicaid patients experienced significantly (p<0.05) more adverse safety events than private pay patients for 12 and 7 Patient Safety Indicators respectively. Specific adverse safety events include: pressure ulcers, central venous catheter blood stream infections, postoperative hemorrhage or hematoma, postoperative sepsis and death among elective-surgical patients (Spencer et al., 2016).

*Access and Availability*

Moskovitz et al. (2014) researched the lack of primary care possibly being the source of bounce backs (patients returning for the same diagnosis within 30 days) in the Emergency Department (ED). It was found that patients who bounced back to the ED were more likely to have Medicaid or lack insurance (p = 0.0015), less likely to have a primary care physician (PCP) (p = 0.0204), and if they had a PCP, it was more likely to be in the clinic setting (p = 0.0072). Furthermore, insurance status was recognized as a statistically significant element for patients returning to the ED, showing an increased difference of 6% likelihood to bounce back in those without insurance. Additionally, patients without a PCP showed a 7% increase in bounce backs to the ED over those with a PCP (Moskovitz et al., 2014). Antwi et al. (2015) focused on changes in the ED usage among young adults following the time at which the Affordable Care Act dependent coverage was implemented. Throughout the study, it was found that the quarterly ED-visit rate decreased by 1.6 per 1,000 population (95% CI 1.2 to 2.1) among targeted young adults after the implementation of the provision, relative to a comparison group. The Patient Protection and Affordable Care Act dependent coverage expansion

was associated with a statistically significant yet modest decrease in ED use, concentrated in the types of ED visits that were likely to be responsive to changes to insurance status (Antwi et al., 2015). Thorburn et al. (2010) examined insurance-based discrimination during prenatal care as well as during labor and delivery, concluding that insurance-based discrimination was significantly associated with the number of breastfeeding support actions. In subsequent analyses, the marginal effect of insurance-based discrimination was significant (OR = 0.43, P = <0.05), indicating that experiencing insurance-based discrimination was associated with receipt of fewer breastfeeding support actions. Slatore et al. (2010) found that patients with Medicaid or no insurance were less likely to receive surgery or radiation, or to receive treatment at a high-volume center. The study additionally discovered patients with lung cancer without insurance do poorly since access to care is restricted and/or they present with more advanced disease that is less responsive to treatment (Slatore et al., 2010). Sutton et al. (2016) examined the insurance status and outcomes of patients with acute appendicitis. The study revealed the uninsured were less likely to receive laparoscopic appendectomy (odds ratio = 0.70, P< 0.01), in comparison to the commercially insured patients (Sutton et al., 2016).

*Quality of Care*

Uninsured patients are sometimes refused care based on their inability to pay, obtain less preventative and chronic care, are at higher risk of preventable hospitalizations and are less likely to participate in recommended follow up care (Sutton et al., 2015). The quality of care that patients receive based on insurance status has been discovered as well as perceived by the patients themselves (Thorburn et al., 2010). While this experience is not based exclusively on those who are uninsured or who have gaps in insurance coverage, these groups are much less likely to receive steady, high-quality medical care (Brouse et al., 2010). Ward et al. (2016) suggest that patients with ST Elevation Myocardial Infarction (STEMI) who do not have insurance are more likely to receive less timely care, which has significant implications for clinical outcomes and mortality (Ward et al., 2016). Klimmek et al. (2010) interviewed patients with cancer and observed and learned their responses to insurance-related challenges

during and after their treatment. From the patients' point of view, obtaining access to care was stressful financially and emotionally. When interacting with their managed care organizations (MCOs) it was difficult for patients to find knowledgeable and helpful personnel, after numerous transfers in different branches. They perceived these challenges as inhumane and uncaring and felt as if they were unable to obtain the necessary information. For some participants, lack of clear information about costs before the initiation of treatment was considered a form of provider irresponsibility and neglect, resulting in a decreased level of trust in both the MCO and the healthcare system. When obtaining authorization, there were perceived challenges such as lengthy waiting periods for referrals, specialists and treatments, providing further challenges for accessibility and quality. Omission of medications from MCO formularies was also a challenge for the patients. Certain patients perceived these conflicts as delays in their treatments, denials leading to questioning of MCO rules and perception of a system without "heart or logic," as well as them feeling as if they have a decreased capability to make educated treatment selections (Klimmek et al., 2010).

## DISCUSSION

Throughout the studies regarding patient insurance status impacting patient outcomes, there were various trends that are cause for concern. Many adverse clinical outcomes were proven to be related to patients obtaining adequate healthcare and the quality of their care. For example, insurance status was one of the strongest influences found among the articles that impacted the patients' overall health outcome (Fargen et al., 2015; Antwi et al., 2015; Bittoni et al., 2015; Ward et al., 2016). Bittoni et al. (2015) found that insurance status was strongly associated with cancer/chronic disease mortality after adjusting for lifestyle factors. The results suggest that inadequate health insurance coverage results in a considerably greater demand for preventative strategies that focus on tobacco control, obesity, and improved dietary quality (Bittoni et al., 2015). Ward et al. (2016) revealed that the lack of insurance is strongly linked with the risk for transfer and delays in STEMI care. Regardless of the underlying reasons, this signifies an essential disparity in care that places patients without health insurance and

those underinsured at increased risk for mortality and morbidity due to the delays associated with interfacility transfer. Prior studies, along with these findings, suggest that acuity of the clinical condition and location of care may not be the only elements altering the transfer decision, but that insurance status may also influence this as well (Ward et al., 2016). Chikani et al. (2015) discovered that higher odds of trauma-related mortality for self-pay patients may be related to a variety of factors. One possible explanation is care coordination in the trauma system, which is exacerbated by shorter length of stay (LOS) for this group.

Insurance status was found to be a significant factor influencing patient health outcomes among the studies. The results demonstrated patients without private insurance were at risk for adverse health outcomes and increased mortality. Therefore, patients with Medicare, Medicaid, both Medicare/Medicaid, or self-pay were all at a higher risk for adverse outcomes when compared to privately insured patients (Sutton et al., 2016; Thorburn et al., 2010; Fargen et al., 2015). Particular adverse outcomes that the patients are at higher risk for include disability, cancer incidences, postoperative sepsis, and complicated appendicitis (Sutton et al., 2016; Spencer et al., 2015; Gardizi et al., 2014). Spencer et al. (2015) discovered Medicare and Medicaid patients experienced considerably more adverse safety events than private pay patients for 12 and 7 Patient Safety Indicators. Several of the patient safety indicators Medicare and Medicaid patients were more prone to have are hip fractures, hemorrhage, respiratory failure, and pneumothorax (Spencer et. al., 2015). Gardizi et al. (2014) explored both medical comorbidity as well as insurance type predicting disability and found that of the independent variables, both self-reported comorbidity and government insurance were major predictors of disability as measured by the Disability Rating Scale. This study also demonstrated that patients with government funded insurance experienced higher levels of disability relative to individuals with commercial insurance (Gardizi et al., 2014). Sutton et al. (2016) found that Medicaid and Medicare patients were associated with higher odds of complicated appendicitis when compared to commercially insured patients. Though on a separate analysis, the uninsured patients were found to be significantly more likely

to present with complicated appendicitis than both Medicare and Medicaid patients (Sutton et al. 2015). Slatore et al. (2010) discovered that when comparing patients with private or Medicare insurance, patients with Medicaid or no insurance had poorer cancer outcomes and poorer survival rates. In addition, the same patients with Medicaid or no insurance were less likely to undergo curative procedures (Slatore et al., 2010). Jimenez et al. (2016) stress the critical meaning of obtaining rehabilitation therapy or consultation as an inpatient to raise the possibility of receiving outpatient rehabilitation (Jimenez et al., 2016). Antwi et al. (2015) suggest that perhaps newly insured young adults were able to utilize medical means more proficiently by acquiring non-urgent medical care in sites other than the ED. The findings demonstrate the national effect of the provision and offer a more thorough understanding of which sorts of urgent visits were most affected when compared to earlier work (Antwi et al., 2015). Sutton et al. (2016) concluded that insurance status is known to affect health care usage. Furthermore, the study found that the uninsured may delay seeking medical assistance, causing a greater incidence of complicated disease and increased costs of treatment (Sutton et al., 2016). Furthermore, when patients reported they were not receiving quality care and treated differently because of their insurance status, they were more likely to receive suboptimal care (Thorburn et al., 2010).

## RECOMMENDATIONS

More studies need to be conducted to determine the effects of insurance status on health outcomes and mortality. Future studies can examine the extent to which payer status has effect modification on length of stay, injury severity, and trauma-related mortality. Based on the featured studies, improving patients' access to care, regardless of insurance status, can improve their overall health and decrease their possibilities of mortality. Educating patients about their health status and how to manage their conditions is another strategy to help prevent them from becoming severely ill and having to visit the ED or hospital.

## CONCLUSION

The results provide validation of the effects of insurance status on patient healthcare outcomes.

Evidence suggests that insurance status is a significant predictor of patient adverse health outcomes as well as increased mortality. Patients with Medicare, Medicaid, or no insurance consistently had worse outcomes than patients privately or commercially insured. Nurses must be aware of the increased health risks correlated with being uninsured or underinsured in order to anticipate modifying nursing interventions and discharge plans to the needs of the individual patient. Existing evidence suggests the need for preventative healthcare measures for patients without insurance and public insurance, such as treating their existing co-morbidities, improving healthcare access, and education regarding their current health status. By applying these interventions, it is likely for the patient without commercial insurance to improve their quality of life as well as reducing their lifelong healthcare costs and the societal burden of uncompensated health care.

## REFERENCES

Akosa Antwi, Y., Moriya, A. S., Simon, K., & Sommers, B. D. (2015). Changes in Emergency Department Use Among Young Adults After the Patient Protection and Affordable Care Act's Dependent Coverage Provision. Annals Of Emergency Medicine, 65(6), 664-672.e2. doi:10.1016/j.annemergmed.2015.01.010

Berdahl, T. A., Friedman, B. S., Mccormick, M. C., & Simpson, L. (2013). Annual Report on Health Care for Children and Youth in the United States: Trends in Racial/Ethnic, Income, and Insurance Disparities Over Time, 2002-2009. Academic Pediatrics, 13(3), 191-203.

Berdahl, T., Owens, P., Dougherty, D., McCormick, M., Pylypchuk, Y., & Simpson, L. (2010). Annual report on health care for children and youth in the United States: racial/ethnic and socioeconomic disparities in children's health care quality. Academic Pediatrics, 10(2), 95-118. doi:10.1016/j.acap.2009.12.005

Bittoni, M. A., Wexler, R., Spees, C. K., Clinton, S. K., & Taylor, C. A. (2015). Lack of private health insurance is associated with higher mortality from cancer and other chronic diseases, poor diet quality, and inflammatory biomarkers in the United States. Preventive Medicine, 81420-426. doi:10.1016/j.ypmed.2015.09.016

Chikani, Vatsal; Brophy, Maureen; Vossbrink, Anne; Hussaini, Khaleel; Salvino, Christopher; Skubic, Jeffrey;

et al.(2015). Association of Insurance Status with Health Outcomes Following Traumatic Injury: Statewide Multicenter Analysis. Western Journal of Emergency Medicine, 16(3). doi: 10.5811/westjem.2015.1.23560. uciem_westjem_23560. Retrieved from: http://escholarship.org/uc/item/1012j57x

Cook, N., Ayanian, J., Orav, E., & Hicks, L. (2009). Differences in specialist consultations for cardiovascular disease by race, ethnicity, gender, insurance status, and site of primary care. Circulation, 119(18), 2463-2470. doi:10.1161/CIRCULATIONAHA.108.825133

Fargen, K. M., Neal, D., Rahman, M., & Hoh, B. L. (2013). The prevalence of patient safety indicators and hospital-acquired conditions in patients with ruptured cerebral aneurysms: Establishing standard performance measures using the Nationwide Inpatient Sample database. Journal of Neurosurgery, 119(6), 1633-1640. doi:10.3171/2013.7.jns13595

Gardizi, E., Hanks, R. A., Millis, S. R., & Figueroa, M. J. (2014). Comorbidity and Insurance as Predictors of Disability After Traumatic Brain Injury. Archives Of Physical Medicine & Rehabilitation, 95(12), 2396-2401. doi:10.1016/j.apmr.2014.06.004

Golberstein, E., Busch, S. H., Zaha, R., Greenfield, S. F., Beardslee, W. R., & Meara, E. (2015). The Effect of the Affordable Care Act's Young Adult Insurance Expansions on Hospital-Based Behavioral Health Care. The American Journal of Psychiatry, 172(2), 182–189. http://doi.org/10.1176/appi.ajp.2014.14030375

Hossler, C., Jenkins, C., & King, M. (2010). The effect of payer status on the quality of diabetes care: results from a REACH 2010 project. Southern Online Journal Of Nursing Research, 10(1), 14p.

Jimenez, N., Symons, R. G., Wang, J., Ebel, B. H., Vavilala, M. S., Buchwald, D., … Rivara, F. P. (2016). Outpatient Rehabilitation for Medicaid-Insured Children Hospitalized With Traumatic Brain Injury. Pediatrics, 137(6), e20153500. http://doi.org/10.1542/peds.2015-3500

Klimmek, R., Snow, D., & Wenzel, J. (2010). Insurance-related and financial challenges reported by managed care enrollees with breast cancer. Clinical Journal Of Oncology Nursing, 14(5), 598-606. doi:10.1188/10.CJON.598-606

Kuhlthau, K.A., Nipp, R.D., Shui, A. et al. J Cancer Surviv (2016). doi:10.1007/s11764-016-0542-7

Moskovitz, J. B., & Ginsberg, Z. (2015). Emergency Department Bouncebacks: Is Lack of Primary Care Access the Primary Cause?. Journal Of Emergency Medicine (0736-4679), 49(1), 70-77.e4. doi:10.1016/j.jemermed.2014.12.030

Saunders, M. R., Ricardo, A. C., Chen, J., Chin, M. H., & Lash, J. P. (2016). Association between insurance status and mortality in individuals with albuminuria: an observational cohort study. BMC Nephrology, 17, 27. http://doi.org/10.1186/s12882-016-0239-1

Slatore, C., Au, D., & Gould, M. (2010). An official American Thoracic Society systematic review: Insurance status and disparities in lung cancer practices and outcomes. American Journal Of Respiratory & Critical Care Medicine, 182(9), 1195-1205. doi:10.1164/rccm.2009-038ST

Smith, Jessica C. and Carla Medalia, U.S. Census Bureau, Current Population Reports, P60-253, Health Insurance Coverage in the United States: 2014, U.S. Government Printing Office, Washington, DC, 2015.

Spencer, C. S., Roberts, E. T., & Gaskin, D. J. (2015). Differences in the rates of patient safety events by payer: implications for providers and policymakers. Medical Care, 53(6), 524-529. doi:10.1097/MLR.0000000000000363

Sutton, T. L., Pracht, E. E., & Ciesla, D. J. (2015). Acute Appendicitis: Variation in Treatment, Outcomes, and Cost by Socioeconomic Status. Journal Of The American College Of Surgeons, 221S121. doi:10.1016/j.jamcollsurg.2015.07.284

Thorburn, S., & Marco, M. (2010). Insurance-Based Discrimination During Prenatal Care, Labor, and Delivery: Perceptions of Oregon Mothers. Maternal & Child Health Journal, 14(6), 875-885. doi:10.1007/s10995-009-0533-7

Ward, M. J., Kripalani, S., Zhu, Y., Storrow, A. B., Wang, T. J., Speroff, T., … Self, W. H. (2016). Role of Health Insurance Status in Inter-facility Transfers of Patients with ST-Elevation Myocardial Infarction. The American Journal of Cardiology, 118(3), 332–337. http://doi.org/10.1016/j.amjcard.2016.05.007

# A LONGITUDINAL STUDY INVESTIGATING THE RELATIONSHIP BETWEEN VISUAL SKILLS AND BATTING PERFORMANCE OF PROFESSIONAL BASEBALL PLAYERS

by LEANNA MARIE DeLEON

## ABSTRACT

The purpose of this study was to investigate the relationship between visual skills and batting performance of professional baseball players. Three hundred and fifty-two (352) professional baseball players were evaluated for visual skills and batting performance during the 2013-2015 minor league baseball seasons. Visual skills were assessed using the Vizual Edge Performance Trainer (VEPT), a commercial software program designed to assess eye alignment, depth perception, convergence, divergence, visual recognition and visual tracking. Individual subtest scores were used to generate a composite VEPT score. All visual skills testing was conducted by professional baseball scouts as part of pre-draft player evaluations. Batting performance was determined based on the 2013-2015 season statistics. This includes batting average (AVG), bases on balls percentage (BB %), strikeout percentage (K %), slugging percentage (SLG), on base percentage (OBP) and on base plus slugging (OPS). Descriptive statistics were used to analyze player performance based on visual skills. Players were divided into quartiles based on their comprehensive VEPT score. Batting performance was then compared for the upper and lower VEPT quartiles. Descriptive statistics indicated practical significance for AVG, .260 to .255, OBP, .333 to .329, and OPS, .716 to .704, while statistical significance was determined for K%, .220 to .244 (p=.015). When comparing the upper and lower 10% of VEPT scores, statistical significance was determined for AVG, .264 to .253 (p=.042) and K%, .207 to .250 (p=.004). Also, the upper quartile in AVG had significantly better visual recognition response time, .987s to 1.15s (p=.015), when compared to the lower quartile. The results of this study provides evidence that superior visual skills are indicative of superior batting performance in several statistical categories including AVG, K%, OBP and OPS. Since visual skills appear to play a significant role in batting performance, coaches, trainers, and administrators may consider using programs such as VEPT to assess baseball player's visual skills.

Keywords: *visual skills, batting performance, visual training, baseball*

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## INTRODUCTION
Vision may be the most variable and selective of all the senses, and current studies suggest that improvements

in visual skills will enhance batting performance of professional baseball players. When athletes attempt to observe the rapid movements inherent in most sports, great demands are placed on their vision (Knudson & Kluka, 1997). While successful batting is fundamental in baseball, it remains one of the most challenging skills to master in all of sports (Fortenbaugh, 2011). The purpose of this study was to investigate the relationship between visual skills and batting performance of professional baseball players. Visual skills were assessed using the Vizual Edge Performance Trainer® (VEPT), a commercial software program. Batting performance was determined based on the 2013-2015 season statistics and include batting average (AVG), bases on balls percentage (BB %), strikeout percentage (K %), slugging percentage (SLG), on base percentage (OBP), and on base plus slugging (OPS). Although the contributions of genetics and practice cannot be overlooked, researchers can also justify the vision components required for successful batting performance.

## LITERATURE REVIEW

*Vision in Sports*

In ball-based sports, athletes are routinely advised to keep their eyes on the ball in order to hit or catch it reliably. Unsurprisingly, "p than non-athletes "In 1996, Laby et al. studied professional baseball players for 4 years who belonged to the Los Angeles Dodgers baseball organization" (Hoshina et al., 2013). The results indicated that visual acuity, contrast sensitivity, and distance stereo acuity were better in professional baseball players than in the general public. This is most likely due to the fact that baseball batting places extremely high demands on eye-hand coordination, requiring focused concentration as well as good visual acuity and depth perception (Clark, 2012). Furthermore, as athletes who play ball games are routinely presented with motion stimuli during the course of their training, such repeated exposure is likely to enhance their perception of moving objects independently of any improvements in eye movements (Uchida et al., 2012). Although human vision is limited in its ability to observe many of the fast motions or short duration events common in sports (Knudson & Kluka, 1997), it appears that, with practice and training, individual improvements in vision can occur over time. Moreover, training programs which allow the players exposure to motion stimuli may best improve visual acuity.

*Visual Skills*

The eye is a very complex organ, and the ability to intake and process visual information varies greatly among players. Visual skills that appear to play a role in sport performance include visual acuity, peripheral vision, eye motility, eye dominance, and reaction time. Visual acuity is t In baseball, both static and dynamic acuities are important for success (Seiderman & Schneider, 1983). Additionally, tFor example, sapproximatelyDespite this relatively low rate of occurrence, cmayevaluatein order to make any necessary to equipment color Good peripheral vision enables baseball players to know where they are relative to the base, other players, and the walls, thus allowing them to avoid collisions.

Eye motility, also known as tracking ability, is integral to a batter. Hitting a baseball has been called the most visually demanding event in sports, and good eye motility is the primary component of being a successful hitter. Eye dominance and fixation also allow the hitters to concentrate on incoming baseballs (Seiderman & Schneider, 1983). Finally, reaction time is critical to batters that are attempting to discern the type of pitch being thrown. In these instances, faster reaction times will allow the batter to contact the ball more accurately. Vizual Edge Performance Trainer

The patented Vizual Edge Performance Trainer® delivers a powerful series of 3D computer-based sports vision improvement tools designed to be a critical part of an athlete's overall training program (Vizualedge. com, 2016) According to Carlo Alvarez, Strength and Conditioning Coordinator for the Pittsburgh Pirates,

The Vizual Edge Program proved to us that visual skills can be taught, trained, practiced, and enhanced. The benefits of the program are simple, to provide visual skills and training. The initial evaluation is approximately 30 minutes. The assessment provides a specific profile of the athlete's strengths and weakness. Once the athlete knows his strengths and weaknesses, the program can be designed especially for him. The training sessions usually take 20 to 30 minutes and should be performed at least twice a week. (Vizualedge. com, 2016)

The 3D exercises sharpen the player's peripheral awareness and visual memory as well as the speed, efficiency, and accuracy of the visual information processing (Vizualedge.com, 2016).

TABLE 1.
Batting Performance Means and Significance Levels

|  | VEPT | AVG | BB% | K% | SLG | OBP | OPS |
|---|---|---|---|---|---|---|---|
| Upper 25% | 86.40 | .260 | .099 | .220 | .383 | .333 | .716 |
| Lower 25% | 70.57 | .255 | .103 | .244 | .377 | .329 | .704 |
| Significance Level (p) | - | - | - | .015 | - | - | - |
| Upper 10% | 87.86 | .264 | .101 | .207 | .387 | .337 | .724 |
| Lower 10% | 66.78 | .253 | .102 | .250 | .379 | .329 | .698 |
| Significance Level (p) | - | .042 | - | .004 | - | - | - |

## METHODS

*Subjects*

Three hundred and fifty-two (352) professional baseball players were evaluated for visual skills and batting performance during the 2013-2015 minor league baseball seasons. Data was retrieved from visual skill testing conducted by professional baseball scouts as part of pre-draft player evaluations.

*Procedures*

The study received approval from the appropriate Institutional Review Board. The results of each professional baseball player's previous minor league season visual skill tests were obtained from Vizual Edge. All players remained anonymous, and confidentiality of results was maintained. Prior to implementation of these computer-based tests, subjects were given both verbal and visual instructions for the specific protocols to be followed. Subjects were allowed several practice trials in order to become familiar with both the equipment and techniques; however, results of these trials were not recorded. Testing was to begin upon completion of this familiarization process. Test administrators monitored the entire visual skills test and provided assistance, as needed. The software used to evaluate current visual skills was Vizual Edge Performance Trainer®. Subjects performed three trials, recording only the best attempt for each of the five visual elements. Upon completion of testing, individual subtest scores were used to generate a composite VEPT score. This final score was based on a scale of 0-100, with 0 being worst and 100 being best. Submitted result scores were then tested in opposition to multiple batting performance variables based on the 2013-2015 season statistics. Specifically, upper and lower VEPT score quartiles were correlated with batting performance.

*Statistical Analysis*

Descriptive statistics were used to analyze player performance based on visual skills. Using Microsoft Excel, means, standard deviations, variances, independent t-tests and Pearson's correlation coefficients (r) were used to interpret statistical significance between each quartile's means for batting average (AVG), bases on balls percentage (BB%), strikeout percentage (K%), slugging percentage (SLG), on base percentage (OBP), and on base plus slugging (OPS). The probability was accepted at $p \leq .05$.

## RESULTS

*Discussion*

S(p= .015) mean between the upper and lower VEPT score quartiles, vs, respectively.R for complete statistical analysisAdditionallyfor a (p= 0.15) ()that of (1.15s) Descriptive statistics also indicated practical significance for AVG (.260 vs .255), OBP (.333 vs .329), and OPS (.716 vs .704). Furthermore, when comparing the upper and lower 10% of VEPT scores, statistical significance was determined for both AVG (.264 vs .253; p=.042) and K% (.207 vs .250; p=.004).

*Conclusion*

The results of this study provide evidence that superior visual skills are indicative of superior batting performance in several statistical categories including AVG, K%, OBP and OPS. Since visual skills appear to play a significant role in batting performance, coaches, trainers, and administrators may consider including programs such as Vizual Edge Performance Trainer® in their assessment of baseball players. While the current study highlights the apparent correlation between visual skills and batting performance, additional research should be conducted in order to further investigate the exact relationship between these variables.

## REFERENCES

Barrett, Brendan. (2015). Vision and Sport: does better vision lead to better performance? *Optometry Today, 55*(12), 50-60.

Beckerman, SA and Hitzeman, SA. (1993). What the literature says about sports vision. *Optometry Clinics: The Official Publication of the Prentice Society, 3*(1):145-169.

Castaneda, Brooke and Gray, Rob. (2007). Effect of Focus of Attention on Baseball Batting Performance in Players of Differing Skill Level. *Journal of Sport & Exercise Physiology, 29*, 60-77.

Clark, J. F., Ellis, J.K., Bench, J., Khoury, J., & Gramna, P. (2012). High –Performance Vision Training Improves Batting Statistics for University of Cincinnati Baseball Players. Retrieved from: http://dx.doi.org/10.1371/0029109

Erickson, Graham B. *Sports Vision*. Oxford: Butterworth-Heinemann, 2007.

Fortenbaugh, David. *"The Biomechanics of the Baseball Swing"*. Open Access Dissertation. University of Miami, 2011.

Gavrisky. (1969). The Colours and Colour Vision in Sport. *Journal of Sports Medicine, 4*, 49-53.

Grimme, T., Memmert, D., and Simons, D.J. (2000). The relationship between visual attention and expertise in sports. *Psychology of Sport and Exercise, 10*(1), 146-151.

Ho, N. Y., Mann, D. L., Souza, N. J, Taylor, S. J., and Watson, D. R. (2007). Is optimal vision required for the successful execution of an interceptive task? *Human Movement Science, 26*(3), 343-356.

Hoshina, Kohji et al. (1996). A Study of Static, Kinetic, And Dynamic Visual Acuity in 102 Japanese Professional Baseball Players. *OPTH,* pp.627.

Khanal, S. (2015). Impact of Visual Skills Training on Sports Performance: Current and Future Perspectives. *Advances in Ophthalmology & Visual System, 2* (1).

Knudson, Duane and Darlene A. Kluka. (1997). The Impact of Vision and Vision Training On Sport Performance. *Journal of Physical Education, Recreation & Dance 68*(4): 17-24.

Seiderman, Arthur and Steven Schneider. (1983). The Athletic Eye. *Aoa.org*.

Spering, M. et al. (2011). Keep Your Eyes On the Ball: Smooth Pursuit Eye Movements Enhance Prediction of Visual Motion. *Journal of Neurophysiology 105*(4): 1756-1767.

Sports Vision - College of Optometrists in Vision Development (COVD). (n.d.). Retrieved from http://www.covd.org/?page=sports

Uchida, Yusuke et al. (2012). Origins of Superior Dynamic Visual Acuity in Baseball Players: Superior Eye Movements or Superior Image Processing. Retrieved from

Vizualedge. (2012). Retrieved from http://www.vizualedge.com

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# BEST PRACTICE FOR NURSES ON EDUCATION FOR PREGNANT WOMEN AND FAMILIES RELATED TO THE PREVENTION OF PERTUSSIS IN INFANTS: A SYSTEMATIC REVIEW OF LITERATURE

by LORISA GALLARDO BSN, SN

## ABSTRACT

Background: *Pertussis is a highly contagious disease with persistent outbreaks and resurgence in the U.S. and other countries despite the availability of a preventive vaccine. Pertussis is on the rise with the most deaths occurring in infants under the age of six months. Pertussis is most serious in neonates and young infants resulting in complications such as cyanosis, apnea, pneumonia, and encephalopathy, and death.*

Methods and Findings: *A systematic review of literature comprising a search of Pub Med, Medline, CINAHL and Cochrane library was conducted. Included were articles reporting on the best nursing education for pregnant women and families for the prevention of pertussis in infants. Twenty-three articles were identified that met selection criteria and were related to techniques pertinent to nursing patient education. Providing education to mothers of an infant about recommended vaccinations and cocooning is essential to inform them of the benefits of protecting their infants from pertussis.*

Conclusions: *Existing evidence suggests a need to educate parents on the importance of pertussis prevention. More studies should be conducted to assess the proper teaching methods to assist families in protecting infants from pertussis.*

Keywords: *Pertussis and Infants*

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## INTRODUCTION

Pertussis, a respiratory illness commonly known as whooping cough, is a highly contagious disease spread from person to person caused by bacteria called Bordetella Pertussis (ACIP, 2011). There have been persistent outbreaks and resurgences in the U.S. and other countries despite the availability of a preventive vaccine (CDC, 2015). According to the Center for

**FIGURE 1.**



Reported pertussis incidence by age group: 1990-2014
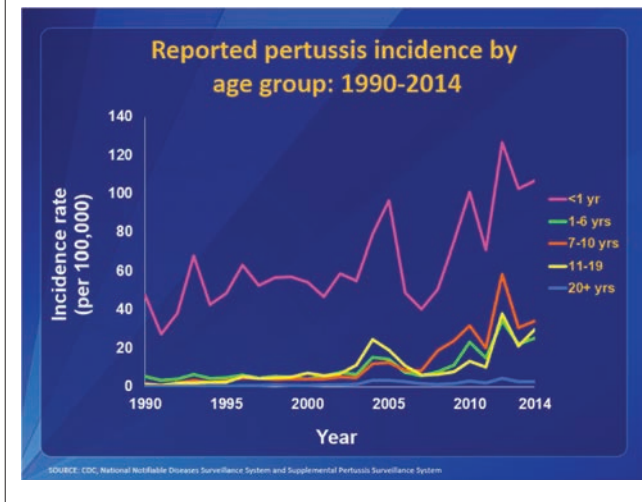
Disease Control, there are an estimated 16 million pertussis cases worldwide and about 195,000 child mortalities each year. Pertussis is also considered one of the leading causes of vaccine-preventable deaths worldwide (CDC, 2015). The CDC surveillance report shows that in 2014 there was a rise in the incidences of pertussis in the US and displays that there are more cases in infants than any other age (Figure 1). Infants are at the greatest risk with most deaths occurring in infants under the age of six months (CDC, 2015). Nurses are in a unique position to educate families and mothers on the importance of preventing pertussis. This systematic review aims to find the best practices for nurses on education for pregnant women and families related to the prevention of pertussis in infants.

## METHODS

### Selection Criteria

The review follows PRISMA reporting guidelines (Appendix 1). Studies were eligible for inclusion if they: (1) included participants who were pregnant, family members of an infant, or obstetric physicians; (2) presented the results of peer-reviewed research based on either a randomized control trial, single non-randomized trial, case control study, cohort study, case series analysis, or experimental study with measures for the outcomes of interest; (3) identified the best practices for nurses on education for pregnant women and families related to the prevention of pertussis in

infants. No restrictions were placed on the setting of the study. Studies were excluded if they: (1) were not published in the last five years; (2) were published in a book, report or other non-peer reviewed publication; (3) not in the English language.

### Search Strategy

A systematic review of literature comprising a search of Pub Med, CINAHL, Medline and Cochrane Review was conducted. Included were peer-reviewed papers reporting on the best nursing practice education for pregnant women and families for the prevention of pertussis in infants. The keywords pertussis and infants were utilized for searches. The search identified 23 articles that related to techniques pertinent to the best nursing education practices. The CDC and the American Academy of Pediatrics recommendations were included for review.

### Data extraction

All authors (LG, LD, CM) independently screened papers for eligibility and appraised the quality of the included studies utilizing Appendix 2. The articles' titles and abstracts were screened and were excluded if they did not meet the inclusion criteria. Data from the included papers were extracted by LG; LD independently extracted data from a random sample of ten of papers as a check for interrater reliability. No differences were found.

### Data analysis

Information of the study design, study sample, outcomes of interest, country and level of evidenced was summarized. Interpretation of the meaning of evidence retrieved from the literature was conducted to find themes in the literature. The five primary outcomes of interest consistently expressed in the articles are (a) administration of Tdap, (b) effectiveness of maternal vaccination, (c) maternal and infant health outcomes, (d) vaccine attitudes and (e) improving vaccination coverage.

## RESULTS

The study selection process is presented in Figure 2. Our literature search returned 175 unique records, of which 126 were excluded following abstract and title screening. The forty-four articles remaining that

FIGURE 2.
Flowchart of primary study selection

IDENTIFICATION

Records identified through CINAHL, Pub Med, Medline, Cochrane Review
Using keywords: pertussis and infant: n= 175

SCREENING

Records after duplicates removed
n= 170

Records screened
n=170

Records excluded

ELIGIBILITY

Full text articles assessed for
eligibility n=44

Full text articles excluded n= 25

Record did not address the
correct population
n=11

Did not present data pertaining to the
best nursing education for pregnant
women and families: n=10

Published before 2010: n=4

INCLUDED

Papers included in review
n=19

potentially met the inclusion criteria were retrieved. After further screening, 18 of the papers were retained for inclusion.

*Key Features of Included Papers*

Table 1 summarizes the key features of the 18 included papers. Of the 18 studies, 12 of the studies were conducted with pregnant mothers, 3 with infants, 3 with physicians and 4 with family members who would be in contact with an infant. Eight studies collected data on administration of Tdap, three on the effectiveness of maternal vaccination, three on maternal and

infant health outcomes, two on vaccine attitudes and three on vaccination coverage.

*Administration of Tdap*

The CDC recommends Tdap for pregnant women in their third trimester and any family members that will be in contact with the infant (ACIP, 2011). The Academy of Pediatrics (1991) recommends that a single dose of Tdap be given to pregnant mothers and to others who anticipate having close contact with an infant younger than 12 months, such as grandparents and other caregivers.

Seven studies reported on the administration of Tdap to prevent pertussis in infants. Three collected data on the maternal administration of the Tdap vaccination. Munoz et al. (2014) reported that Tdap immunization in the third trimester of pregnancy was well tolerated and immunogenic, infants of immunized women had a higher concentration of antibodies and Tdap did not interfere with the infant antibody response to

DTaP (Munoz et al., 2014). There weren't any serious adverse effects reported that occurred in either the mother or infants (Munoz et al., 2014). Injection site reactions were reported in 78.8% (CI: 61.1%, 91.0%) of pregnant women and 80% (CI of 51.9%, 95.7%) of postpartum women, with injection site pain being the chief symptom (Munoz et al., 2014).

Terenella et al. (2013) reported that pregnancy vaccinations could lessen yearly infant pertussis frequency by more than postpartum vaccination, reducing cases by 33% versus 20%, hospitalizations by 38% versus 19%, and deaths by 49% versus 16% (Terenella et al., 2013). The study also reported that a cocooning dose for fathers and one grandparent could prevent pertussis in an additional 16% of cases (Terenella et al., 2013).

Healy et al. (2012) assert that maternal antibodies wane quickly (CI=95%). Furthermore, even though there is highly efficient placental transport of maternal antibodies in women immunized within two years of delivery, they were unlikely to be high enough to passively protect infants through two or three months of age (Healy et al., 2012). Some limitations to the study were the small sample size and the sample race being predominantly Hispanic (Healy et al., 2012).

Two studies reported on the administration of parental Tdap. Quinn et al. (2014) identified that parents infected by pertussis account for 50% of the cases of pertussis among young infants. Moreover, the study observed a reduction in the risk among infants contracting pertussis whose parents were vaccinated (Quinn et al., 2014). The risk of pertussis in an infant younger than four months was reduced by 51% (CI: 95%) (Quinn et al., 2014). Also, the maternal vaccination and an immunized father reduced the risk by 51% (CI: 95%) (Quinn et al., 2014). Peters et al. (2012) also reported that immunizing the mother and father could reduce the rate of pertussis in infants less than four months of age (Peters et al., 2012). Additionally, the study found that the greatest benefit comes from Tdap vaccination that is administered at least two weeks prior to delivery (Peters et al., 2012).

Two studies reported on cocooning families by administering vaccination to anyone who comes into contact with an infant under twelve months of age.

Cocooning means immunizing everyone a newborn comes in contact with so none of them are able to transmit pertussis to the infant, giving the infant a time to build its own immunity through vaccinations (CDC, 2015). Rosemblum et al. (2014) reported that 84.8% of all members in the household obtained the vaccination prior to discharge of the infant, whereas the control group only reported 52.2 %. (p<0.05) (Rosemblum et al., 2014). The study concluded that a full cocoon could be established prior to the discharge of an infant in 76% in the intervention group and only 29.3% in the intervention group of households included (Rosemblum et al., 2014). There was a slight relationship found between the intervention group and the size of the household and full cocooning (p=0.051) (Rosemblum et al., 2014). A possible limitation of the study could have been that the length of time between intervention and survey may have caused a recall bias (Rosemblum et al., 2014). Healy et al. (2014) achieved an overall Tdap vaccination rate of 91% before the infant was discharged.

*Effectiveness of Maternal Vaccination*

Two studies tested the effectiveness of maternal pertussis vaccination in protecting newborn infants from pertussis. Dabrera et al. (2015) concluded that maternal vaccination is effective with their estimated vaccination effectiveness of 93%. (OR 0.09, CI 95) (Dabrera et al., 2015). Furthermore they found that vaccination effectiveness is a combined effect from transplacental antibody transfer and reducing household transmission. (Dabrera et al., 2015). Shakib et al. (2010) concluded that infants whose mothers display serological evidence of previous pertussis infection were estimated to be more likely to have potentially protective antibody levels at six weeks compared to mothers without previous infection (p=0.03). Some limitations of the study were small sample size and the antibodies being extrapolated instead of measured (Shakib et al., 2010).

*Maternal and Infant Health Outcomes*

Three articles reported on the safety of the Tdap vaccination by identifying maternal and infant health outcomes. The study demonstrated that women immunized during pregnancy and their infants were no more likely to experience adverse events than concurrent control mother- infant pairs in the study

(Shakib et al., 2013). One or more birth defect was identified in 3.7% (CI: 95%) of case infants and 4.4% (CI 95%) of control infants (P=0.079) (Shakib et al., 2013). Some limitations of the study are the low rate of Tdap administration and the small cohort size (Shakib et al., 2013).

Berenson et al. (2016) did not detect any overall increase in risk associated with Tdap administration during pregnancy for mothers or infants. A sensitivity analysis was conducted and found that including women with less than four prenatal visits would have increased bias towards poorer outcomes for unvaccinated mothers, which led to only including mothers who had adequate prenatal care (Berenson et al., 2016). The study found: (1) infants of vaccinated mothers were heavier than unvaccinated mothers (p=0.001), (2) vaccinated mothers were less likely to deliver by cesarean compared to unvaccinated mothers, (3) birth defects were rare and there were no significant differences noted in frequency of birth defects by maternal vaccination status (Berenson et al., 2016). Some limitations recognized by the study were, small sample size and only included conditions documented in patients' chart (Berenson et al., 2016).

*Vaccine Attitudes*

Two studies reported on the vaccine attitudes towards the administration of Tdap vaccination during pregnancy. Bonville et al. (2015) presented survey results that showed 80% of physicians routinely recommended vaccines to eligible patients, 67% administered vaccines in the office and 40% referred patients elsewhere for vaccinations (Bonville et al., 2015). The study found that provider knowledge of vaccine recommendations (OR 23.3), routine provider recommendation of influenza vaccine (OR 12.5) and administration of pertussis vaccine in the office (OR 7.01) were all factors strongly associated with eligible pregnant women (p <0.05) (Bonville et al., 2015). Pregnant women with negative vaccine attitudes were more likely to be immunized with a heath care provider recommendation compared to women with positive attitudes who did not receive recommendations from a health care provider (Bonville et al., 2015).

Macdougall et al. (2016) also discovered that pregnant women had a positive vaccine attitude with 62% of women agreeing to the maternal pertussis immunization. Some of the concerns voiced by women were the safety and adverse effects of immunization for themselves or for their infant (Macdougall et al., 2016). Additionally, 89% of the women revealed they would be willing to receive the vaccination if it were recommended to them (CI: 95%) (Macdougall et al., 2016). Only 70.3% of women agreed or strongly agreed that maternal vaccination was safe and 63.9% of women strongly agreed or agreed that receiving the immunization had less of a potential risk compared to an infant contracting pertussis (Macdougall et al., 2016). Some limitations of the study were that all the women were asked to participate in a clinical trial of maternal immunization that could have caused a biased positive attitude toward the vaccination (Macdougall et al., 2016).

*Improving Vaccination Coverage*

Six studies discussed improving vaccination coverage in mothers and caregivers of infants. Jones et al. (2016) provided toolkits to help increase vaccination administrations, which increased physicians offering Tdap from 59% to 77% (Jones et al., 2016). Post-intervention physicians were more likely to offer the Tdap vaccination routinely to their patients compared to pre-intervention (84.5% versus 67.0%, p < .001) (Jones et al., 2016). One of the limitations of the study was the low response rate by physicians (Jones et al., 2016).

Two studies were done on Tdap coverage in the military. Lam et al. (2013) note that, despite access to health care, Tdap coverage rates were low. A month after the intervention, the vaccination rates increased for patients receiving it within 30 day from 0.38% to 6.5% (p<0.005) (Lam et al., 2013). The study revealed that one of the barriers to women receiving the vaccine was their concern over its safety (Lam et al., 2013). Some limitations of the study were the inability to gather demographic data and the risk of confounding that could not be addressed (Lam et al., 2013). Eick-Cost et al. (2015) reported an improvement in vaccination rate from 3% in 2011 to 54% in 2014. Women enlisted in the Navy had the highest coverage with 65%, and women in the Coast Guard had the lowest with 21% vaccination coverage during pregnancy (Eick-Cost Et al., 2015). The study recognized the possibility of underestimating

due to the possibility of Tdap vaccinations not being recorded in the service-specific immunization tracker or being recorded incorrectly (Eick-Cost Et al., 2015).

Stockwell et al. (2012) researched the impact of text message reminders designed to increase vaccination coverage. The participants who received a text message reminder were significantly more likely to receive a recommended vaccination (Stockwell et al., 2012). There was a significant difference in mothers that received the intervention compared to the controls at 4 weeks (15.4% versus 18.2&; p <.001), 12 weeks (26.7 versus 13.9%; P <.005) and 24 weeks (36.4 % versus 18.1%; P <.001) (Stockwell et al., 2012). Some limitations of the study were that some women may have received undocumented vaccines, the population was predominantly Hispanic, and the study primarily focused on parents with a recorded cell phone, which could cause a bias towards subjects being more or less likely to vaccinate (Stockwell et al., 2012).

Walter et al. (2009) concluded that offering Tdap vaccine in the pediatric office increases access to vaccination for both new fathers and mothers. The vaccination coverage after the cocooning intervention was 58% among eligible mothers and the vaccination rate was 51.2 % among fathers and mothers (Walter et al., 2009). A limitation of the study could be the possible lack of generalizability due to the population not being diverse (Walter et al., 2009).

## DISCUSSION

Providing education to mothers and families is essential to inform them of the benefits of protecting their infants from pertussis (Bonville et al., 2015). Throughout the articles, women reported being hesitant because they were unsure of the safety of the vaccine and the effect it could potentially have on their infant. (Munoz et al., 2014). Another dilemma noted for women was the blunting effect it could potentially have on the DTaP vaccination that is given at two months (Berenson et al., 2016). Many of the studies reported that women who were approached or educated about the need for the pertussis vaccine were more likely to obtain the vaccine during their pregnancy (Macdougall et al., 2016). The articles showed that women believed the benefits outweighed the risks and would choose to vaccinate (Healy et al., 2012). Two studies reported women and

infants were no more likely to experience adverse events than unvaccinated mothers and/or infants (Shakib et al., 2013; Munoz et al., 2014).

Another study found that only a quarter of infants were potentially protected from pertussis (Healy et al., 2015). The studies showed that there is a waning of the maternal antibodies during the first and second trimester, which would suggest having mothers take the vaccination in the third trimester (Munoz et al., 2014). Vaccinating in the third trimester would provide protection during the highest risk of pertussis-associated mortality and morbidities (Healy et al., 2012). The studies support providing a cocoon for an infant by administering a vaccine to both parents and family members that will be in contact with the infant (Rosenblum et al., 2014). Also, in a study it was revealed that inability to receive the vaccination is a factor that impedes family members from obtaining the vaccination (Eick-Cost et al., 2015).

*Limitations of the Review*

This systematic review excluded non-peer reviewed literature. Articles were only included if written in English and available through electronic databases. Articles were also restricted to 2010-2016. Many of the articles had small sample sizes and lacked diversity in the population which could affect the power and generalizability of the study.

*Recommendations*

There is limited evidence available pertaining to the patient education on pertussis needed for mothers and families having a child. More studies need to be done to test the safety and effectiveness of the ACIP recommendations. Nurses are in a position to provide education for health promotion. Studies should be done to assess the effect of nursing education recommendations for vaccinating mothers and providing cocooning for the infant. Increased education for physicians and nurses is needed on the best delivery methods of patient education, specifically to mothers and families on effective ways of decreasing the frequency of pertussis in infants. Another way to improve vaccination would be for physicians and nurses to administer the vaccination to the parents during child visits. Vaccination should be more readily available for those who have minimal to no insurance. Also, part of a nurse's role is to promote optimal health, which

includes providing education to parents. Nurses should provide parents with the following recommendations:

- Provide education to pregnant women and families about pertussis and explain how detrimental it can be for an infant.

- Inform women that unvaccinated pregnant women should receive Tdap, preferably in the third or late second (after 20 weeks gestation) trimester.

- Inform women that the benefit of protection from maternal antibodies in newborns outweighs the potential risk for shifting disease burden to later in infancy.

- Educate about cocooning an infant by providing Tdap vaccinations for unvaccinated persons who anticipate close contact with an infant.

## CONCLUSIONS

Pertussis is a vaccine preventable disease that is still occurring in developed countries, which cause serious adverse effects for newborns such as mortality (CDC, 2016). Existing evidence suggests the need to educate parents of the important steps to be taken to prevent pertussis. Physicians and other healthcare professionals such as nurses should suggest vaccinating women during their third trimester and family members to provide a cocooning effect. There is a limited amount of research pertaining to the best nursing education for parents of an infant. More studies need to be done to assess the proper teaching methods to assist families in preventing pertussis in an infant.

## REFERENCES

Acellular Pertussis Vaccine: Recommendations for Use as the Initial Series in Infants and Children. (1997). *Pediatrics, 99*(2), 282-288. doi:10.1542/peds.99.2.282

Andrew Terranella, Garrett R. Beeler Asay, Mark L. Messonnier, Thomas A. Clark and Jennifer L. Liang. (2013). Pregnancy Dose Tdap and Postpartum Cocooning to Prevent Infant Pertussis: A Decision Analysis. *Pediatrics,* 2013. DOI: 10.1542/peds. 2012-3144.

Angelia A., Eick-Cost, PhD; Zheng Hu, MS. (2015). Tdap Vaccination Coverage During Pregnancy, Active Component Service Women, 2006-2014. *Medical Surveillance Monthly Report, 22*(5).

Berenson, A. B., Hirth, J. M., Rahman, M., Laz, T. H., Rupp, R. E., & Sarpong, K. O. (2016). Maternal and infant outcomes among women vaccinated against pertussis during pregnancy. *Human Vaccines & Immunotherapeutics,* 1-7.

Bonville, C. A., Cibula, D. A., Domachowske, J. B., & Suryadevara, M. (2015). Vaccine attitudes and practices among obstetric providers in New York State following the recommendation for pertussis vaccination during pregnancy. *Human Vaccines & Immunotherapeutics*, *11*(3), 713–718. http://doi.org/10.1080/21645515.20 15.1011999

C. Mary Healy, Marcia A. Rench, Carol J. Baker. Implementation of cocooning against pertussis in a high-risk population. Clinical Infectious Disease. 2011 January 15; 52(2): 157–162.

Gavin Dabrera, Gayatri Amirthalingam, Nick Andrews, Helen Campbell, Sonia Ribeiro, Edna Kara, Norman K. Fry, and Mary Ramsay. A Case-Control Study to Estimate the Effectiveness of Maternal Pertussis Vaccination in Protecting Newborn Infants in England and Wales, 2012–2013 *Clin Infect Dis*. (2015) 60 (3): 333-337 first published online October 19, 2014 doi:10.1093/cid/ciu821

Healy, C. M., Rench, M. A., & Baker, C. J. (2012). Importance of Timing of Maternal Combined Tetanus, Diphtheria, and Acellular Pertussis (Tdap) Immunization and Protection of Young Infants. *Clinical Infectious Diseases, 56*(4), 539-544. doi:10.1093/cid/cis923

Healy, M., Rench, M., & Baker, C. (2014). Importance of Timing of Maternal Combined Tetanus, Diphtheria, and Acellular Pertussis (Tdap) Immunization and Protection of Young Infants. *Clinical Infectious Diseases*, 56(4), 539-544.

Jones, K. M., Carroll, S., Hawks, D., Mcelwain, C., & Schulkin, J. (2016). Efforts to Improve Immunization Coverage during Pregnancy among Ob-Gyns. *Infectious Diseases in Obstetrics and Gynecology, 2016*, 1-9. doi:10.1155/2016/6120701

Lam, S. T., George, S., Dunlow, S., Nelson, M., & Hartzell, J. D. (2013). Tdap coverage in a military beneficiary population: room for improvement. *Military Medicine*, *178*(10), 1133-1136. doi:10.7205/MILMED-D-12-00366

Macdougall, D. M., Halperin, B. A., Langley, J. M., Mcneil, S. A., Mackinnon-Cameron, D., Li, L., & Halperin, S. A. (2016). Knowledge, attitudes, beliefs, and behaviors of pregnant women approached to participate in a Tdap maternal immunization randomized, controlled trial. *Human Vaccines & Immunotherapeutics, 12*(4), 879-885.

Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097.

Munoz, F. M., Bond, N. H., Maccato, M., Pinell, P., Hammill, H. A., Swamy, G. K., . . . Baker, C. J. (2014). Safety and Immunogenicity of Tetanus Diphtheria and Acellular Pertussis (Tdap) Immunization During Pregnancy in Mothers and Infants. *Jama, 311*(17), 1760.

Peters, T. R., Banks, G. C., Snively, B. M., & Poehling, K. A. (2012). Potential Impact of Parental Tdap Immunization on Infant Pertussis Hospitalizations. *Vaccine*, *30*(37), 5527–5532. http://doi.org/10.1016/j.vaccine.2012.06.047

Quinn, H. E., Snelling, T. L., Habig, A., Chiu, C., Spokes, P. J., & McIntyre, P. B. (2014). Parental Tdap Boosters and Infant Pertussis: A Case-Control Study. *Pediatrics*, *134*(4), 713-720 8p. doi:10.1542/peds.2014-1105

Rosenblum, E., Mcbane, S., Wang, W., & Saywer, M. (2014). Protecting Newborns by Immunizing Family Members in a Hospital-Based Vaccine Clinic: A Successful Tdap Cocooning Program During the 2010 California Pertussis Epidemic. *Public Health Reports*, *129*(3), 245-251.

Shakib, J. H., Korgenski, K., Sheng, X., Varner, M. W., Pavia, A. T., & Byington, C. L. (2013). Tetanus, Diphtheria, Acellular Pertussis Vaccine During Pregnancy: Pregnancy and Infant Health Outcomes. *The Journal of Pediatrics*, *163*(5), 1422–1426.

Shakib, J., Ralston, S., Raissy, H., Stoddard, G., Edwards, K., & Byington, C. (2010). Pertussis antibodies in postpartum women and their newborns. *Journal Of Perinatology*, *30*(2), 93-97. doi:10.1038/jp.2009.138

Stockwell, M. S., Kharbanda, E. O., Martinez, R. A., Lara, M., Vawdrey, D., Natarajan, K., & Rickert, V. I. (2012). Text4Health: Impact of Text Message Reminder–Recalls for Pediatric and Adolescent Immunizations. *American Journal of Public Health*, *102*(2), e15–e21. http://doi.org/10.2105/AJPH.2011.300331

Updated Recommendations for Use of Tetanus Toxoid, Reduced Diphtheria Toxoid and Acellular Pertussis Vaccine (Tdap) in Pregnant Women and Persons Who Have or Anticipate Having Close Contact with an Infant Aged <12 Months --- Advisory Committee on Immunization Practices (ACIP), 2011. (2011). *MMWR: Morbidity & Mortality Weekly Report*, *60*(41), 1424-1426.

Walter, E., Allred, N., Rowe-West, B., Chmielewski, K., Kretsinger, K., & Dolor, R. (2009). Cocooning infants: Tdap immunization for new parents in the pediatric office. *Academic Pediatrics*, *9*(5), 344-347.

| Author and Year | Study design | Sample | Outcome of interest | Country | Level Of Evidence |
|---|---|---|---|---|---|
| Munoz (2014) | Randomized Control Trial | N=48, 33 received Tdap, 15 received postpartum Tdap | Maternal Pertussis Immunization | USA | Level I |
| Berenson (2016) | Randomized control trial | n=48, 33 women who were vaccinated, 15 women unvaccinated | Maternal and Infant health outcomes | USA | Level I |
| MacDougall (2016) | Randomized Control Trial | N=326 women | Vaccine Attitudes | Canada | Level I |
| Healy (2010) | Single Non-Randomized Trial | N=11,174 received Tdap vaccination | Tdap vaccination and cocooning of families | USA | Level II |
| Rosenblum (2012) | Cohort Study | N=1350, 243 postpartum mothers and 1287 family members | Cocooning of families | USA | Level II |
| Lam (2013) | Cohort Study | N= 1421 pregnant mothers | Maternal pertussis immunization | USA | Level II |
| Terranella (2013) | Cohort Study | N=4,131,019 infants born in 2001 | Maternal pertussis immunization and cocooning of families | USA | Level II |
| Shakib (2010) | Cohort Study | N= 81 mother- infant pairs | Effectiveness of maternal vaccination | USA | Level II |
| Shakib (2012) | Retrospective Cohort Study | N= 690 pregnancies, 138 vaccinated women, 552 control- women without Tdap vaccine | Maternal and Infant health outcomes | USA | Level II |
| Peters (2012) | Cohort study | N= 4,317,119 births in 2007 | Parental Tdap Vaccination | USA | Level II |
| Eick-Cost (2015) | Cohort Study | N=137, 133 live births | Maternal Pertussis immunization | USA | Level II |
| Jones (2016) | Cohort Study | N=1370 obstetricians and gynecologists | Improving vaccination coverage | USA | Level II |
| Walter (2009) | Case-study | N=200 parents of newborns | Cocooning of families | USA | Level III |
| Dabrera (2015) | Case-control study | N=113, 58 cases, 55 controls | Effectiveness of maternal vaccination | England and wales | Level III |
| Quinn (2014) | Case- Control Study | N=816, 585 cases, 217 controls | Parental Tdap Vaccination | Australia | Level III |
| Healy (2013) | Case-study | N=105 mothers | Effectiveness of maternal vaccination | USA | Level III |
| Bonville (2014) | Qualitative Study | N=133 Obstetric providers | Vaccine attitudes | USA | Level VII |

# MICROSATELLITE ANALYSES OF LIONFISH (PTEROIS VOLITANS) LENDS SUPPORT TO ROUTE OF INVASION FROM THE CARIBBEAN HYPOTHESIS

by JOHN JOHNSON

## ABSTRACT

*Lionfish have recently invaded Atlantic waters and rapidly spread through the Caribbean and into the Gulf of Mexico (GoM), including the Flower Garden Banks National Marine Sanctuary (FGBNS) in Texas. Previous genetic analyses have determined that there are two species involved (Pterois volitans/P. miles) and suggest that there are two differentiated populations of* P. volitans, *one in the Atlantic and one in the Caribbean. Observational data suggest that populations in the GoM may have come from the Florida Atlantic population, but little is known of the diversity of the GoM invasion. Here we determined the genetic diversity of lionfish at the FGBNMS using microsatellite markers to (1) compare genetic diversity of GoM populations to Atlantic and Caribbean populations and, (2) to determine the likely route (i.e. North Atlantic or Caribbean) that lionfish invaded the Texas GoM. Understanding the genetic diversity and patterns of connectivity of lionfish can aid in multi-agency management efforts to control lionfish populations.*

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## INTRODUCTION

Biological invasions have dramatic effects on biodiversity and alter the balance of natural habitats (Mack et al., 2000). Yet they also provide, from an evolutionary standpoint, excellent natural experiments for studying the genetic factors and ecological forces that shape colonization and expansion of invasive species into new habitats. Lionfish (*Pterois volitans* [Linnaeus, 1758] and *Pterois miles* [Bennett, 1828]) are the first non-native marine fishes to become established in the Western Atlantic (WA), and their populations are expanding rapidly through the warm-temperate north-west Atlantic, the Caribbean Sea and the Gulf of Mexico (Whitfield et al., 2007; Schofield, 2009). The US Geological Survey Nonindigenous Aquatic Species database (USGS-NAS; http://nas.er.usgs.gov/) has recently documented the chronology and extent of the lionfish invasion based on confirmed occurrences (Schofield, 2009). A fisherman reported the first specimen off Dania, Florida, in 1985 (Morris & Akins, 2009). Lionfish subsequently became established in the Bahamas between 2004 and 2006, and have been spreading rapidly into the Caribbean and most recently into the GoM in 2009. As of May 2014, recreational divers have sighted adult lionfish as far south as the Brazilian Atlantic coast.

Lionfish are voracious predators that feed on post-settlement reef fishes and can cause severe impacts on native coral reef abundance and diversity. Previous research shows that upon settling onto a reef, lionfish caused a reduction of prey species by up to 79% over a five-week period (Albins & Hixon, 2008). Furthermore, negative impacts of lionfish have been shown to decrease the biomass of prey up to 65% in as few as two years (Green et al., 2012) Although eradication of invasive lionfish is virtually impossible, control strategies need to be developed and implemented (Morris et al., 2011).

Here, we expand upon previous genetic studies of invasive lionfish in two locations, North Carolina and Belize, by adding data from the GoM to cover a wider range of the WA invasion. We examine six different microsatellite loci for the purpose of identifying measures of genetic diversity including allelic richness (k), expected ($H_E$) and observed heterozygosity ($H_O$). Our aim is to explore the biogeographic barriers between the Atlantic, Caribbean, and the Gulf of Mexico and compare the genetic diversity in each region that follows the history of the lionfish invasion in the Western Atlantic. Understanding the genetic diversity of the lionfish invasion can help to understand the ongoing invasion into new areas and potential barriers to lionfish population expansion.

## METHODS AND MATERIALS

*P. volitans* tissue samples were collected from the West Bank at the FGBNMS. Lionfish were collected via scuba and fins were clipped by researchers at the FGBNMS from 2011-2014. All tissue samples were preserved in 95% ethanol and shipped to our lab for DNA extraction. All DNA was extracted using the Qiagen DNEasy genomic DNA extraction protocol including all optional steps. After extraction, 6 microsatellite loci (Table 1) were genotyped following the same process as Schultz et al. (2013).

PCR conditions were modified for optimal performance from conditions set forth in Schultz et al. (2013). All loci used the following PCR reaction amounts: 8.7 µl deionized water, 1.5 µl 10x PCR Buffer, 1.8 µl 25mM $MgCl_2$, 1.2 µl 2.5 mM dNTP's, 0.15 µl 10 µM labeled (VIC, PET, FAM, NED) T3 primer, 0.15 µl 10 µM Reverse primer, and 1.5 µl template DNA. All samples were amplified on Eppendorf thermocyclers using the

### TABLE 1.
### Microsatellite Loci Primer Data

| Locus | Repeat Motif | Primers |
|---|---|---|
| PVM7 | (AGAT)9 | F:ACTCTTCAATCCAGCCAACG R:AATTGGGACGTTTTGAGGTG |
| PVM11 | (GGAT)9 | F: TCTATGTGCCCTGTGATGGA R:GGGCCTGAATGATCATATTGTT |
| PVM12 | (ACAG)11 | F: TGGTTGGGACTATGCAGACA R: CCCACACTCAATACCAGCAC |
| PVM14 | (AGAT)12 | F: GGATTCTTTCAGGGCAGGTT R: TTGTGACCATGACAGCATCA |
| PVM15 | (ATCC)7 | F: CATGCATCCCTTCATATTTGC R: ATATCATGCACCGCTGTCAA |
| PVM42 | (ATC)11 | F: GTGTGTCAGACGCTGAAGGA R: ACGTACAGCGGGTTAGGATG |

same conditions for all samples. All 48 reactions were programmed using the following conditions modified from Schultz et al. (2013): 95 °C @ 4 minutes; 35 cycles of 95 °C @ 15 seconds, 62 °C @ 15 seconds, 72 °C @ 30 seconds; 8 cycles of 95 °C @ 15 seconds, 54 °C @ 15 seconds, and 72 °C @ 30 seconds; 72 °C @ 5 minutes, 12 °C final hold. Fragment size analyses of PCR products were conducted at TAMUCC Core Genomics Lab using an ABI 3730XL automated sequencer (Applied Biosystems). Size fragments were determined using GeneMarker software. Observed and expected heterozygosity, and allelic richness were calculated for our sample population and conformation to Hardy-Weinberg equilibrium (HWE) was determined using ARLEQUIN v. 3.5 (Excoffier and Lischer, 2010). Each analysis was calculated using 1,000,000 Markov chain steps with 100,000 Dememorization steps.

## RESULTS

For all markers, between three and seven alleles were found, averaging five alleles per locus. Observed heterozygosity among loci ranged from 48% to 67% with an average of 59%, while the expected heterozygosity ranged from 49% to 81% with an average of 68%. Deviations from HWE were found in two of the six loci. Comparing our Texas sample to those in North Carolina and Belize, there appears to be a decrease in heterozygosity between the North Carolina location in the North Atlantic and the West Flower Garden Banks location in the Gulf of Mexico (Table 2).

TABLE 2.
Microsatellite DNA Analysis
$N_a$ = number of alleles, $H_o$ = observed heterozygosity, $H_e$ = expected heterozygosity (* = significant deviation from HWE).

| Locus | West Flower Garden Banks, Texas (2013) | | | | Belize (2012) | | | | North Carolina (Schultz et al. 2013) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $N_a$ | $H_o$ | $H_e$ | P-Value | $N_a$ | $H_o$ | $H_e$ | P-Value | $N_a$ | $H_o$ | $H_e$ | P-Value |
| PVM7 | 6 | 0.583 | 0.807 | 0.091 | 7 | 0.810 | 0.791 | 0.610 | 7 | 0.846 | 0.835 | 0.900 |
| PVM11 | 3 | 0.667 | 0.595 | 0.930 | 4 | 0.556 | 0.559 | 0.780 | 6 | 0.733 | 0.549 | 0.103 |
| PVM12 | 7 | 0.591 | 0.753 | 0.004* | 16 | 0.648 | 0.817 | 0.006* | 20 | 0.700 | 0.824 | 0.091 |
| PVM14 | 7 | 0.628 | 0.790 | 0.790 | 8 | 0.656 | 0.808 | 0.000* | 12 | 0.615 | 0.846 | 0.009* |
| PVM15 | 4 | 0.486 | 0.639 | 0.020* | 5 | 0.628 | 0.622 | 0.038* | 7 | 0.885 | 0.733 | 0.460 |
| PVM42 | 3 | 0.565 | 0.493 | 0.402 | 4 | 0.479 | 0.481 | 0.074 | 3 | 0.677 | 0.582 | 0.780 |
| AVG. | 5.00 | 0.59 | 0.68 | - | 7.33 | 0.63 | 0.68 | - | 9.17 | 0.74 | 0.73 | - |

## DISCUSSION

Comparing patterns of genetic diversity across the invaded range of the lionfish can allow us to infer the likely route of invasion into new regions (i.e., Gulf of Mexico) and to determine whether there were founder effects as these populations expanded into new areas. As the invasion progressed from the North Atlantic (North Carolina) into the Caribbean (Belize), we see a decrease in genetic diversity. Similarly, we see a decrease in diversity as the lionfish invaded the GoM (Flower Garden Banks) from the Caribbean (Belize). The GoM location shares more genetic diversity with the Caribbean than the North Atlantic (Table 2) indicating that the route of invasion into the GoM was most likely from the Caribbean and not from the North Atlantic.

Previously using mitochondrial DNA sequencing studies observed the same drops in genetic diversity across regional boundaries observed here using microsatellite markers (Butterfield et al., 2015; Johnson et al., *In Press*). Combined these data support the theory that a small number of founders, harboring a subset of genetic diversity, initially invaded each of these regions followed by a rapid population expansion which prevented the subsequent influx of genes from the source populations (a.k.a., gene surfing; Hallatschek & Nelson 2008).

In comparison to previous mtDNA analyses (Johnson et al. *In Press*), we find that microsatellite loci have retained greater magnitude of diversity as the lionfish populations have expanded compared to mitochondrial diversity. This is possibly due to the fact that microsatellites are hypervariable compared to mitochondrial sequence data, caused by higher mutation rates in these kinds of loci.

It would be interesting to determine if, over time, the diversity of the GoM populations remains different and lower from that seen in the Caribbean and North Atlantic. All GoM samples analyzed here were obtained soon after lionfish were first reported in the region. Since then there has undoubtedly continued to be an influx of individuals and genes from the Caribbean, the original source of GoM lionfish. Thus, it may be that this GoM sampling reflects an initial dispersal wave, or that differential post settlement survival owing to stochastic events resulted in the observed haplotype differences. Under this scenario, subsequent waves of dispersal from the Caribbean and into the North Atlantic from the GoM may lead to the genetic homogenization of the WA populations of lionfish.

## REFERENCES

Albins, M. A., & Hixon, M. A. (2008). Invasive Indo-Pacific lionfish *Pterois volitans* reduce recruitment of Atlantic coral-reef fishes. *Marine Ecology Progress Series*, *367*, 233-238.

Butterfield, J. S., Díaz-Ferguson, E., Silliman, B. R., Saunders, J. W., Buddo, D., Mignucci-Giannoni, A. A., & Hunter, M. E. (2015). Wide-ranging phylogeographic structure of invasive red lionfish in the Western Atlantic and Greater Caribbean. *Marine Biology*, *162*(4), 773-781.

Excoffier, L. and H.E. L. Lischer (2010) Arlequin suite ver 3.5: A new series of programs to perform population genetics analyses under Linux and Windows. *Molecular Ecology Resources*. 10: 564-567.

Green, S. J., Akins, J. L., Maljkovi , A., & Côté, I. M. (2012). Invasive lionfish drive Atlantic coral reef fish declines. *PloS one*, 7(3), e32596.

Hallatschek, O., & Nelson, D. R. (2008). Gene surfing in expanding populations. *Theoretical population biology*, 73(1), 158-170.

Johnson, J.E., Bird, C.E, Johnston, M.A., Fogg, A.Q., Hogan, J.D. (In Press). Regional genetic structure and genetic founder effects in the invasive lionfish: comparing the Gulf of Mexico, Caribbean and North Atlantic. Marine Biology.

Mack, R.N., Simberloff, D., Lonsdale, W.M., Evans, H., Clout, M. & Bazzaz, F.A. (2000). Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications, 10, 689–710.

Morris, J.A. & Akins, J.L. (2009). Feeding ecology of invasive lionfish (*Pterois volitans*) in the Bahamian archipelago. Environmental Biology of Fishes, 86, 389–398.

Morris, J.A., Shertzer, K.W. & Rice, J.A. (2011). A stage-based matrix population model of invasive lionfish with implications for control. Biological Invasions, 13, 7–12.

Schofield, P.J. (2009) Geographic extent and chronology of the invasion of non-native lionfish (*Pterois volitans* [Linnaeus 1758] and *P. miles* [Bennett 1828]) in the Western North Atlantic and Caribbean Sea. Aquatic Invasions, 4, 443–449.

Whitfield, P.E., Hare, J.A., David, A.W., Harter, S.L., Munoz, R.C. & Addison, C.M. (2007) Abundance estimates of the Indo-Pacific lionfish *Pterois volitans/ miles* complex in the Western North Atlantic. Biological Invasions, 9, 53–64.

# INVESTIGATION OF MICELLE FORMATION WITH MOLECULAR MODELING AND NMR

by CORBIN LEWIS

## ABSTRACT

*Molecular dynamic simulations with NMR spectroscopy were used to investigate molecular recognition of amino acid based macromolecular assemblies. The macromolecular micelle assemblies to be examined will be composed of amino acid based surfactants with the L-form of alanine and phenylalanine as polar head groups. Preliminary studies have shown the impact of the surfactant head group geometries and size on micelle aggregation. The alteration of head group constituents not only impacted how the micelles formed but also the physical characteristics of the micelle surface. This leads to changes in the solvent-accessible surface area. These geometric changes impact the formation of chiral binding sites. In other words, a simple swapping of an amino acid head group can lead to distinct changes in chiral selectivity and micelle formation. Modeling the formation of these micelles and coupling spectroscopic analysis has led us to enhance our understanding of the formation of these micelles.*

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## INTRODUCTION

The enantiomers of chiral molecules often have differing chemical and pharmacological effects. Most notably is the case of thalidomide, a chiral drug that was used to treat nausea and morning sickness in pregnant woman up until the early 60's. This "wonder drug" was later correlated to birth defects in pregnant woman. It was discovered that there were two types of the drug, both nearly identical and composed of the same atoms, but were mirror images, slightly different in 3D. These slightly different molecules had very different biological properties, one was the medication that worked so well and the other was toxic, causing birth defects. This resulted in FDA guidelines issued in 1992 which required that each enantiomer (mirror image form of the molecules) to be investigated separately to determine its effects before the drug could be sold. This requirement lead to the development of chiral drug separation methods, making separation an important factor in drug discovery [1]. One method of chiral separation is using chiral micelles in micellar electrokinetic chromatography (MEKC) which is used to separate the enantiomers by differing association strength between the enantiomers and micelles [1].

Chiral surfactants are highly versatile compounds that hold an importance in many areas of science and health [2-4]. Amino acid chiral surfactants consist of a polar amino acid head and non-polar hydrocarbon tail, creating an amphiphilic compound. The micellar association of an amphiphilic molecule in water is a result of a dynamic weak bonding interactions such as hydrogen bonding and hydrophilic/hydrophobic interactions, forcing the polar head groups to align externally, while the non-polar tails are protected internally [5-7]. This resulting micelle structure is a dynamic system, where free surfactant molecules can freely flow in or out, leading to the dynamic creation and destruction of micelles. Micelle formation is controlled not only by weak bonding interactions but is an entropically driven process which decreases the ordering of water molecules on the hydrophobic portion of the surfactant. The total concentration of surfactant is also important; once a critical micelle concentration (CMC) is reached micelle formation becomes highly favored [6,8-11].

The use of amino acids as polar head groups for surfactants has increased in popularity in recent years. Amino acids are natural, environmentally inert and have unique chemistry. Since the usage and chemistry of both amino acids and surfactants are in many areas of science, health and industry, these amino acid based surfactants present quite an interesting system to study [3,4,6,7,10]. Amino acids themselves have amide ($\alpha$-amino) and carboxylic acid functional groups and some R groups add more amides or carboxylic groups. Therefore the pH of the solution would be expected to affect micelle shape, aggregation and ionization of surfactant head groups [12,13]. Protonation/deprotonation of these polar head groups can allow for a reduction in the electrostatic repulsion, allowing surfactant molecules to pack closer together in the micelle. This could then result in an increase in aggregation number and favoring of micelle formation, in turn lowering the CMC and creating a more favorable environment for more hydrogen bonding to occur [6,10].

This study is part of a larger effort to characterize how the micelles interact with the chiral ligands, which leads to chiral separations. In this study we will use molecular dynamic simulations (MD) to construct theoretical models of two monomeric surfactant systems. These two surfactants (UND-Ala and UND-Phe) were chosen based upon similarities in amino acid structure and the presence of a benzene ring, which we assume could enhance chiral separation with aromatic chiral ligands. The models will be based on diffusion measurements with nuclear magnetic resonance (NMR), aggregation number and CMC which will be determined with both NMR and conductivity.

## EXPERIMENTAL PROCEDURES

### NMR Diffusion Experiments

The micelle diffusion coefficients were determined by Diffusion Ordered Spectroscopy (DOSY) NMR at 25°C in a solution of 90% de-ionized $H_2O$ and 10% $D_2O$, with a small addition of the reference standard tetramethylsilane (TMS). The NMR probe produced a maximum gradient strength, G, of 40 G·cm-1, with a shielded z-gradient coil. The pulse sequence provided by Dr. Kevin Morris of Carthage College, a bipolar pulse pair encode-decode pulse sequence, was used for the diffusion coefficient measurements [14]. For each surfactant system, 15 NMR spectra were collected with varying magnetic gradient field strengths from 5 to 30 G·cm-1 with a pulse duration ($\delta$) of 4.0 ms, delay between gradients ($\tau$) at 0.20 ms and the diffusion time ($\Delta$) of 250.0 ms. Lastly, the removal of the $H_2O$ water peak was obtained via a radio frequency suppression, included in the diffusion pulse sequence [15]. Both micelle systems were recorded in triplicate for error analysis.

The obtained spectrum was then Fourier transformed and underwent baseline correction. The resonances recorded were then relative to the tetramethylsilane (TMS) peak which was added as an NMR reference standard. The TMS peak was used as the reference peak for the micelles since the only TMS present in the solution would be solubilized in the micelle core, recording the correct diffusion value for only the micelles, not the free surfactants. The intensity of the reference peak was then recorded at each gradient strength and the natural logarithm was calculated for each value. A plot was then prepared of the natural log of the intensities vs the value $(\gamma \bullet G \bullet \delta)^2 (\Delta - \delta/3 - \tau/2)$ with $\gamma$ being the magnetogyric ratio [14]. Linear regressive analysis was then used

to generate a function for the data with the slope of the linear function equal to –D, the diffusion coefficient of the system micelle. A R2 value was then calculated for the linear fits, averaging at 0.99 or greater.

*Computational Method*

The micelle systems of undecyl alanine (UND-Ala) and undecyl phenylalanine (UND-Phe) were chosen for the simulations. Single surfactant molecules were placed in close proximity to one another, using the recorded aggregation number for each micelle to determine the number of molecules per each system. The average aggregation number for UND-Ala at room temperature was 55 and 84-100 monomers for UND-Phe. In the simulation the UND-Ala micelle were composed of 55 monomer units with 10 Å spacing, solvating with 9869 water residues. Due to uncertainty in the UND-Phe aggregation number, two systems composed of 84 and 100 monomers were used, requiring 13505 and 12207 water molecules for solvation respectively. [16]. Once the base model was constructed, sodium ions were added in proximity to the carboxylate group on each surfactant molecule to obtain a neutral system using the monovalent ion parameters provided by Joung & Cheatham [17]. Using the TIP3P water model, each system was solvated with water residues, forming a 10 Å buffer region between the surfactants and the edge of the octahedral periodic box. The simulations were then carried out in a GPU accelerated AMBER14 environment with 14SB force field [18-20].

Octahedral geometry of the periodic box was used as the corresponding boundary condition to the simulation preformed. The systems were equilibrated and optimized before the bulk calculation took place. A short 20ps simulation was performed to first heat the initial system from 0K to 300K, keeping some restraints on the position of the molecules to prevent full dispersion. Afterwards a 1ns equilibration was preformed to allow the system to reach 1 atm, still at 300K. Lastly the bulk simulation was ran for 60ns on the equilibrated structure with a time step of 2fs and a 2ps save time. The resulting data was then analyzed with the cpptraj utility to test for a variety of properties and data validity. [18].

**TABLE 1.**
**NMR diffusion data for 50mM UND-Phe and 100mM UND-Ala.**

50 mM UND-Phe + NaHCO3

| Diffusion Coefficients x 10-6 (cm2s-1) | | fb | Radius (Å) |
|---|---|---|---|
| UND-Phe | TMS | UND-Phe | |
| 1.40 ± 0.14 | 1.39± 0.14 | 1.00 ± 0.02 | 17.4 ± 0.1 |

100 mM UND-Ala + NaHCO3

| Diffusion Coefficients x 10-6 (cm2s-1) | | fb | Radius (Å) |
|---|---|---|---|
| UND-Ala | TMS | UND-Ala | |
| 3.28 ± 0.01 | 2.13 ± 0.01 | 0.70 ± 0.01 | 9.7 ± 0.1 |

## RESULTS AND DISCUSSION

*NMR Data*

NMR diffusion experiments were performed with 100mM UND-Ala and 50mM UND-Phe surfactant solutions in 90:10 deionized (DI) $H_2O$:$D_2O$. The solutions were spiked with a small 100 µl addition of the reference standard, tetramethylsilane (TMS). The TMS being immiscible in water will solubilize itself into the micelle core, and thus will have a diffusion coefficient equal to the micelle's diffusion coefficient [21]. Diffusion coefficients are recorded as the linear decay of the natural logarithm of peak intensity over an increasing gradient strength. Comparing the TMS decay to the surfactant's decay shows a smaller diffusion value because the surfactant's decay is an average of both the micelle and free surfactant diffusion coefficients [21]. The diffusion coefficients were measured for the surfactant's decay ($D_{obs}$) which was the weighted-average of the slower micelle-bound surfactants ($D_{micelle}$) and faster than the free surfactant ($D_{free}$) values. Using this relationship, equation (1) was used to calculate the fraction of the surfactant monomers bound to the micelles, represented by $f_{b,surf}$.

$$(1) \quad D_{obs} = f_{b,surf} \cdot D_{micelle} + \left(1 - f_{b,surf}\right) D_{free}$$

The micelle diffusion coefficients were then used with the Stokes-Einstein relation to calculate the hydrodynamic radii of the micelles [22]. Using $D_{micelle}$ as the micelle diffusion coefficient, as Boltzmann's constant, T as absolute temperature, $\eta$ as the viscosity, and $R_h$ as the micelle hydrodynamic radius, equation (2) was solved for the radii.

$$(2) \quad D_{micelle} = \frac{k_B \cdot T}{6 \cdot \pi \cdot \eta \cdot R_h}$$

As can be seen in Table 1, there is a clear difference in the diffusion coefficients between UND-Ala and UND-Phe micelles, showing that UND-Ala diffuses faster than UND-Phe, resulting in a smaller radii.

Using root-mean-square deviation (RMSD) (Figure 1), each simulation file was checked for equilibration by comparison to the starting structure (figure 2), once equilibration occurred the RMSD values plateau (around 200,000 steps or 40ns). Once this constant RMSD is achieved, the bulk simulation was halted and data analysis was conducted on the trajectory file. Solvent accessible surface area (SASA) results were then used in conjunction with 3D imaging software to compare the simulations to physical data from NMR. Due to specific uncertainty in the exact aggregation number of UND-Phe micelles, two systems were used, having 84 and 100 monomer units respectively (the lower and upper limit of the uncertainty).

Both phenylalanine and alanine micelle systems achieved bulk equilibration around the 40ns mark, both systems having about a 20% deviation from the original micelle structure (Figure 1). Multiple images were taken over the course of each simulation at key stages to depict the breaking up and re-aggregation of the surfactant molecules as shown in Figure 2. Using the 3D imaging software, an average radius was calculated for the final structure of each system, giving 15Å for UND-Ala, comparable to NMR determined value of 9. 7 ± 0.1 Å (Table 1). The two UND-Phe systems of 84 and 100 monomer units averaged a radius of 22Å and 20Å respectively, with the 100 monomer system closer to the experimental value of 17.4 ± 0.1 Å. These radial differences are similar to the recorded



FIGURE 1.
RMSD data for both Ala and Phe micelle systems, the red bar signifies the equilibration point.
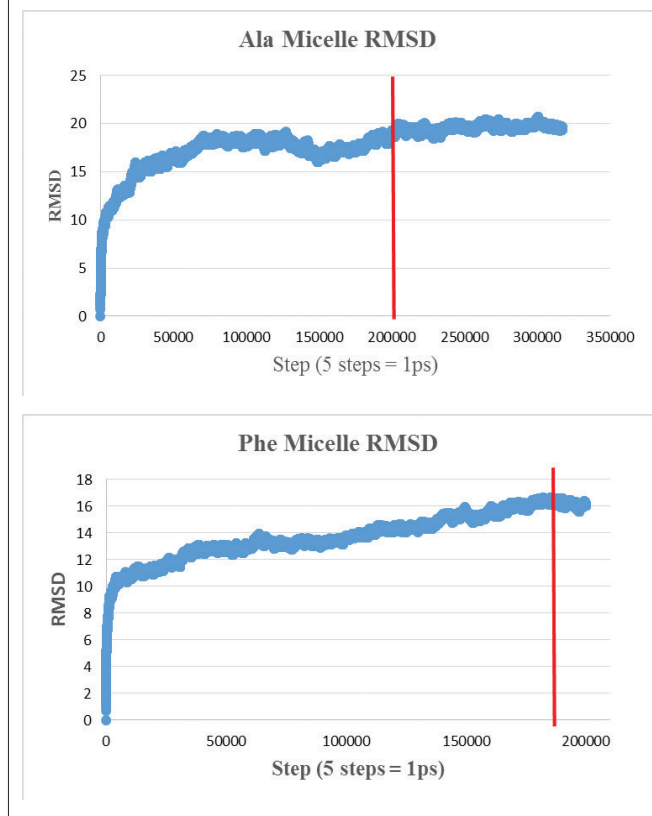
NMR values in table 1, still showing the trend of UND-Ala being significantly smaller then UND-Phe. The possible increase in micelle size could suggest that a longer computational time is required for a complete equilibration.

The SASA results calculated for each simulation, over the course of the computation time, the total surface area accessible to solvent decreased, reaching a roughly constant value at equilibration. Taking the average of the last 1000 data points for each system yielded a SASA of 25.5 Å² for UND-Ala, with little variance. However, UND-Phe averaged at 150.6 Å² and 114.0 Å² for the 84 and 100 monomer systems respectively, significantly different from UND-Ala. This follows with the radius trend, giving UND-Ala the smallest SASA. The increase in the SASA for the 84 monomer unit UND-Phe system could most likely mean that the aggregation number is higher than 84, since the most favored micelle system would have the smallest SASA. This could

FIGURE 2.
Structure of micelle systems over the course of the simulation.
(UND-Ala – top, 84 monomer UND-Phe – middle and 100 monomer UND-Phe – bottom).
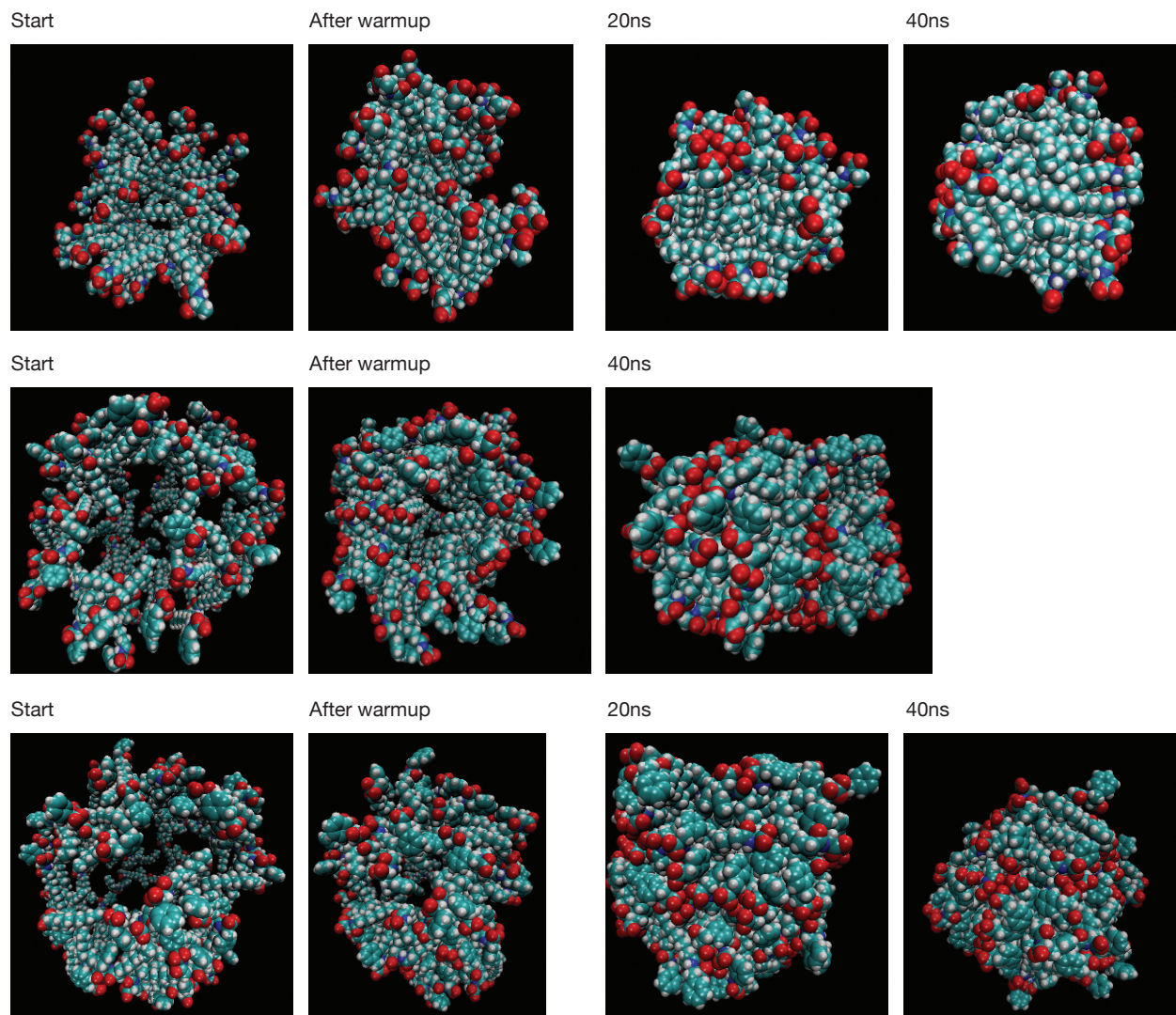


suggest the UND-Phe aggregation number is closer to 100 monomer units. The slight differences in the UND-Phe micelles radii might also be due to this behavior as well. Future studies will be required to test the validity of this argument.

## CONCLUSION

From the presented data, the molecular modeling software developed acceptable and predictive models of both micelle systems for a single micelle in a solution. The issue arises that physically surfactant solutions above the CMC contain more than one micelle at any given moment, which is not accounted for in the simulations. Further work will be required to test the program's ability in modeling multiple micelles in a given solution. The multi micelle model should then shed light into how multiple micelles interact in a surfactant solution, provided that future models are developed in conjunction with physical experimentation.

**FIGURE 3.**

**SASA results over the whole simulation for UND-Phe and UND-Ala.**
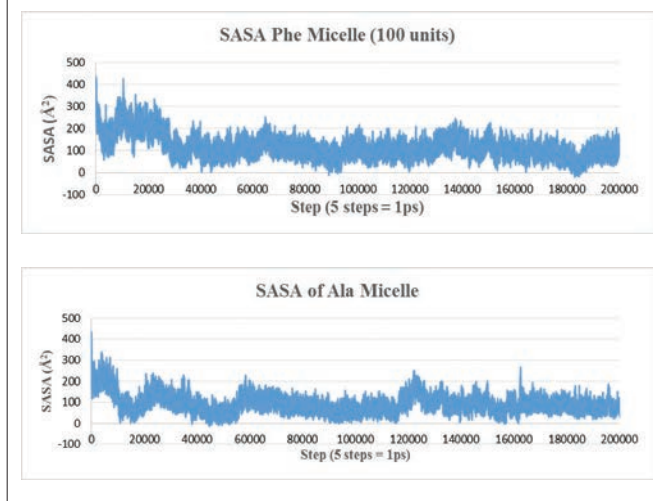
## REFERENCES

T. J. Ward and K. D. Ward, "Chiral Separations: FUNDamental Review," *Analytical Chemistry*, Vol. 82, No. 12, 2010, pp. 4712-4722.

Azarmi, R., Ashjaran, A., Type and application of some common surfactants *Journal of Chemical and Pharmaceutical Research* (2015), 7(2), 632-640.

Kim, S.H., J.H. Satcher, T.Y. Han, Hierarchical ZnO Structures Templated with Amino Acid Based Surfactants, *Microporous and Mesoporous Materials* 151:64 (2012).

Li, Y., K. Holmberg, and R. Bordes, Micellization of true amphoteric surfactants, *Journal of Colloid and Interface Science* 411:47 (2013).

Tamrakar, S.; Darwhekar, G. N.; Sharma, R.; Mantry, P.; Soudawat, R., Self-emulsifying drug delivery systems: A Review of the Applicability in Drug Delivery Technologies, *Advance Research in Pharmaceuticals and Biologicals* (2014), 4(4), 785-790.

Eastoe, J.; Tabor, R.F., Surfactants and Nanoscience, Edited by Berti, D.; Palazzo, G. *Colloidal FoUNDations of Nanoscience* (2014), 135-157.

Moradi, M.; Yamini, Y., Surfactant roles in modern sample preparation techniques: A Review, *Journal of Separation Science* (2012), 35(18), 2319-2340.

Felhofer, J.L.; Chumbimuni-Torres, K.Y.; Mora, Maria F.; Haby, G.G.; Garcia, C.D. Edited by Garcia, Carlos D.; Chumbimuni-Torres, Karin Y.; Carrilho, Emanuel, Critical Evaluation of the use of Surfactants in Capillary Electrophoresis, *Capillary Electrophoresis and Microchip Capillary Electrophoresis* (2013), 1-22.

Negm, N.A.; Tawfik, S.M., Environmentally Friendly Surface Active Agents and their Applications, Edited by Biresaw, Girma; Mittal, Kashmiri Lal, *Surfactants in Tribology* (2013), 147-193.

Kumar, N.; Tyagi, R., Applications of Dimeric Surfactants: A Review, *Journal of Dispersion Science and Technology* (2014), 35(2), 205-214.

Brandao, M.S.B.Edited by SomasUNDaran, P, Self-assembly and self-organization of surfactants in agriculture, *Encyclopedia of Surface and Colloid Science (2nd Edition)* (2012), 5527-5543.

Kamal, M.S., A Review of Gemini Surfactants: Potential Application in Enhanced Oil Recovery, *Journal of Surfactants and Detergents* (2016), 19(2), 223-236

Fan, H., F. Han, et. al., Active Control of Surface Properties and Aggregation Behavior in Amino Acid-based Gemini Surfactant Systems, *Journal of Colloid and Interface Science* 321:227 (2008).

D. H. Wu, A. D. Chen and C. S. Johnson. Jr. "An Improved Diffusion Ordered Spectroscopy Experiment Incorporating Bipolar Gradient Pulses," *Journal of Magnetic Resonance*, Vol. A115, No. 2, 1995, pp. 260-264.

M. Piotto, V. Saudek and V. Skienar, "Gradient-Tailored Excitation for Single Quantum NMR Spectroscopy of Aqueous Solutions," *Journal of Biomolecular NMR*, Vol. 2, No. 6, 1992, pp. 661-665.

E. J. Billiot, "Chiral Recognition with Polymerized Dipeptide Surfactants in Capillary Electrophoresis," Ph.D. Dissertation, Louisiana State University, Baton Rouge, 1998.

I.S. Joung, T.E. Cheatham, "Determination of Alkali and Halide Monovalent Ion Parameters for Use in Explicitly Solvated Biomolecular Simulations", University of Utah, Salt Lake City, 2008.

D.A. Case, R.M. Betz, W. Botello-Smith, D.S. Cerutti, T.E. Cheatham, III, T.A. Darden, R.E. Duke, T.J. Giese,

H. Gohlke, A.W. Goetz, N. Homeyer, S. Izadi, P. Janowski, J. Kaus, A. Kovalenko, T.S. Lee, S. LeGrand, P. Li, C. Lin, T. Luchko, R. Luo, B. Madej, D. Mermelstein, K.M. Merz, G. Monard, H. Nguyen, H.T. Nguyen, I. Omelyan, A. Onufriev, D.R. Roe, A. Roitberg, C. Sagui, C.L. Simmerling, J. Swails, R.C. Walker, J. Wang, R.M. Wolf, X. Wu, L. Xiao, D.M. York and P.A. Kollman (2014), AMBER 2014, University of California, San Francisco.

R. Salomon-Ferrer, A.W. Goetz, D. Poole; S. Le Grand, and R.C. Walker Routine microsecond molecular dynamics simulations with AMBER - Part II: Particle Mesh Ewald.*J. Chem. Theory Comput.* 9, 3878-3888 (2013).

J.A. Maier, C. Martinez, K. Kasavajhala, L. Wickstrom, K.E. Hauser and C. Simmerling. ff14SB: Improving the Accuracy of Protein Side Chain and Backbone Parameters from ff99SB. *J. Chem. Theor. Comput.* 11, 3696-3713 (2015).

Stilbs, P., Fourier Transform Pulsed-Graident Spin-Echo Studies of Molecular Diffusion, *Progress in NMR Spectroscopy* 19:1 (1987).

D. K. Wilkins, S. B. Grimshaw, V. Receveur, C. M. Dobson, J. A. Jones and L. J. Smith, "Hydrodynamic Radii of Native and Denatured Proteins Measured by Pulse Field Gradient NMR Techniques," *Biochemistry*, Vol. 38, No. 50, 1999, pp. 16424-16431.

# PLASMA ACTUATOR CONTROLLED UAV

by ANTHONY MATHESON

## ABSTRACT

*Plasma is the fourth sate of matter and new research has shown that plasma could have many applications especially for the aircraft industry. A plasma actuator is a device that uses plasma to control airflow. A device like this can be applied to wings on an aircraft or an unmanned aerial vehicle (UAV) to decrease drag resistance and reduce turbulence. This research showed that, in ambient air conditions, the device could generate an induced velocity which in effect could decrease air drag when placed on top of a UAV wing. Spacing between electrodes was also compared and results showed that 1/16th of an inch was the most ideal spacing to generate more plasma. However, controlling the UAV with a plasma actuator was not tested due to power source failure.*

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## INTRODUCTION

For decades now the airline industry has been looking for ways to fly more efficiently. Due to recent emission regulations from the Environmental Protection Agency (EPA), the commercial airline industry has been desperate to find ways to cut fuel consumption (Davis, 1). Naturally, the industry's first solution is to remove as much weight as possible. However, this is not enough to reduce fuel consumption by a significant margin. New aeronautical research has shown that low temperature plasma could not only increase efficiency by decreasing drag but also increase the ability to control the plane without any moving parts on the wing.

Plasma is considered the forth state of matter and is much like gas. The main difference is that the particles of plasma are ionized, consisting of positive ions and free electrons. Plasma has shown to have a wide variety of applications from medical to industrial purposes. The newest application shows that plasma can manipulate airflows using low temperature plasmas. The wing and plasma actuator configuration based on research from the Aerodynamic Research Institute in China has shown "promising prospect in aerodynamic efficiency and environmental requirements in the future, including high lift-to-drag ratio, low drag and excellent stealth character" (Han, 377). Research has also shown that with a plasma actuator an aircraft can

fly at higher angles of attack without stalling and with a higher lift-to-drag ratio which means a plane can take off at shorter distances.

A Single Dielectric Barrier Discharge (SDBD) plasma actuator is a device demonstrated to be a flow separation control device that could help with turbulence and increase lift on planes and unmanned aerial vehicles or (UAVs). SDBDs are described as "inexpensive, lightweight, reliable solid-state devices" and "have immediate application to reduce landing aircraft noise through wake control, increasing wind turbine efficiency and the possibility for complete flapless controlled flight using electric fields" (Chiryath, 1). A SDBD consists of two electrodes, high voltage and high frequency in the kilovolts and kilohertz, and a dielectric barrier between the two electrodes that prevents dielectric breakdown that could result in arching. When a high voltage current runs through the electrodes, surface plasma is created. Once the plasma is created, it ionizes the air around it causing an acceleration of charged particles in the electric field. This is defined as the electro-hydrodynamic effect (Chiryath, 1).

The current study will focus on the use of a non-thermal SDBD plasma actuator device and the manner in which it can reduce drag on the surface of UAV wings. A typical plane or fixed-wing UAV has flaps on the tail end of the wings called ailerons. These ailerons are responsible for controlling the rolling moment or rotation on its longitudinal axis. When an aileron is engaged the drag or friction on the surface of the wings increases which requires the UAV to use more energy to overcome drag. The researchers' hypothesis is that SDBD plasma actuators can replace traditional ailerons or flaps that move on the wing by using the plasma actuators' electric field to generate a force on the wing causing it to roll and increasing the efficacy by reducing the drag of the UAV in the process.

## METHODOLOGY

*Building of the Plasma Actuator*

The basic configuration of a plasma actuator consist of two electrodes and a dielectric barrier between them. Due to the high electrical conductivity, copper tape was the best option for the electrodes. Kapton tape will be used as the dielectric barrier because it has strong



FIGURE 1.

dielectric properties and is also relatively thin so the tape can be layered for stronger dielectric strength. The first plasma actuator that was tested had two 8-inch long electrodes. One was a ¼ inch wide and the other was 1-inch wide. Between the two electrodes are nine layers of .1 millimeter Kapton tape. The top electrode was placed so that there was not any spacing between the two electrodes. Figure 1 shows the first tested plasma actuator. The main error with the first Actuator was the amount of air bubbles between each layer of Kapton tape. The air bubbles could possibly cause arching which will deteriorate the Kapton material and also burn the electrodes which will shorten the life span of the plasma actuator.
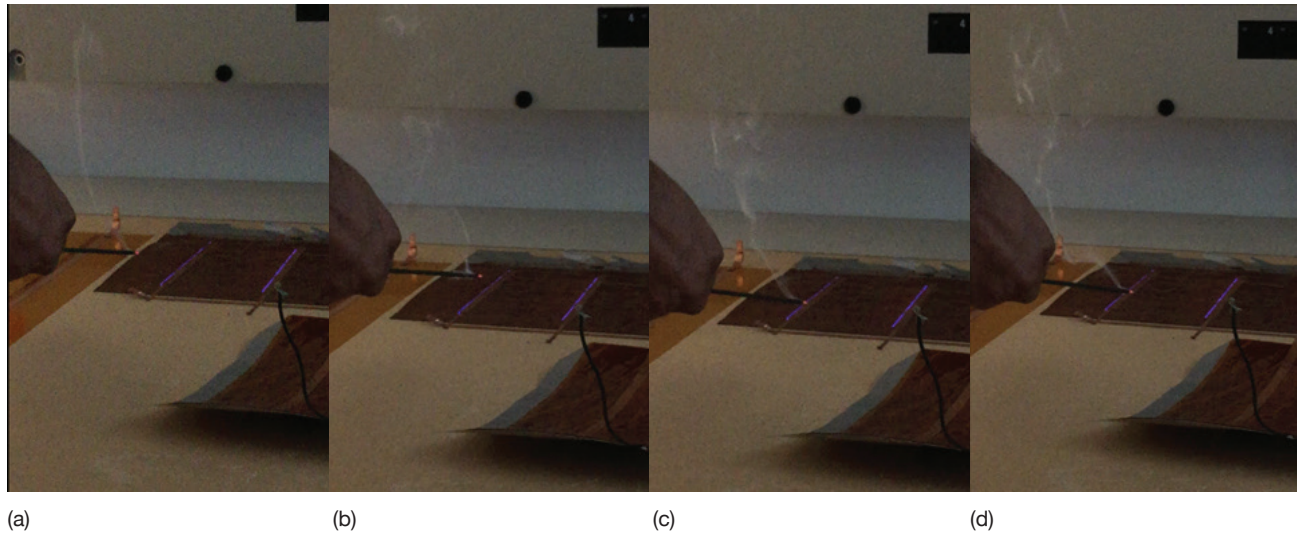
*Testing*

To test to see if the first plasma actuator worked, a plasma AC driver was used. This driver was able to manipulate the voltage and frequency to sufficiently power the plasma actuator. With a sufficient amount of volts and at the correct frequency range, the plasma actuator will form plasma at the end of the top electrode flowing towards the encapsulated electrode.

*Final configuration*

Once the testing was completed, a new Actuator was built and placed on the wing of a UAV. The UAV wings were about 28.5-inches long from the body to tip and 7.8-inches wide. The plasma actuators were placed on an 18 x 7.5-inch section on each wing. See figure 3 and figure 5 for details.

FIGURE 2.



(a)  (b)  (c)  (d)

## RESULTS

*Tuning of the Plasma*

Testing showed that increasing the frequency would refine the plasma and make it more uniform. To test if the plasma could create an induced velocity in ambient air conditions an incense stick was lit to create smoke and placed behind the top electrode. When the plasma was present, the smoke flowed away from the plasma, and when the plasma was not present, the smoke rose and had minimum horizontal movement. This proved that plasma can cause an induced velocity even in ambient air. The four photos below show the incense stick at different orientations. Figure 2(a) shows that the incense stick is further towards the end of the plasma actuator. Even though the smoke is at the end the streamline flows slightly away from the plasma showing that air is being drawn away from the plasma. Figure 2(b) shows that the incense stick is placed directly over the plasma at a slightly higher position. This streamline shows that the smoke gathered at the end of the stick then rose above it. In Figure 2(c) and 2(d) the incense stick is again placed directly over the plasma however at lower heights. Figure 2(d) shows the best representation of the induced velocity generated by the plasma. The reason figure 2(b) streamline is not ideal is because the stick was too high for the ionized gas to push the smoke away.  To achieve a better efficiency for a UAV a higher induced velocity needs to be created and to do so more plasma needs to be present.
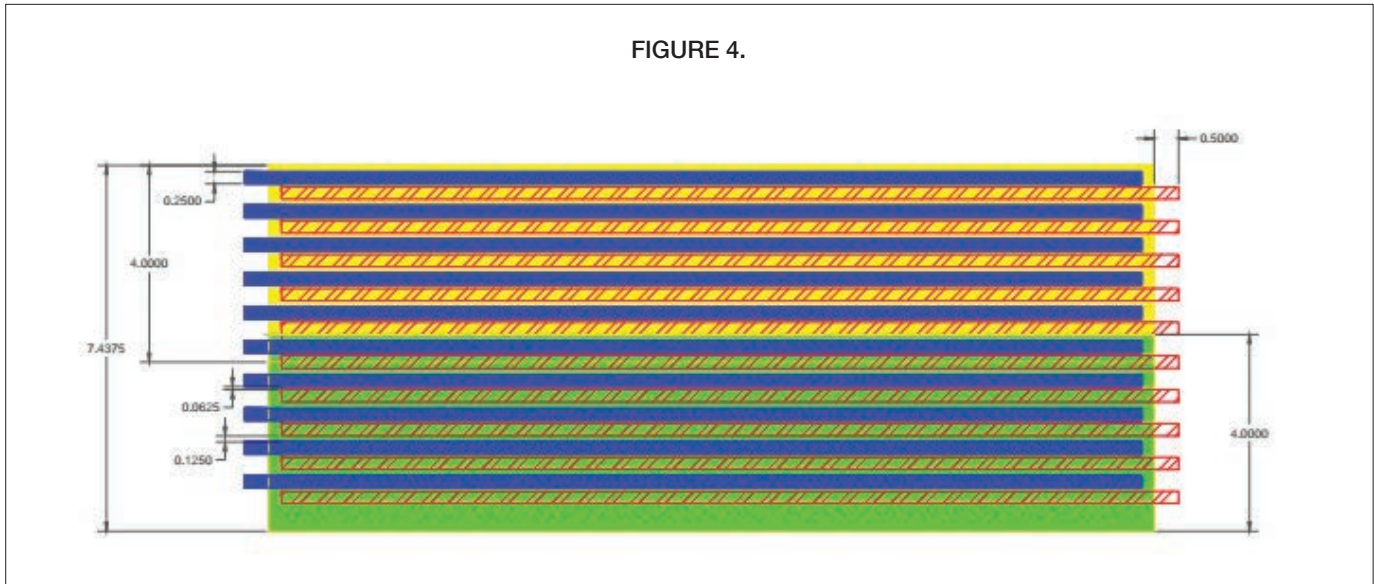
FIGURE 3.
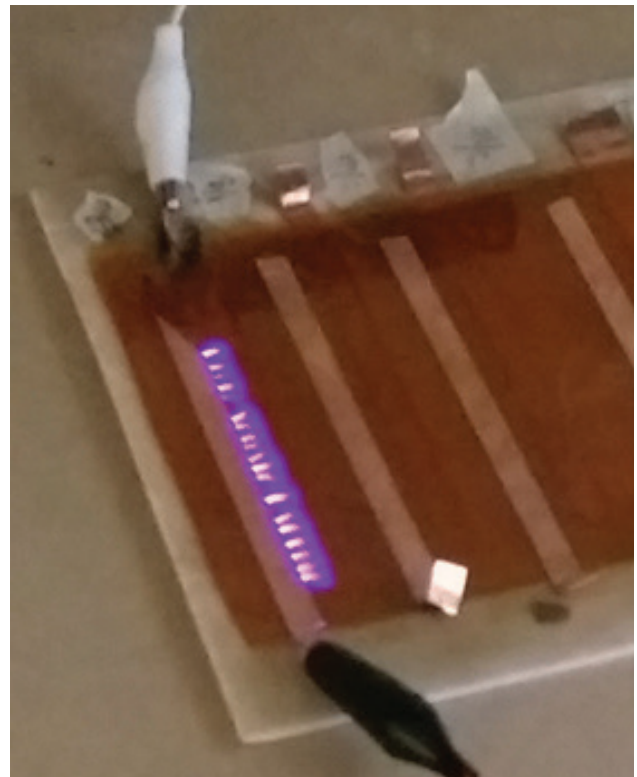
FIGURE 4.



FIGURE 5.



*Spacing of the Electrodes:*

During testing the effect of electrode spacing was also studied, with 1/16, 1/8, and 3/16-inch spacing being compared. The 3/16 inch spacing required so much voltage that it overloaded our power source therefore 3/16-inch spacing is not probable to use. At 1/8 inch, plasma was generated; however, the voltage was higher than the plasma without spacing between the electrodes. Because of the spacing the plasma was not uniform and had many streamers positioned randomly between the electrodes. At 1/16-inch spacing the voltage was a little bit higher than without spacing, but the plasma was more uniform than 1/8 and 3/16-inch spacing. Figure 2 shows the plasma formation between the 1/16-inch spacing.

The plasma shown is not very uniform and has many random streamers. However, the voltage and frequency were not at the optimal setting. Random streamers may also be caused by air bubbles or "if a fold exist in the exposed electrode or the edge is not flushed with the dielectric surface a point of high electric stress occurs, which is where the plasma will ignite first" (Erfani, 137). With more refined tuning the plasma will become more uniform. The purpose of this testing was to increase the plasma surface area because if more plasma is present than the induced velocity will increase. The next figure shows the final configuration of the plasma Actuators that will be placed on the UAV wings. Figure 3 shows two sets of actuators layered on top of each other at a precise location to make sure the spacing between each pair of electrodes are even.

Each section consists of a 4 inch wide by 18 inch long piece of Kapton tape. Total of 10 electrodes per piece of tape, 5 are encapsulated by the Kapton tape and 5 are exposed on the top. The spacing between the exposed and encapsulated electrode will be 1/16 inch. Between each set of electrodes will be 1/8 of an inch spacing, this needed to be greater than 1/16 so the next Actuator does not disrupt the previous one. Once the Final Actuator was built more testing will be needed to optimize the plasma generation. Once optimization is complete the Actuators will be placed on each wing of the UAV as shown in figure 5.

## DISCUSSION

From the start the area of focus was to see if plasma actuators can replace traditional ailerons and effectively control the plane in midflight. However, due to time constraints and faulty testing equipment this study was not concluded. In the mist of testing the different spacing of electrodes the researcher noticed that the farther the electrodes are apart from each other the more voltage is required. Because of this relationship when testing the 3/16 inch spacing the plasma AC driver was overloaded and the next day all of the oil in the oil reservoir for the driver was depleted, rendering the driver incapable of being used again. Fortunately the researcher tested to see if plasma can cause an induced velocity before testing the spacing of electrodes. This test concluded that plasma can in fact cause an induced velocity by the electric field it generates as demonstrated by the smoke from incense.

The main reason why plasma flight control was not concluded was because the actuators that were placed on the UAV required a new DC power supply which was examined in another study. The DC power supply required one 12-volt battery and a neon power supply that amplifies the 12 volt battery into a pulsating 7.5 kilovolt. This power supply was not enough to maintain plasma generation and during testing the neon power supply was also overloaded, rendering the entire power supply useless. DC power also has many disadvantages. For example, some batteries are relatively heavy which means the UAVs will have to carry more weight and also DC power supply technology is not advanced enough for uses of plasma due to high voltage requirements. Plasma actuators have shown promising results in manipulating air flow on objects like a wing on an UAV. However, DC power supply technology needs more advancement to control plasma actuators more effectively.

## REFERENCES:

Chirayath, Ved, and Dr. Juan J. Alonso. "Plasma Actuated Unmanned Aerial Vehicle - The First Plasma Controlled Flight in History Single Dielectric Discharge Devices as an Efficient and Novel Means of Aircraft Control." Stanford University Department of Physics (2010): 1-15. Print.

Davis, Alex. "Planes Have to Get More Efficient. Here's How to Do It." Wired.com. Conde Nast Digital. Web. 14 Apr. 2016.

Erfani, R., Zare-Behtash, H., Hale, C., & Kontis, K. (2015). Development of DBD plasma actuators: The double encapsulated electrode. Acta Astronautica, 109, 132-143. Retrieved February 22, 2016.

Han, Menghu, Jun Li, Zhongguo Niu, Hua Liang, Guangyin Zhao, and Weizhuo Hua. "Aerodynamic Performance Enhancement of a Flying Wing Using Nanosecond Pulsed DBD Plasma Actuator." Chinese Journal of Aeronautics 28.2 (2015): 377-84. Science Direct. Web. 23 Feb. 2016.

# WATER BEARS: IDENTIFICATION OF MARINE TARDIGRADA WITHIN CORPUS CHRISTI BAY, A TEXAS COASTAL WATERWAY

by MICHELLE McGAHA

## ABSTRACT

We completed an assessment of marine tardigrades within Corpus Christi Bay, a Texas coastal waterway, over a one-year period starting August 2015. Sand, algae, and barnacles (typical substrates within the intertidal region) were sampled from various locations along Corpus Christi Bay that included University Beach, Swantner Park, Cole Park and Corpus Christi Marina. Tardigrades were only found in barnacle samples collected at Swantner Park, where twenty-four specimens were identified utilizing a dissecting microscope and Irwin loop. Assessment and determination of morphology and gut contents were achieved through use of phase-contrast microscopy. Concentrations of diverse populations of microfauna within selected substrates suggest presence of predators capable of impacting localization and abundance of tardigrades.

## MENTOR
### Dr. Xavier Gonzales

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## INTRODUCTION

Tardigrades of the phylum Tardigrada, also known as water bears, are a microscopic animal found in marine, freshwater, and terrestrial habitats. Nearly 1000 species inhabiting marine, freshwater, and terrestrial habitats are known worldwide (Degma et al., 2011). The tardigrade fauna of Texas has received limited attention. Only two reports of marine tardigrades have been identified in Texas marine waters: Chitwood (1951) and Mehlen (1969). This paper will report the results of marine tardigrades found within Corpus Christi Bay, a Texas coastal waterway.

## MATERIALS AND METHODS

*Study Site*

Corpus Christi Bay is 497 km$^2$ located in the southern Texas Coastal Bend (27.79$^o$N, 30$^o$ W) in a semi-arid region. The inflow of freshwater is very low with sources of freshwater drainage into Corpus Christi Bay being the Nueces River and Oso Creek. The average depth is 3.0 m, and average salinity is 22 ppt.

*Collection and Analysis*

Twenty samples were taken from August 2015 – August 2016 at non-specific days and times. Samples consisted of three substrates (sand, algae, and barnacles) found along the intertidal region of Corpus Christi bay. Specific collection sites were University Beach,
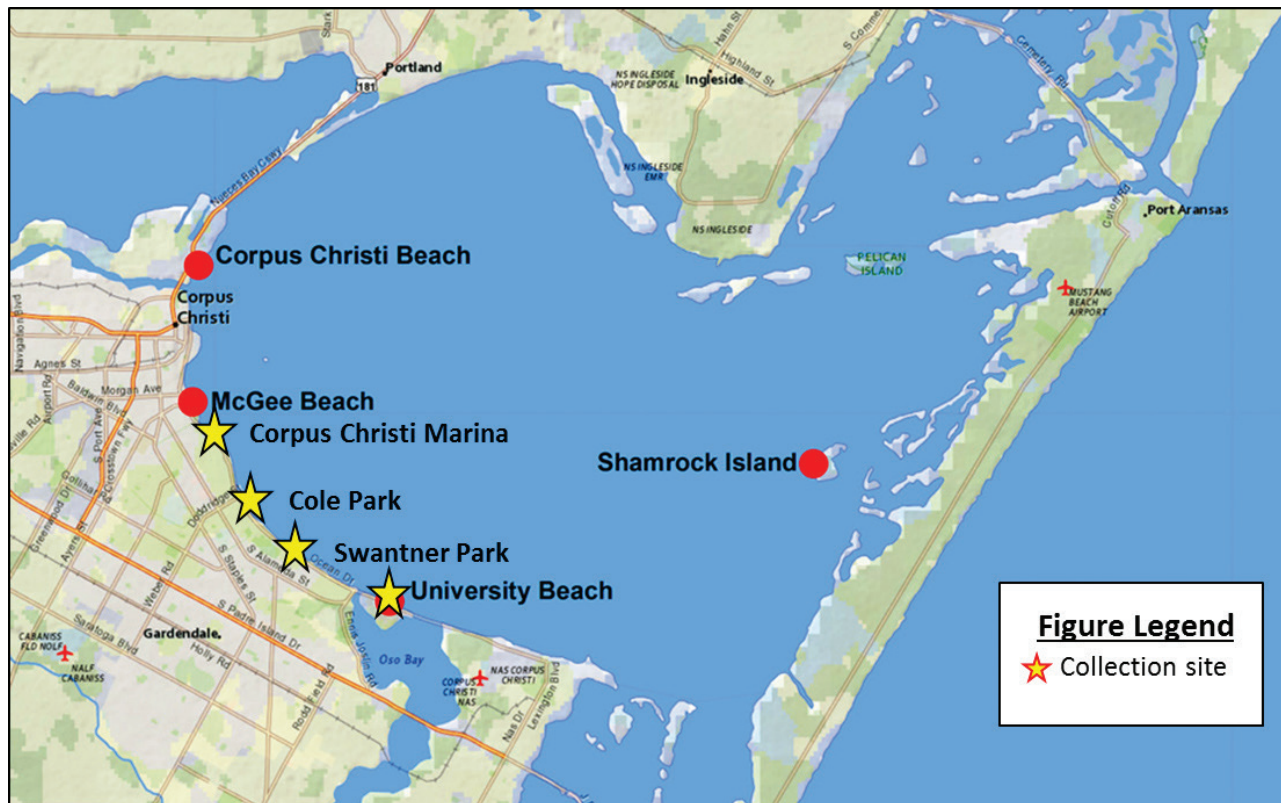
FIGURE 1.

Modified map of Corpus Christi Bay from Conrad Blutcher Institute website (http://www.cbi.tamucc.edu/CHRGIS/Education/) with stars denoting the four collection sites: Corpus Christi Marina, Cole Park, Swantner Park and University beach.



Swantner Park, Cole Park and Corpus Christi Marina (Figure 1). Sand samples were collected by removing 4cm of sand from the surface utilizing an inverted labeled plastic bag. Algae and barnacles were collected into a labeled plastic bag by scraping with a putty knife. All samples were transported at ambient temperature to the Environmental Microbiology Laboratory at Texas A&M University-Corpus Christi for further processing.

For processing, we utilized previous methods established by Perry and Miller (2015). Individually collected samples were placed in glass petri dishes and immersed in spring water for twenty-four hours and later viewed with the aid of a dissecting microscope. Individual tardigrades are counted with the help of an Irwin loop and recorded. For assessment of tardigrade morphology and gut content, randomly selected tardigrades from reviewed samples were placed on a glass slide using an Irwin loop, and a drop of polyvinyl alcohol was placed over the tardigrade and cover slip was placed on top. The slide was viewed under a phase-contrast microscope.

FIGURE 2.

Phase-contrast microscopy image of a tardigrade. Gut content indicates the presence of chloroplast, zooplankton, and various other debris.

## RESULTS

Of the three substrates utilized for sample assessment, we only found tardigrades among barnacles. Out of all the samples collected, there were 24 tardigrades found. Swantner Park had the highest tardigrade population among all other sample locations. In all the collected samples, we identified variable concentrations of microfauna such as isopods, copepods, amphipods, and sea worms. Phase-contrast microscopy assessment of tardigrade gut content indicated the presence of chloroplast, zooplankton, and various other debris (Figure 2).

## DISCUSSION

The results suggest that there are tardigrades present within the Corpus Christi Bay. Barnacles were the only sample source in which tardigrades were identified. Previous reports have determined that on rocky shores similar to our sampling sites, tardigrades (especially species of *Echiniscoides*) are found primarily in algae and barnacles (Nelson, 2002). The presence of tardigrades only in barnacles could be due to environmental conditions (i.e., pH, salinity, or temperature), food availability, or predation. For this study, we did not review environmental conditions or food availability. The identification of gut content gives us an idea of what they are consuming and suggests that food could be a variable of location and population size. As for predation, typical predators include nematodes, other tardigrades and mites (Ramazzotti and Maucci, 1983). The prominence of various microfauna within our samples suggest that predation is a possibility; however, we did not quantify the specific types of microfauna beyond tardigrades. Nonetheless, variation in tardigrade abundance and diversity is common in seemingly identical microhabitats (Meyer, 2006). Further assessment of various substrates along a broader range of Corpus Christi bay is strongly recommended, despite indicators in this study suggesting that tardigrades within Corpus Christi bay intertidal region favor barnacles.

## REFERENCES

Chitwood, B.G. (1951) A marine tardigrade from the Gulf of Mexico, *Texas Journal of Science,* 3, 111-112.

Degma, P.,Bertoani, R. & Guidetti, R. (2011) Actual checklist of Tardigrada species. Available online at http://www.tardigrada.modena.unimo.it/miscellanea/ Actual checklist of tardigada.pdf (Accessed 1 May 2011)

Hinton, J.G. Meyer, H.A., McDaniel, N.D., Bergeron, C.B., Keely, S.J., & Matte, A. (2014) Lone Star Bear: The tardigrade of Big Thicket National Preserve, Texas, *Southeastern Naturalist,* 13(5), 131-136.

Mehlen, R.H. (1969) New Tardigrada from Texas, *American Midland Naturalist,* 81, 395-404.

Meyer, H.A. (2008) Distribution of Tardigrades in Florida, *Southeastern Naturalist,* 7 (1), 91-100.

Meyer, H.A. (2006) Small Scale spatial distribution variability in terrestrial tardigrade populations, *Hydrobiologia,* 7, 133-139.

Moretzsohn, F., Sánchez Chávez J.A., Tunnell, J.W. Editors (2016) GulfBase: Resource Database for Gulf of Mexico Research. Available from: http://www.gulfbase.org, (accessed 5 September 2016)

Nelson, D.R. (2002) Current Status of the Tardigrada: Evolution and Ecology. *Integrative and Comparative Biology*, 42, 652-659.

Perry, E.S. & Miller, R.W. (2015) Echiniscoides Wyethi, a new marine tardigrade from Maine, U.S.A. (Heterotardigrade: Echiniscoidea: Echiniscoididae), *Processdings of the biological society of Washington*, 128(1), 103-110.

Ramazzotti, G. da & Maucco, W. (1983) II Phylum Tardigrada, *Memorie dell'Istituto Italiano di Idrobiologia,* 41, 1-1011.

Williams, D. (2016) Four Shore, beach, or habitat restoration projects. Available from: http://www.cbi.tamucc.edu/CHRGIS/Education/, (accessed 5 September 2016)

## ACKNOWLEDGEMENTS

# EXAMINING DISTRACTED, AGGRESSIVE, AND IMPROPER DRIVING BEHAVIORS IN NUECES COUNTY 2016

by JERMEKA MORRISON

## ABSTRACT

The purpose of this paper is to examine the problems of distracted, aggressive, and improper driving behaviors. These distractions include manipulating audio controls, cell phone usage, eating or drinking, reading, writing, texting, and personal grooming. Aggressive driving includes getting mad and retaliating, tailgating, impatience, and yelling or gesturing at other drivers. Improper driving includes speeding, running red lights, and driving under the influence of alcohol. Poor driver behaviors contribute to a greater rate of DUI and distraction-related fatalities. Nueces County DUI crashes accounted for a larger proportion of fatalities than in the State of Texas from 2009 to 2013 (Rhoades, 2015). This research will answer the following questions: 1) Do drivers exhibiting poor driving behavior have more traffic crashes than drivers with good driving behavior? 2) Do drivers that have more vehicle crashes have crashes because they have more traffic citations? This research is needed to continue assisting an ongoing initiative to increase community awareness and design traffic safety presentations and literature. This research will also expand the knowledge on relative relationships between driver behaviors and traffic crashes. Participants in this study had to be 18 years or older and be residents of Texas. The goal of this study is focused on distracted, improper, and aggressive driving behaviors while analyzing data and finding correlations as found in previous studies.

## MENTOR
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## INTRODUCTION

Understanding driver habits, behaviors, and distractions would enhance knowledge and promote ways of influencing driver behavior. Understanding the results of this research will aid in expanding awareness and contribute to planning and public education efforts. What is distracted driving exactly? Distracted driving is defined as a driver doing another activity which removes the driver's ability to stay attentive (Center for Disease Control and Prevention, 2016). Aggressive driving occurs when a driver commits a combination of moving traffic offenses, which endangers other persons or property according to Richard, C. M., et al. (2012). Improper driving is driving while intoxicated, speeding,

and similar behaviors which endanger persons or property (Sarsour, 2015).

This study examines the research questions:

1. Do drivers exhibiting poor driving behavior have more traffic crashes than drivers with good driving behavior?

2. Do drivers that have more vehicle crashes have crashes because they have more traffic citations?

A survey of drivers in Nueces County, Texas will be used to explore these questions. Based on the review that follows, it is believed that:

1. Drivers who engage in distracted, aggressive, and/or improper driving behaviors will receive more tickets,
2. Drivers who engage in distracted, aggressive, and/or improper driving behaviors will experience more traffic crashes, and
3. Drivers that receive more tickets will experience more traffic crashes.

## LITERATURE REVIEW

According to the CDC (2016), research in driving shows that over 8 people are killed each day in the United States, and 1,161 are seriously injured in vehicle crashes. Furthermore, the CDC (2013) says "there are three main types of distractions," 1) visual, 2) manual, and 3) cognitive. This article explains these types of distractions as such: 1) Visual is when the driver takes their eyes off the road, 2) A manual distraction is when the driver takes their hands off the steering wheel, and 3) Cognitive is when your mind is not focused on driving. Prior research regarding aggressive driving, distracted drivers, driving under the influence of alcohol or prohibited drugs, speeding, and running red lights requires multiple studies.

Related sources and data collection are vital in determining if drivers exhibiting poor driving behaviors have more traffic crashes than drivers with good driving behaviors. Prior studies have found that these types of behaviors play a significant role in causing traffic crashes. In an industrialized society, driving is the most dangerous activity for many (James & Nahl, 2000). Research shows that driving is emotionally

challenging due to unexpected and dangerous habits. According to the National Safety Council (2016), 53% of drivers actually believe that since manufacturers put "infotainment" dashboards and hands free technology in vehicles and thus it must be safe.

*Distracted Driving*

Distracted driving is dangerous and potentially the cause of deadly behavior. Federal estimates suggest that distractions contribute to 16% of all fatal crashes, leading to around 5,000 deaths every year according to the AAA Foundation for Traffic Safety (2016). There are four types of driver distractions: 1) visual, 2) auditory, 3) manual, and 4) cognitive (GHSA, 2015). The Association conducted a study of 100 drivers over the period of 1 year and found that these drivers were distracted between one-quarter and one-half of the time. The Washington Traffic Safety Commissions found that accidents caused by several driver distractions accounted for 6.5 percent of 57,000 vehicle crashes within the first six months (Copeland, 3A, 2006). New research will continue to validate these figures.

Cell phone usage while driving is considered the most dangerous distraction, more so than anything else. In fact, cell phone use is worse than driving while intoxicated at the legal limit (Lee, Champagne, & Francescutti, 2013). Cell phone usage slows down a driver's reaction time by 18%, while alcohol decreases reaction time by 12%. Even though many drivers know the risk, they will still use their cell phones. Four states and the District of Columbia have banned the use of handheld cell phones by drivers while driving. It is prohibited or restricted in thirteen states, including Washington D.C., for young drivers to utilize cellular devices, including hands-free devices (Copeland, 3A, 2006).

Accessing audio controls while driving is another dangerous distraction. An immersive fMRI study indicates how brain activity is identified and how the frontal lobes become sensitive to the type of driving task (Schweizer, 2013). The research shows how the posterior brain actives several parts of the brain with the most important being the visual-motor integration. Many electronics that can be used in the home or office can be utilized in a vehicle such as televisions, computers, iPods, iPads, DVD players, game

systems, and navigational systems. While technology continues to advance, society will desire more access to these devices in their vehicles (Copeland, 3A, 2007).

## Alcohol

In the United States, 28 people die every day in motor vehicle crashes that involve an alcohol-impaired driver. According to this research, one death occurs every 53 minutes, carrying an annual cost of more than $44 billion dollars for alcohol-related crashes (CDC Prevention, 2016). Dual performance deficits persisted through practice and transfer-driving conditions while utilizing a fixed base driving simulator, a study was able to incorporate realistic driving conditions and proprietary vehicle dynamics (Cooper & Stayer, 2008). Improper driver habits cause accidents. Research shows that when drugs are used negatively driving behaviors is affected

## Speeding

Nueces County speeding contributing factors were determined in 2013 to be 46.9% of fatal crashes, 5.09% serious injury crashes, 2.68% of other injury crashes compared to 34.7%, 9.54% and 4.29% respectively for Texas (Rhoades, 2015). While demographic variables as age, gender, situational factors, and personal factors such as attitudes towards reckless driving (Richard, C. M., et al.). Although distracted or inattentive driving in Texas contributed to 13.6% of fatal crashes reported in 2012, more, 15.2%, in Nueces County (Rhoades, 2015). According to The National Highway Transportation Safety Administration defines speeding is "exceeding the posted speed limit or driving too fast for conditions" and is one of the most prevalent factors that contribute to traffic crashes" (Traffic Safety, 2000). The Motivation for Speeding (2012). project conducted several focus groups and gathered data on driver opinions with hopes of gaining insight and identify risky speeders and opportunistic speeders Drivers in this study identified factors which caused them to speed which included; situational or specific trip factors (running late for work), social pressure from passengers, inattention to driving, and positive feelings about driving. The findings of the report concluded that situational factors, opportunity, and demographic factors played a key role in the effects of the driver.

## METHODS

### Participants

Four hundred and fourteen individuals participated in this study according to approved IRB procedures. Once this survey instrument and locations was approved by Texas A&M University-Corpus Christi Institutional Review Board approval were approved. The survey was administered at the local university, a community college, and the Nueces County Courthouse from prospective jurors and individuals conducting business at the motor vehicle registration department. Data was collected through a survey instrument consisting of various questions. The primary focus of the surveys that were administered at colleges were the younger demographic of student drivers. Utilizing this methodology provided diversity across the demographic dimensions.

### Materials and Procedure

Participants were asked if they were 18 years old or older and younger persons were excluded from the survey. Each prospective individual was provided with a detailed verbal explanation of the nature of the survey and given the opportunity to decline. Once participants agreed to participate, each individual received a pen or pencil and a survey that contained forty questions. If any participants declined, they continued about their day. Monetary compensation was not offered and participants completed the survey anonymously to rule out bias.

The survey was comprised of limited demographic questions such as age, gender, ethnicity, education, income, employment status, and years of driving experience. The survey instrument consisted of a two-page questionnaire. A longer format was used in the same county back in 2000 and followed by a shorter version in 2002, 2006, and 2009 for this research. The survey included questions of one's own safety, driving behaviors, safe practices with children, legal knowledge, safety belt usage, traffic citations, and bicycle and motorcycle safety. Identifying markers were not collected nor needed for this survey. The data collection process kept all participants anonymous throughout the study.

## RESULTS

The participants were asked about their ethnicity. The composition of the sample was 23% Anglo, 54% Hispanic, 12.1 % African American, .8% Native American, 2.3% Asian, and 7.8% Other. The ages of the respondents were collected in categories. Of the sample 47.4% stated they 18-24, 14.0% answered 25-35, 12.3% answered 36-45, 14% answered 46-55, 8.5% answered 56-65, and 3.8% selected age 66 and or older. The sample was 47.9% male and 52.1% female. When participants were asked if they drive, the majority of respondents (93.3%) answered yes while 6.7% of the respondents answered that they do not drive.

The study provides data that demonstrates that drivers' behaviors are significant reasons for motor vehicle crashes. Only the results that relate to the study's hypotheses are provided here. The data have been used both as nominal, ordinal, and bi-variate variables.

*Distracted Driving*

A cross-tabulation was conducted to determine how many respondents read or write while driving. Of the respondents that stated they did read or write while driving, 71.1% reported receiving tickets, while 39.1% that did not read or write received tickets. People who read or write while driving are therefore more likely to receive tickets than those that do not read or write. These findings are statistically significant (PHI ≥ .204, p < .000). Details are provided in Table 1.

Similar findings occurred with the other questions related to other distracted driving behaviors. The finding concerning the distractions of personal grooming, (Phi = .136, p = .007), adjusting vehicle controls (Phi = .238, p = .000), eating or drinking (Phi = .180, p = .000), cell phone use (Phi = .252, p =.000) and texting (Phi = .326, p = .000) all demonstrated that drivers that engage in such behaviors are significantly more likely to receive citations compared to those that do not.

In regards to crashes (see Table 1), the results demonstrate that those that engage in distracting behaviors while driving are more likely to have traffic crashes than those that do not. The findings for reading or writing (Phi = .124, p = .013), cell phone use (Phi = .162, p= .001), and texting (Phi = .184, p = .000) show that distracted drivers are more likely to have crashes than drivers that are not distracted at statistically significant levels.

**TABLE 1.**
Distracted Driving by % With Tickets and Crashes

|  | Tickets | No Tickets | Crashes | No crashes |
|---|---|---|---|---|
| Grooming | 58.1 | 39.5 | 24.2 | 18.5 |
| Adjusting Controls | 50.4 | 24.6 | 21.4 | 45.5 |
| Eating and Drinking | 51.3 | 33.5 | 21.4 | 18.4 |
| Reading and writing | 71.1 | 39.1 | 33.3 | 17.7 |
| Cell Phone use | 56.4 | 31.3 | 28.8 | 13.9 |
| Texting | 68.5 | 32.5 | 31.2 | 14.9 |

The findings for eating and drinking, use of vehicle controls, and personal grooming all indicated that distracted drivers were more likely to have crashes, but the findings were not statistically significant.

*Aggressive Driving*

Those that report engaging in aggressive driving behaviors are more likely to report receiving tickets and having traffic crashes than those that do not drive aggressively (see Table 2). Those that report the aggressive behaviors of getting mad and retaliating against other drivers (Phi = .147, p = .003), get impatient at traffic lights (Phi = .142, p = .004), get impatient with slow drivers (Phi = .154, p = .002), and drive aggressively (Phi = .181, p = .000) are more likely to receive tickets than those that do not report these behaviors at statistically significant levels. Those that report tailgating, yelling or gesturing at other drivers are more likely to receive tickets, but the differences were not statistically significant.

Again, similar findings occur in regard to traffic crashes (see Table 2). The results show that individuals that engage in aggressive driving behaviors are more likely to have crashes than those that do not. The findings for getting mad and retaliating against other drivers (Phi = .150, p = .003) and yelling or gesturing at other drivers (Phi = .037, p = .466) show that aggressive drivers are more likely to have crashes compared to drivers that do not engage in aggressive behavior. Those that report getting mad and retaliating against other drivers report these behaviors at statistically significant level.

| TABLE 2. Aggressive Driving by % With Tickets and Crashes | | | | |
|---|---|---|---|---|
| | Tickets | No Tickets | Crashes | No crashes |
| Getting Mad | 53.5 | 38.0 | 28.6 | 15.8 |
| Impatient at Lights | 51.2 | 36.9 | 23.4 | 17.3 |
| Impatient with Slow Drivers | 51.1 | 35.8 | 22.1 | 18.1 |
| Drive Aggressively | 60.2 | 38.1 | 25.6 | 18.2 |
| Tailgate | 51.2 | 41.7 | 26.8 | 18.5 |
| Yelling or Gesturing | 48.0 | 41.3 | 22.2 | 18.9 |

| TABLE 3. Improper Driving by % With Tickets and Crashes | | | | |
|---|---|---|---|---|
| | Tickets | No Tickets | Crashes | No crashes |
| Driven above the posted speed | 49.3 | 24.0 | 21.1 | 16.5 |
| Driven through a traffic signal after it turned red | 55.0 | 37.9 | 23.4 | 19.0 |
| After consuming alcoholic beverages | 56.9 | 39.8 | 27.7 | 18.5 |
| After taking prescribed medications | 51.6 | 40.4 | 18.2 | 20.5 |
| After taking prohibited drugs | 76.9 | 40.8 | 25.9 | 19.2 |

The findings for drivers who get impatient at traffic lights, get impatient with slow drivers, drive aggressively, and tailgate all indicated that aggressive drivers were more likely to have crashes, but the findings were not statistically significant.

*Improper Driving*

The questionnaire asked if drivers sped, ran red lights, drove after drinking alcohol, or drove after taking prohibited drugs within the past month as well as how many tickets they received (see Table 3). Reported here are findings for the questions concerning improper driving habits over the past month. Drivers that reported driving above the posted speed limit in the past month (Phi = -.226, p = .000), through a traffic signal after it turned red (Phi = -.158, p = .003), after consuming alcoholic beverages (Phi = -.129, p = .011), after taking prescribed medications (Phi = -.096, p = .057), or after taking prohibited drugs (Phi = -.181, p = .000), were all more likely to receive citations compared to those that did not engage in the behaviors.

In regards to crashes (see Table 3), the results demonstrate that individuals that engage in improper driving behaviors are more likely to have crashes that those that do not. The findings for individuals that reported driving above the posted speed limit, through a traffic signal after it turned red, after consuming alcoholic beverages, after taking prescribed medications or after taking prohibited drugs are more likely to have crashes than those that do not report these behaviors, but the findings were not statically significant.

*Tickets and Crashes*

The results from this research indicates that drivers who exhibit distracted, aggressive and improper driving behavior receive more tickets and have more traffic crashes than drivers with good driving behaviors. To examine the relationship between receipt of tickets and having crashes, the categorical variables for tickets and crashes were converted to bivariate variables indicating whether the respondents had or had not had a ticket or a crash. Cross-tabulations were conducted. The proportion of those that had received tickets and had experienced crashes was 31.6% while the proportion experiencing crashes that had not received tickets was only 10.5%. This difference was significant (Phi = .263, p. 000). A second analysis (see Figure 1) considered the tickets and crashes variables to be scales that reflected the number of tickets and crashes experienced in the past two years. An ANOVA analysis was conducted to determine if those with a greater number of tickets experienced a greater mean of crashes. The results indicate that those with more tickets experienced more crashes at a statistically significant level (F = 8.546, p = .000). Thus, the finding indicates that those receiving more tickets experience a greater number of traffic crashes than those with fewer tickets.

**FIGURE 1.**

**Crashes by Tickets**
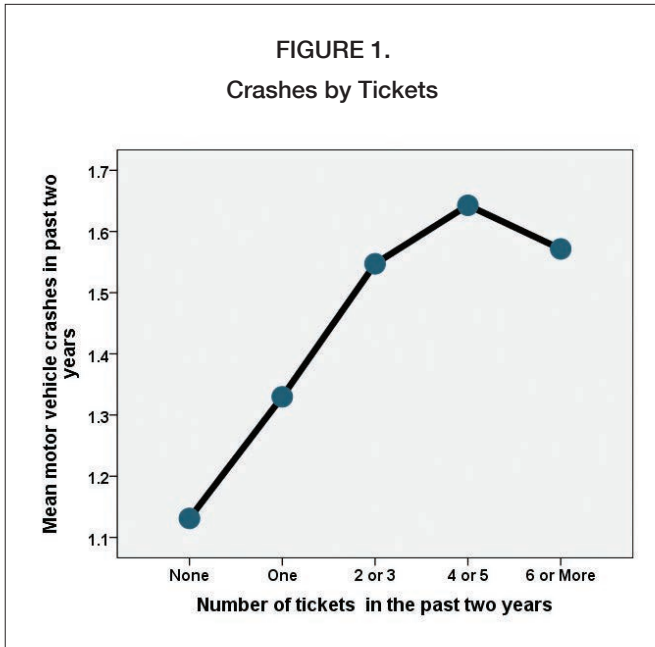


## DISCUSSION AND CONCLUSIONS

The purpose of this research was to determine the correlation between driver behaviors and both vehicle crashes and traffic citations. The hypothesis that drivers who engage in distracted, aggressive, and/or improper driving behaviors receive more tickets than drivers that do not engage in these behaviors is confirmed. This study demonstrates, as previous studies in the literature have, that drivers who engage in distracted, aggressive, and/or improper driving behaviors receive more tickets. The study's findings confirm the hypothesis that drivers who engage in distracted, aggressive, and/or improper driving behaviors will experience more traffic crashes than drivers that do not engage in these behaviors. Finally, the hypothesis that drivers that receive more tickets experience more traffic crashes than drivers that do not receive tickets is confirmed. The majority of the findings for the relationships that support the hypotheses were statistically significant. The importance of this research is that it can be utilized in efforts to inform the public about the severity of this ongoing issue. It provides information that may be used in planning and in the production of public education literature and presentations. The study helps to provide an understanding of distracted, aggressive, and improper driving behaviors.

One of the limitations regarding this study was that the entire sample was not random. A portion of the survey was a convenience sample with participants from Del Mar Community College and Texas A&M University-Corpus Christi. This was due to a focus on younger drivers in support of efforts to provide knowledge about their behaviors. The students are not an accurate representation of Nueces County's non-student drivers. However, the survey was random to an extent, because the majority of the participants used in this study were jurors. State law mandates a random process of selecting prospective jurors. If you are a registered voter, have a Texas driver's license or Texas personal ID card and you live in Nueces County, your name is entered in a computer system designed to randomly select prospective jurors (Nueces County Website, 2014).

Additional research on the issues examined here is needed. A concept surrounding the theoretical construct of risk taking would greatly enhance knowledge about why some individuals continue to drive in risky ways after experiencing citations or crashes. This study may present many opportunities for future research that would include analysis of the hypotheses in regard to demographic categories such as gender, age, education, and economic status.

## REFERENCES

Rhoades, P. (2015). Safe Communities Safe Driving Public Education Campaign. A grant submitted to the Texas Department of Transportation. 2016-TAMUCC-G-1YG-0153

Schweizer, T.A., Kan, K., Hung, Y., Tam, F. Naglie, G., & Graham, S. J (2013). Brain activity during driving with distractions: an immersive fMRI study. *Frontiers in Human Neuroscience* (February). Retrieved from journal.frontiersin.org/article/10.3389/fnhum.2013.00053/full

Richard, C. M., Campbell, J. L., Lichty, M. G., Brown, J. L., Chrysler, S., Lee, J. D., & Reagle, G. (2012). Motivations for speeding, Volume I: Summary report. (Report No. DOT HS 811 658). Retrieved from http://www.nhtsa.gov/Aggressive

Governors Highway Safety Association, (2013). Distracted Driving. Retrieved from www.ghsa.org/html/files/pubs/sfdist11.pdf. Communications Director, *GHSA*.

Copeland, L. (2006). Distracted Driving Big Cause of Crashes. *USA Today* (November) *Retrieved* from http://web.lexis-lexis.com/universe/document?_m

CDC Distracted Driving. (2016). from Retrieved from http://www.cdc.gov/motorvehiclesafety/distracted_driving/

Distracted Driving. (Mar 7, 2016). Retrieved from www.cdc.gov/.../distracted_driving/

Sarsour, J. (2015). Fairfax County Criminal Defense Attorney. What is the difference between reckless driving & improper driving?

Schweizer, T., Kan, K., Hung, Y., Tam, F., Naglie, G., Graham, S.J.

Front Hum Neurosci. (2013). Feb28. doi: 10.3389/fnhum.2013.00053 PMCID: PMC3584251

James, L. & Nahl. D. (2000). Conference Paper. Information Science University of Hawaii Retrieved from http://drdriving.org/courses/conference_paper.htm

National Safety Council (2016). Distracted Driving: One Call Can Change Everything. Retrieved from http://www.nsc.org/learn/NSC-Initiatives/Pages/distracted-driving.aspx

AAA Foundation for Traffic Safety (2016). Distracted Driving. Retrieved from https://www.aaafoundation.org/distracted-driving . 723-725, Distracted Driving

Lee, V.K, Champagne, C.R, Francescutti, L.H (2013). Fatal Distractions – PubMed Central (PMC CFP MFC Can Fam Physician. 2013 Jul; 59(7): 723-725. PMC3710028, Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3710028/

District Clerk Office, (n. d.). Nueces County Tax Office Jurors info. Retrieved from http://www.co.nueces.tx.us/taxoffice/

## ACKNOWLEDGMENTS

# EFFECT OF PH AND COUNTERION CHOICE ON THE CHIRAL SEPARATION OF BINAPHTHYL DERIVATIVES BY L-UNDECYL-LEUCINE SURFACTANTS

by ZOE ELISE RAMOS

## ABSTRACT

*In this study the chiral selectivity of L-undecyl-leucine (und-Leu) for binapthyl derivatives was examined with the use of arginine and sodium counterions and with solutions at pH's ranging from 7 to 11. The objective of this project was to investigate whether a chiral amino acid such as arginine would achieve enhanced chiral selectivity when utilized as the counterion in place of sodium in micellar electrokinetic chromatography. The data indicates that und-Leu has significantly improved chiral selectivity towards 1,1'-Binaphthyl-2,2'-diyl hydrogenphosphate (BNP) enantiomers in the presence of arginine counterions in comparison to sodium. However, no significant difference was observed for the enantiomers of 1,1'-Bi-2-naphthol (BOH).*

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## INTRODUCTION

Amino acid based surfactants are used in micellar electrokinetic chromatography (MEKC) in order to separate chiral analytes and study the mechanisms for chiral recognition (1-5). In previous studies, Shamsi et al. separated 58 anionic, cationic and neutral enantiomers using undecyl-leucine-valine surfactant micelles, Billiot et al. achieved the separation of 12 analytes using 18 types of amino acid surfactant micelles, and Agnew-Heard et al. used N-Undecylenyl-l-valinate to separate neutral, acidic, and basic compounds (1, 3, 7). Other studies have investigated the effects of such factors as the number of amino acid molecules in each surfactant, amino acid order, and the number of chiral centers in each surfactant (7-17) on chiral selectivity. Some studies have also examined the effect of steric factors, polydispersity levels, solution temperature, and the depth of penetration of analytes into the micellar core (7, 18-22) on enantiomeric recognition.

For this study, the nature of chiral interactions in the amino acid based surfactant L-undecyl-leucine (und-Leu) will be investigated through comparing the performance of arginine and sodium counterions. Arginine was chosen for this study because it has a cationic side chain which is susceptible to predictable changes in ionization state when solution pH is changed.

## EXPERIMENTAL

### Chemicals

Leucine amino acid, L-Arginine, D-Arginine, and racemic mixtures of binaphthol (BOH) and binaphtholphosphate (BNP) were purchased from Sigma-Aldrich (St. Louis, MO). Undecyl L-leucine surfactants were synthesized from N-hydroxysuccinimide ester of undecylenic acid according to a previously reported procedure (23). The structures of these surfactants, analytes, and arginine are provided in Figure 1.

### Capillary electrophoresis procedure

The chiral separations were performed using a Hewlett-Packard (HP) 3D CE model #G7100A. The fused silica capillary [effective length of 45 cm (to detection window), 50-μm i.d., with a total length of 56 cm] was purchased from Agilent Technologies and mounted in an HP capillary cartridge. The temperature of the cartridge was consistent at 25°C throughout this experiment. Solutions of 50 mM und-Leu with arginine and sodium were prepared in a 5 mM sodium borate buffer and pH was adjusted to values of 7-11 with the use of NaOH and/or HCl. These solutions were diluted to concentrations ranging from 15 to 50 mM and were filtered through a 0.45-μm filter before use. A new capillary was conditioned for 30 min with 1M NaOH, followed by 10 min with triply distilled water. The capillary was then flushed with buffer for 3 minutes prior to injection of the sample. Analyte standards were prepared in 1:1 methanol–water at 0.1 mg/mL. Samples were injected for 5 s at 10 mbar pressure. Separations were performed at + 30 kV, with UV detection at 230 nm.

### Results and discussion

The chiral recognition of amino acid based surfactants is largely based upon electrostatic, hydrophobic, steric interactions and hydrogen bonding. These forces in return effect the depth at which an analyte penetrates the micellar core. Previous studies have shown that neutral hydrophobic analytes tend to bind at a greater depth into the micellar core while hydrophilic analytes interact closer to the surface of the micelle, enantiomers of BOH that are mostly neutral at pH's below 9, and interact closer to the core of amino acid based micelles while negatively charged enantiomers of BNP interact closer to the surface (22). Also, surfactants with amino acid headgroups have both amide and carboxylic acid functional groups and therefore solution pH would be expected to effect the percent ionization of the carboxylic groups and the rate at which amide protons exchange with the solvent (24). The degree of headgroup ionization and amide proton solvent exchange rate would thus be expected to affect depth of the penetration of the analyte into the micellar core and thus chiral recognition.

This study investigated the effect of solution pH on the chiral recognition of und-Leu in the presence of sodium and arginine as counterions. Arginine was chosen for this experiment because it is typically positively charged at pH's below its side chain's pKa (see Fig. 1), making this amino acid a good candidate for a counterion of negatively charged und-Leu surfactants. Also, arginine is capable of forming hydrogen bonds with a chiral analyte as well as leucine functional groups. In addition, solution pH can affect arginine counterions more than sodium. In fact, it has been shown that pH can have a significant effect on the size of amino acid based micelles with arginine as the counterion while very little effect is observed when sodium is used as the counterion. Studies have shown that at pH ~7 the average hydrodynamic radii of und-Leu micelles is ~14 Angstroms when arginine is used as its counterion, but this decreases to ~10 Angstroms when this same solution is at pH 11. This phenomena is not observed when sodium is used as a counterion for the same surfactant. When sodium is used as a counterion for und-Leu surfactants, this same study has shown that the hydrodynamic radii remains relatively constant (~ 9.5 Angstroms) from pH ~7.5 to ~ 10. After pH 10, a slight increase in hydrodynamic radii is observable, but that change is relatively small compared to when arginine is used as the counterion. These findings suggest that at higher pH's arginine more easily dissociates from micelles due to the loss of positive

charge that occurs after this change in pH environment (24). For this reason, the effect of pH upon the chiral separations of binapthyl derivative by both und-Leu-Arg and und-Leu-Na was examined.

*Separation of BNP enantiomers*

Enantiomers of BNP were separated in MEKC using und-Leu and either sodium or arginine as counterions at various pHs and surfactant concentrations. As can be seen in Figure 2, when arginine is used as the counterion for the separation of BNP, the enantiomeric separations increase as a function of surfactant concentration from ~ 15mM to ~30-40 mM where the resolution begins to level off. Also shown in the insert in Figure 2 is the effect of pH on the enantiomeric resolution of BNP as a function of pH. The results show a nearly linear relationship between pH and chiral recognition ability: as the pH increases the enantiomeric resolution of BNP decreases.

A comparison of the enantiomeric resolution of BNP achieved when arginine and sodium are each used as the counterion is shown in Figure 3. In looking at Fig. 3, arginine would appear to be a better counterion for the enantiomeric separation of BNP in comparison to sodium. When sodium is used as the counterion, the enantiomeric resolution of BNP never exceeds 0.6. However, when arginine is the counterion, resolutions as high as 4.1 are achieved. In addition, the weakest enantiomeric resolution (Rs = 0.8 at pH 10 for 20 mM und-Leu) achieved with the use of arginine as a counterion is better than the highest enantiomeric resolution (Rs = 0.6 at pH 7 for 50 mM und-Leu) achieved when sodium is used as a counterion (see Fig. 3).

In regards to the trend displayed between buffer pH and the chiral recognition of BNP in the presence of arginine, resolution is likely to decline with an increase in pH due to a resultant loss of positive charge in arginine side chains which causes the dissociation of arginine from micelles (see Fig. 1 for pKa). Previous studies on the fraction bound (fb) of Arginine to und-Leu support the likelihood of this interaction as measures of fb decrease with increasing pH. At the pH range of 7 to 9, fb remains near 39% while this measure decreases to 28% at pH 9.5 and 10% at pH 11.5 (24).

*Separation of BOH enantiomers*

For the analyte BOH, chiral separation may be said to be roughly equal in magnitude when either sodium or arginine counterions are used with sodium possibly being a slightly better performing counterion (see Fig. 4). In looking at the effect of und-Leu concentration on the enantiomeric separation of BOH, no predictable associations may be said to occur though there are some notable patterns. For und-Leu-Na, the maximum resolution (Rs= 3.2) occurred at pH 11 and at a 15 mM concentration of the buffer while for und-Leu-Arg, the maximum resolution (Rs=2.5) occurred at pH 9 and at 25 mM und-Leu. These results indicate that at pH's 7-9, optimum resolution is observed around 20 mM und-Leu-Na. In looking at the chiral selection of BOH by und-Leu-Arg, a decline in resolution from 2.5 to 1.0 occurred at pH 9 from 20 to 50 mM und-Leu. A similar decline was observed at pH's 10 and 11. However, the difference for pH 11 between concentrations of the buffer was not as significant: at pH 11, the resolution declined from 2.3 to 1.8 from 15 mM to 50 mM of the buffer.

*Comparison of retention factors (k') for BOH and BNP*

Shown in Figure 5 is a comparison of the retention factors (k') as a function of pH, surfactant concentration and counterion for BNP and BOH. As is apparent, the retention factors for BOH and BNP are very similar in terms of both measures and trends. That said, at lower pH values, the retention factors of BOH and BNP are higher when arginine is used as a counterion as opposed to sodium. Despite this, as pH increases, the differences in the retention factors between und-Leu-Arg and und-Leu-Na decrease. In fact, at pH of 11 the retention factors between both solutions may be said to be approximately equal.

This data may be looked at in concert with other studies looking at the effect of pH on the size and shape of amino acid based surfactant micelles. For these, it has been shown that at low pH's the hydrodynamic radii of amino acid micelles is smaller when arginine is used as a counterion as opposed to sodium. In fact, the size of the micelle when sodium is the counterion has been shown to be relatively constant with changes in pH while the size of the micelle decreases with an increase in pH when arginine is the counterion (24).

Both of these phenomena (changes in k' and micelle size) are likely due to changes in electrostatic attraction between the micelle and the counterion as a function of pH. As discussed previously, arginine has two amines with the α-amine having a pKa of ~ 9.8 and the side chain amine having a pKa of ~ 10.5. Therefore, at a pH of 9.8, the α-amine is around 50% neutral and at a pH of ~10.8 it has lost most (~90%) of its charge (24). The decrease in the positive charge on the α-amine causes a decrease in the overall electrostatic attraction between arginine and the negatively charged carbocyclic group on the und-Leu surfactant head group.

Also, it is significant that the retention factors for BNP at higher pH values are practically the same for both counterions because this fact indicates that the enhanced chiral selectivity obtained when arginine is the counterion is not due to an increase in k' but rather a change in the nature of interactions with BNP when arginine is the counterion. Also, this enhanced chiral selectivity brought on by the use of arginine as a counterion is likely due to the formation of chiral pockets rather than stronger direct chiral interactions between BNP and arginine. This possibility is supported by other results of this experiment showing that both L and D forms of arginine perform similarly as counterions. For both L and D forms of arginine (data not shown), there was shown to be no reversal of enantiomeric order nor a decrease in the enantiomeric resolution. Thus, it can be concluded that the increase in chiral recognition is not due to the chirality of arginine.

## CONCLUSION

Billiot et al. reported that enantiomers of BNP interact preferentially with the C-terminal of undecyl-leucine-leucine surfactants while enantiomers of BOH interact preferentially with the N-terminal of undecyl-leucine-leucine (22). Results of this study suggest that since BNP interacts closer to the surface of the micelle, arginine counterions affect chiral selectivity more than BOH enantiomers. Also, interactions between arginine and binapthyl analytes are not related to the chirality of arginine counterions since similar interactions were observed using D-arginine and und-Leu surfactants.

The results of this study also indicate that the use of arginine as a counterion may enhance the chiral separation of BNP in the presence of und-Leu. This finding supports previous studies indicating that the ionization state of an amino acid may cause charged analytes to preferably interact with such amino acid heads (6). As well, it is hypothesized that the charge of analytes effects locations where they interact on the molecule (22). Also, the variation of resolution with pH seemed to support previous findings indicating that micelle shape is highly affected by the acidity or basicity of the environment (24). This variation of shape is thought to affect micelles' ability to interact with analytes for the reason that surface area and stereochemistry are changed which may inhibit certain chiral or hydrogen to hydrogen interactions. In addition, the differing shape of micelles at different pH's may change the steric qualities of the micelle, and it has been documented in previous studies that steric factors are crucial to the interactions that precede chiral separation (7, 13, 20-21). To conclude, although arginine was demonstrated to be a better performing counterion for only the separation of BNP, it is significant that the chirality of arginine was found to have little impact on its performance as a counterion. This indicates that chiral interactions are not the most important basis for the chiral recognition of binapthyl derivatives by und-Leu. Further studies are needed to investigate the interactions that cause the enhanced chiral recognition of the negatively charged analyte BNP.

## ACKNOWLEDGEMENTS

## REFERENCES

Shamsi, S. A., Valle, B. C., Billiot, F., & Warner, I. M. (2003). Polysodium N -undecanoyl- l -leucylvalinate: a versatile chiral selector for micellar electrokinetic chromatography. *Anal. Chem.,* 75(3), 379-387.

Billiot, F. H., Thibodeaux, S. J., Billiot, E., & Warner, I. M. (2002). Enantiomeric separations using poly(l-

valine) and poly(l-leucine) surfactants. *J. Chromatogr. A, 966*(1-2), 179-186.

Billiot, E., Billiot, F. H., & Warner, I.M. (2008). Optimization of 12 chiral analytes with 8 polymeric surfactants, *J. Chromatogr. Sci., 46*(9), 757-763.

Billiot, F. H., Billiot, E., Ng, Y., Warner, I.M. (2006). Chiral separation of norlaudanosoline, laudanosoline, laudanisone, chlorothalidone, and three benzoin derivatives using amino acid based molecular micelles, *J. Chromatogr. Sci.*, 44(2), 64-69.

Yarabe, H., Billiot, E.J., & Warner, I.M. (2000). Enantiomeric separations by use of polymeric surfactant electrokinetic chromatography, *J. Chromatogr. A*, 875, 179-206.

Agnew-Heard, K. A., Peña, M. S., Shamsi, S. A., & Warner, I. M. (1997). Studies of polymerized sodium N -undecylenyl- l -valinate in chiral micellar electrokinetic capillary chromatography of neutral, acidic, and basic compounds. *Anal. Chem., 69*(5), 958-964.

Billiot, F. H., Billiot, E. J., & Warner, I. M. (2001). Comparison of monomeric and polymeric amino acid based surfactants for chiral separations. *J. Chromatogr. A., 922*(1-2), 329-338.

Haddadian, F., Billiot, E. J., Shamsi, S. A., & Warner, I. M. (1999). Chiral separations using polymeric dipeptide surfactants: effect of number of chiral centers and steric factors. *J. Chromatogr. A., 858*(2), 219-227.

Morris, K. F., Billiot, E. J., Billiot, F. H., Lipkowitz, K. B., Southerland, W. M. & Fang, Y. (2013). A molecular dynamics simulation study of two dipeptide based molecular micelles: effect of amino acid order, *Open J. Phys. Chem.*, Vol. 3 No. 1, , pp. 20-29.

Billiot, F.H., McCarroll, M., Billiot, E., Rugutt, J., & Warner, I.M. (2002). Comparison of the aggregation behavior of 15 polymeric and monomeric dipeptide surfactants in aqueous solution, *Langmuir* ; 18(8); 2993-2997.

Billiot, E. & Warner, I.M. (2000). Examination of structural changes of polymeric amino acid-based surfactants on enantioselectivity: effect of amino acid

order, steric factors, and number and position of chiral centers, *Anal. Chem., ,* 72, 1740-1748.

Rugutt, J.K., Billiot, E.J., & Warner, I.M. (2000). NMR study of interaction of monomeric and polymeric chiral surfactants with (R)- and (S)- 1-1'-binaphthyl-2-2'-diyl hydrogen phosphate, *Langmuir*, 3022-3029.

Haddadian, F., Billiot, E.J., Shamsi, S.A., & Warner, I.M. (1999). Chiral separations using polymeric dipeptide surfactants: effect of number of chiral centers and steric centers, *J. Chromatogr.*, 1999, 858, 219-227.

Billiot, E., Agbaria, R., Thibodeaux, S.J., Shamsi, S.A., & Warner, I.M. (1999). Amino acid order in polymerized dipeptide surfactants: effect on physical properties and enantioselectivity, *Anal. Chem.*, 71, 1252-1256.

Billiot, E., Thibodeaux, S.J., Shamsi, S.A., & Warner, I.M. (1999) Evaluating chiral separation interactions by use of diastereomeric polymeric dipeptide surfactants, *Anal. Chem.*, 71, 4044-4049.

Billiot, E., Thibodeaux, S.J., Macossay, J., Shamsi, S.A., & Warner, I.M. (1998). Chiral separations using dipeptide polymerized surfactants: effect of amino acid order, *Anal. Chem.*, 70, 1375-1381.

Morris, K. F., Billiot, F. H., Billiot, E. J., Lipkowitz, K., Southerland, W., & Fang, Y. (2013). A molecular dynamics simulation study of two dipeptide based molecular micelles: effect of amino acid order. *J. Phys. Chem*. www.scirp.org/journal/ojpc/

Tarus, J., Agbaria, R. A., Morris, K., Mwongela, S., Numan, A., Simuli, L., & Warner, I. M. (2004). Influence of the polydispersity of polymeric surfactants on the enantioselectivity of chiral compounds in micellar electrokinetic chromatography. *Langmuir,* 20(16), 6887-6895.

Billiot, F. H., McCarroll, M.C., Billiot, E.J., & Warner, I.M. (2004). Chiral recognition of binaphthyl derivatives using electrokinetic chromatography and steady-state fluorescence anisotropy: effect of temperature, *Electrophoresis*, 25(4-5), 753-757.

Thibodeaux, S.J., Billiot, E., Torres, E., Valle, B. C., & Warner, I. M. (2003). Enantiomeric separations using polymeric L-glutamate surfactant derivatives: effect of increasing steric factors, *Electrophoresis*, 24(6), 1077-1082.

Thibodeaux, S. J., Billiot, E., & Warner, I.M. (2002). Enantiomeric separations using poly(-valine) and poly(-leucine) surfactants; investigation of steric factors near the chiral center, *J. Chromatogr. A.*, Volume 966, Issues 1-2, 9 2002, Pages 179-186.

Billiot, F. H., Billiot, E. J., & Warner, I. M. (2002). Depth of penetration of binaphthyl derivatives into the micellar core of sodium undecenoyl leucyl-leucinate surfactants, *J. Chromatogr. A.* 950, no. 1-2: 233-39.

Lapidot, Y., Rappoport, S., & Wolman, Y. (1967). Use of Esters of N-hydroxysuccinimide in the synthesis of N-acylamino acids, *J. Lipid Res.*, 8 p. 142. doi:

Lewis, C., Hughes, B., Vasquez, M., Wall, A., Northrup, V., Morris, K.F., Billiot, F.H., Billiot, E.J., & Fang, Y. (2016). Effect of pH on binding of sodium, lysine, and arginine, *in press*.

**FIGURE 1.**

Structures of (a) und-Leu, (b) arginine, (c) BNP, and (d) BOH with pKa's labelled.
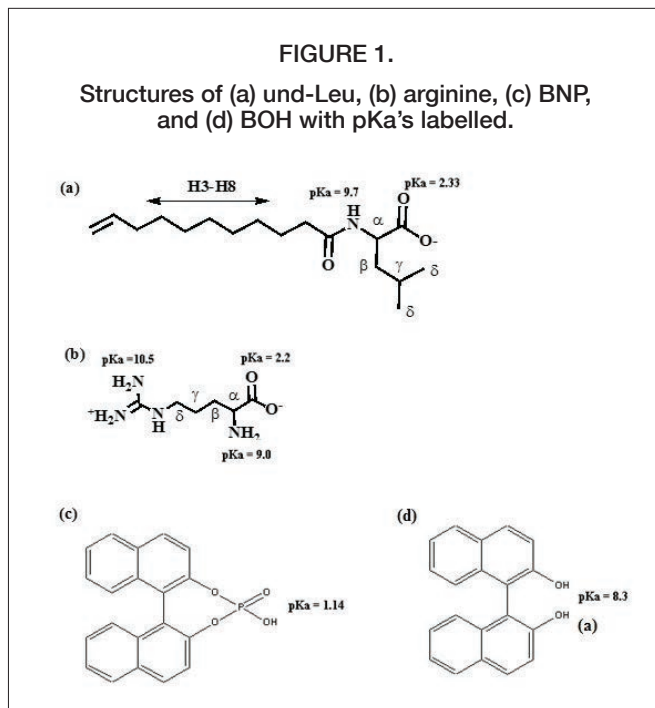


**FIGURE 2.**

Effect of concentration of und-Leu on the resolution of BNP with arginine as a counterion and at various pH's
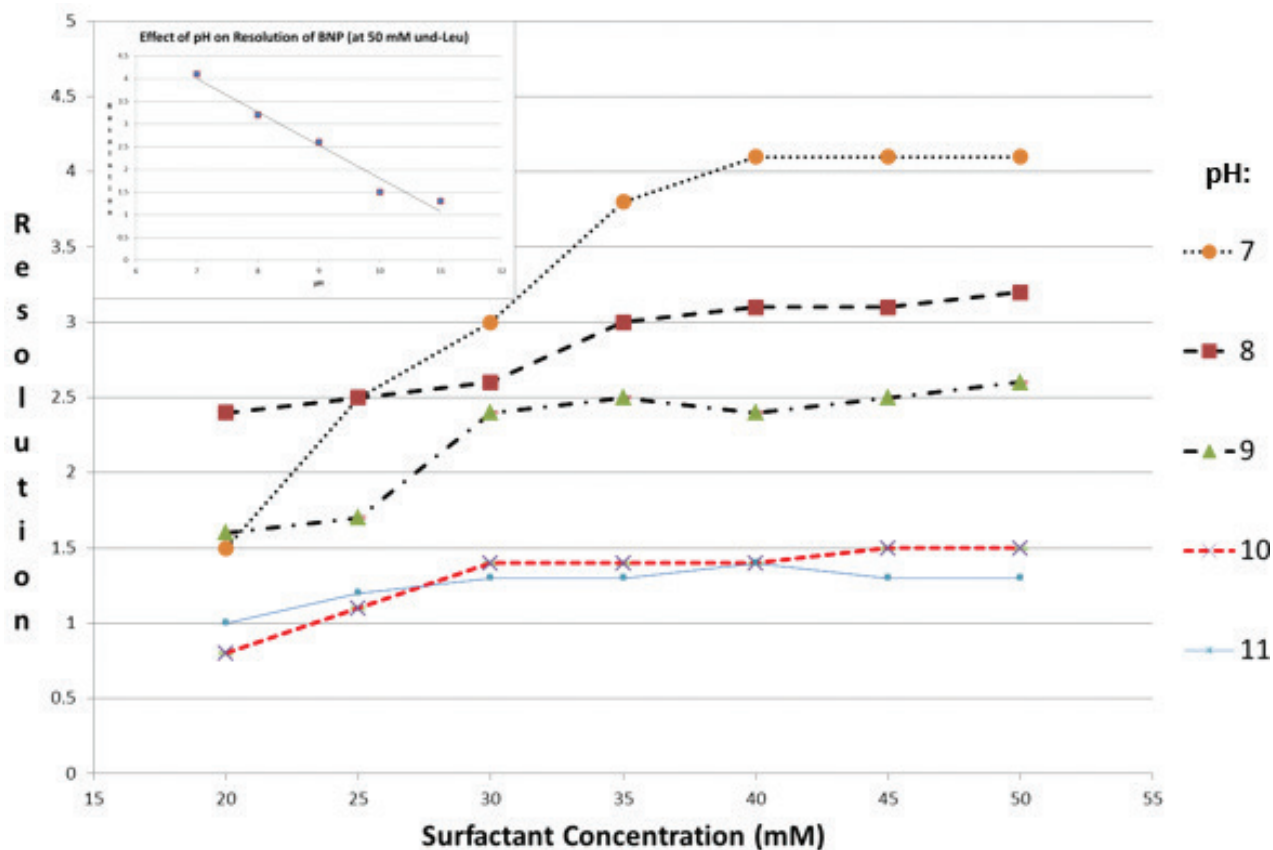
FIGURE 3.

The resolution of BNP enantiomers with the use of sodium and arginine counterions, at concentrations of und-Leu buffer ranging from 15 to 50 mM, and at pH's of 7 to 11. Detection was at 230 nm, applied voltage was at +30 kV.
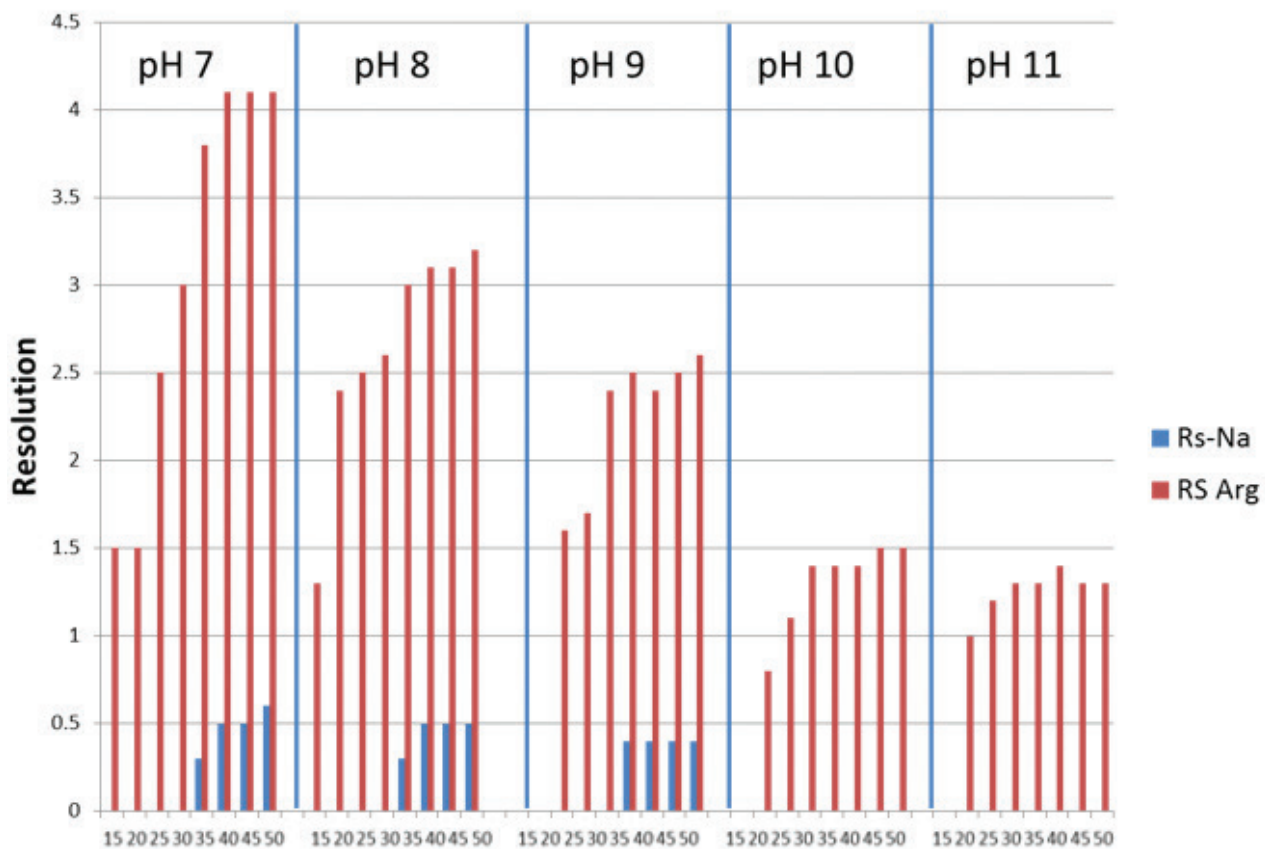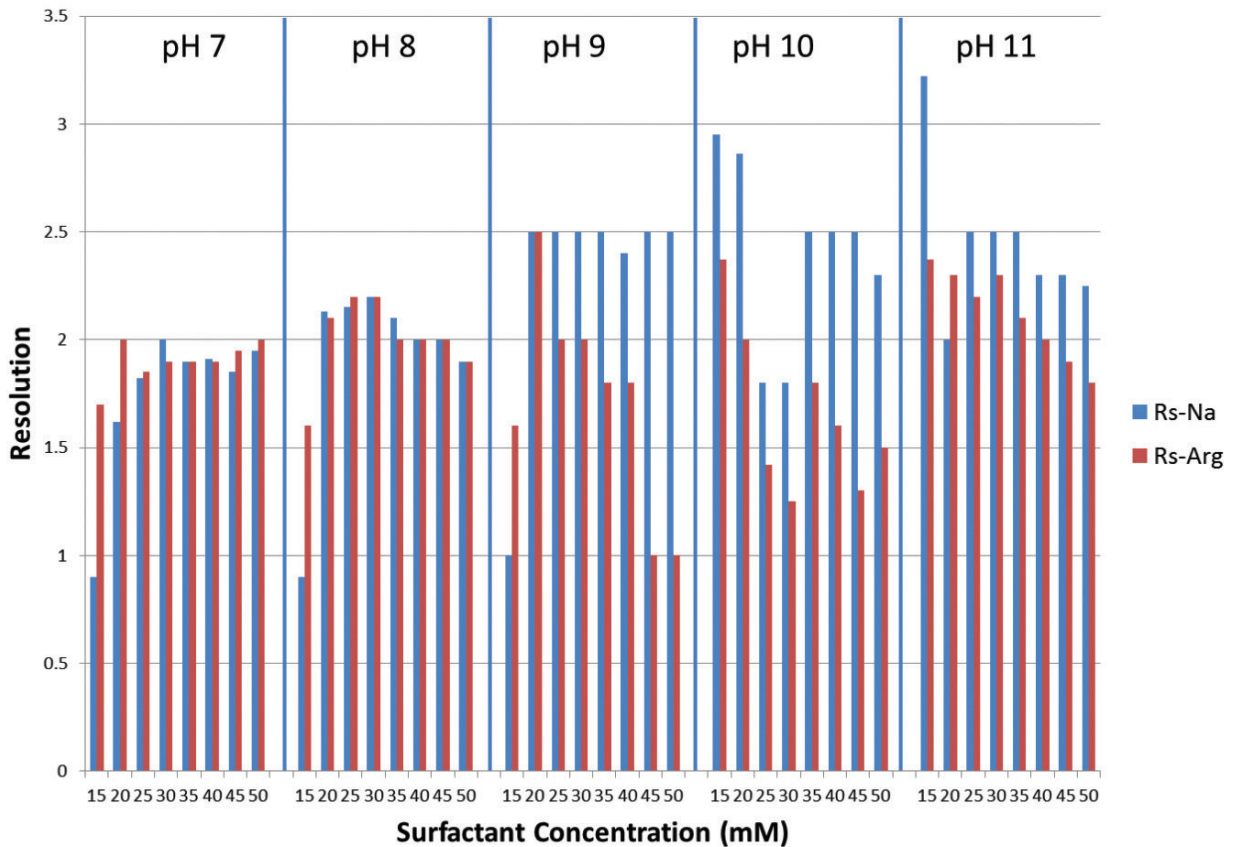
FIGURE 4.

The resolution of BOH enantiomers with the use of sodium and arginine counterions, at concentrations of und-Leu buffer ranging from 15 to 50 mM, and at pH's of 7 to 11. Detection is at 230 nm, applied voltage was at +30 kV.



FIGURE 5.

Comparison of k' (a) BOH (b) BNP with the use of sodium and arginine counterions, at concentrations of und-Leu ranging from 15 to 50 mM, and at pH's of 7 to 11. Detection is at 230 nm, applied voltage was at +30 kV.
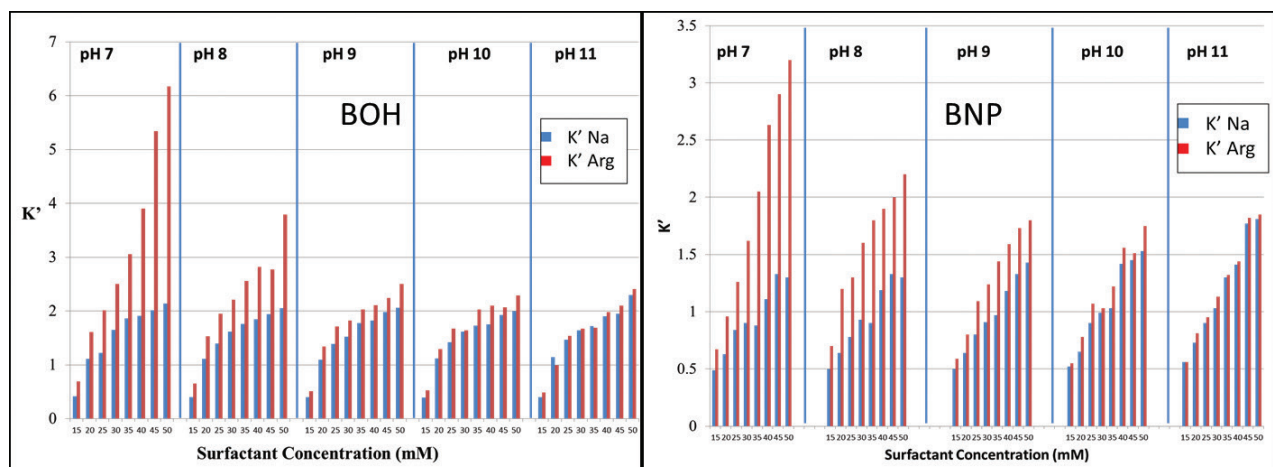
# I'M NOT SOME WEIRDO!: STIGMA MANAGEMENT AMONG CONSUMERS OF JAPANESE MEDIA

by ELISA A. SILVA

## ABSTRACT

*How do individuals deal with the stigma they are faced with? Do the strategies employed vary across subcultures? In this study, stigma and stigma management among the consumers of Japanese media will be analyzed. Stigma is the result of one's perceived blemished identity by others. It can be the result of a characteristic such as race, gender, health status, and a number of many other things. In the case of this study, it is the result of participation within anime culture—the culture which extends from simply watching anime and reading manga, to participating at conventions and cosplaying. In short, the stigma placed upon this culture results from uninformed outsiders' assumptions about what anime consists of, as well as the kind of people who participate in the culture. Those who face stigma often employ methods to cope, such as identity management. The participants of this culture were found to use the identity management method, avoidance, and the security provided by the anime community.*

Keywords: *anime, stigma, stigma management, manga, weirdo, nerd.*

## INTRODUCTION

How have consumers of Japanese media managed stigma? How do individuals deal with the stigma they are faced with? Do the strategies employed vary across subcultures? There has been much sociological work which has analyzed stigma and stigma management methods across various subcultures, with the exception of American consumers of Japanese media such as anime, manga, and music. The current study intended to explore the stigma management methods of this population.

*Identity and its Creation*

To understand why stigma occurs and why the individuals who face it employ methods to manage it, one must become familiar with the concept of identity, and the components that make up stigma and stigma management. One's identity serves to mark an individual's status within society, as well as to contribute to how an individual will experience the world around them. This in mind, what are the components that make up an individual's identity? Schwalbe and Schrock (1996) argued that one's identity within society is the

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result of a process that they referred to as *identity work*. This is the process by which a group or individual creates and utilizes the symbolism awarded to things such as music, clothing, and behaviors to convey the identity the individual wishes to present to other members of society. Put more simply, identity is the compilation of symbols an individual or group adopts to establish their standing within society. However, the concept of identity can be defined differently among other disciplines.

In the words of Schwalbe and Schrock (1996), identities could be created as a collective effort, and could also be taken on by an individual. Both are accomplished with the utilization of identity work. The first kind of work is achieved through the collective effort of constructing identities as widely understood signs with a set of rules and conventions for their use. The second and individual category of work constitute the use of the constructed signs, rules, and conventions by individuals to align themselves with a particular identity (Schwalbe & Schrock, 1996). Together both forms of identity work create a category of people (via the collective effort), and place individuals within the categories. It is only by having categories, and placing people into those categories, that we know how to interact with others within a particular social space. An example could be someone who is a member of a religious organization and a political organization. This individual, belonging to multiples social spheres, must categorize the people from each in order to keep a hold of what is both appropriate and inappropriate within each circle of interaction.

Goffman explains social identity as a tool to be used in categorizing people. Goffman (1963) argues that when confronted by a stranger, the appearance of the stranger allows us to make predictions about the category and attributes the stranger can be identified with. He continues by describing two concepts: a virtual social identity and an actual social identity. A virtual identity is a compilation of the normative expectations and beliefs that a person from a specific category *ought* to be. The actual social identity is often in opposition of an individual's *virtual* identity in cases of stigma because it is what causes the stigma. An individual's *actual* identity is made up of the attributes and the category that the stranger possesses in reality. Goffman states that sometimes when a stranger is present before an individual, signals can arise and put

the stranger in a less desirable standing within society. This new standing stems from the signals showcasing the stranger as possessing attributes different from their assumed group, and can result in appearing weak, morally corrupt, dangerous, and so on. This undesirable attribute, whatever it may be, then acts to reduce the person in the eyes of society, and becomes what is known as stigma (Goffman, 1963).

*The Need for Stigma Management*

As previously mentioned, when an individual displays attributes that are contrary to what their assumed identity should have, the individuals standing within society becomes blemished and stigma is created. Stigma affects some to the extent that they feel pressure to employ strategies to manage the stigma. For example, in their work, *The Social Cognition of Gifted Adolescents in Schools: Managing the Stigma of Giftedness*, Cross, Coleman, & Terhaar- Yonkers (2014), examine the stigma management strategies utilized among academically gifted adolescents. The group members' stigma stemmed from the contrast between the average (and therefore accepted) level of intelligence versus the gifted adolescents' perceived elevated level of intelligence. In the case of the gifted adolescents, the participants felt the need to fit in with the crowd of "normal" or "average" intelligence level, which could only be done when the students used methods that disguised their true academic ability (Cross et al., 2014).

*Summary and Rationale for Current Study*

Stigma management is a concept studied across many subcultures. For example, one study described the coping strategies of the Japanese Kyaba-Cula waitresses (Kamise, 2013). There, the researcher interviewed waitresses who were often seen by the public as deviant because of the assumed and unfounded sexual component of their work. The researcher then found that the waitresses controlled the stigma they faced by employing different techniques (Kamise, 2013). Studies such as these demonstrated to the public that many populations may presumably be at risk for being stigmatized. However, no work of this kind has been done among another group of people—the American consumers of Japanese media. The purpose of this study is to analyze the stigma the members of this population encounter, as well as to identify how these members manage the stigma. The analysis of the findings of this

### TABLE 1.
### Participant Demographics

| Participant | Age | Racial Identity | Gender Identity | Socio-Economic Background | Self-described level of dedication | Education Level | Field of Study |
|---|---|---|---|---|---|---|---|
| Kylie | 25 | Other | Female | Working Class | Low | Bachelor's Degree | Psychology |
| Courtney | 27 | White/ Native American | Female | Working Class | Low | Bachelor's Degree | Psychology |
| Katrina | 23 | White | Female | ** | Medium | Associates Degree | Studio Arts |
| Bruno | 23 | | Male | Working Class | Low | Undergrad | Mechanical Engineering |
| Jared | 22 | Mexican American | Male | Middle Class | ** | Associates Degree | Mechanical Engineering |
| Hank | 23 | Half white/ Half Filipino | Gender Fluid | Middle Class | Medium | Undergrad | Mechanical Engineering |
| Kennedy | 22 | Hispanic | Female | ** | ** | Bachelor's Degree | Psychology |
| Danna | | White | Female | Middle Class | ** | High School | N/A |
| Dacey | 25 | Hispanic | Female | Lower Middle Class | ** | Associate's Degree | Liberal Arts |
| Felix | 26 | Hispanic | Male | Middle Class | ** | High School | Electrician |

NOTE: Categories marked with ** symbolize categories the participants did not wish to be reported.

### TABLE 2.
### Experience with Stigma

| Category | Number of participants in category |
|---|---|
| Spoke on experiencing negative, positive, and neutral reactions | 10 of 10 |
| Employed some method of coping with stigma | 10 of 10 |

### TABLE 3.
### **Reported** Methods of Stigma Management

| Stigma Management Method Employed | # of participants who used this method |
|---|---|
| Information Control | 5 of 10 |
| Confrontation of Ignorance | 1 of 10 |
| Avoidance | 4 of 10 |
| Strength in numbers philosophy | 1 of 10 |
| Brushing it off | 2 of 10 |

study will contribute to the knowledge of stigma and its management within the field of sociology.

## METHODOLOGY

*Participants*

In order to qualify as a participant of this study, members must be consumers of Japanese media, including anime, manga, and music, as well as be at least 18 years old. Participants of the study were recruited through ads on the social media website Facebook and recruitment flyers posted around the Texas A&M University-Corpus Christi campus. Participants were both male and female, ranging in age from 20-27. Participants were selected due to their expressed interest in participating.

*Procedure*

Once selected, the researcher provided more info about the study and rights of the participants by presenting the participants with the consent form. The researcher then arranged meeting times for data collection with the participants. The interviews took place in locations

chosen by the participants to ensure their comfort. The researcher then audio-recorded semi-structured interviews that were later transcribed with pseudonyms given to the participants.

The average length of the interviews was about forty-five minutes. The questions focused on the differences between interactions with those within and outside of anime culture, how the participants cope with their stigmatized identity, as well as questions to understand the structure of the community.

## RESULTS & ANALYSIS

Upon completion of the interviews, the researcher transcribed each interview verbatim and analyzed the transcripts. The analysis came from the use of Glaser and Strauss's *Grounded Theory* (1967). This theory allows the study's assumptions to arise for themselves, from the process of interviewing and the answers the participants provide to the researchers.

## DISCUSSION

I initially anticipated that the participants would face mostly extreme negative reactions from outsiders of the culture once they realized the participants' consumptions. However, the current study instead found that the participants' experienced positive, negative, and neutral reactions. Even more interesting, the participants revealed that all three reactions came from no specific group, contrary to my assumption that there would be a model group of nay-sayers. For example, one individual may face negative reactions from their family members when they revealed consumptions that were seen as merely a quirk to another's family, and even a positive characteristic to yet another family. Such a finding would make sense once taking into account that what is perceived as "deviant" or "worthy of stigma" is heavily influenced by cultural background, socio-economic background, and religion. Through the process of analysis, it was found that the participants are all aware of the stigma attached to their anime consumptions. Though all had interesting accounts of both first-hand experiences with the stigma as well as how they dealt with it, the interviewees also provided insightful views as to what the stigma attached to their consumptions stems from.

Stigma occurs when an individual does or doesn't possess a trait that the society they inhabit expects of someone of their place within the society. In the case of the stigma connected to anime consumption, I was able to narrow the sources of the stigma to three general factors: cultural differences, the hentai assumption, and "nerd" tokenism.

*Cultural Differences*

In sociology, we know that exposure and representation are key in the process of normalizing a subject. Through research, it seems that although the anime culture has been steadily growing in popularity, exposure, and consumable media, it remains a culture that has not yet been mainstreamed for the majority of people. With the unfamiliarity that most people have of the culture, their ignorance allows outsiders to make unfounded assumptions about anime culture and its members. Without being part of a culture, there is a degree of effort that is required to understand elements within that given culture and in this case specifically, the anime subculture. As previously mentioned, anime has its roots within Japanese culture. Once released in Japan, fans and distributors work to create subtitles for consumption across the world, while some also have English dubbed versions created. When asked where she thinks the stigma stems from, Dacey replies,

> I think it's more because a lot of anime is not yet dubbed into English, and you have to read. A lot of people don't like to read.

Anime is sometimes comprised of cultural references that are used to enrich the stories. People within the Japanese culture have to exert little effort to understand such references being that they have a first-hand understanding. However, such culturally rich media could be arguably harder to understand when placed in a completely different culture. Dacey provides an example of a cultural reference in one anime,

> I think it's called *Inu X Boko SS*, it's really cool because they're all yōkai, which are Japanese demons, but they're like passed down from generations. They have a lot of cultural references.

In such an anime, a non-Japanese viewer who is unfamiliar with the folklore and symbolism surrounding

y kai, may have to exert a greater amount of effort in order to understand the anime's storyline.

*It's Not Tentacle Porn*

Aside from cultural differences, the anime subculture and its members face the difficulty of overcoming the "hentai" or "tentacle porn" assumption. For those unfamiliar with the term, hentai is defined as "a subgenre of the Japanese genres of manga and anime, characterized by overtly sexualized characters and sexually explicit images and plots" (Hentai 2016). To put it simply, shocking things gain traction and popularity quickly. However, most people do not understand that hentai is *only a subgenre* of anime—meaning there are other genres that are completely free of sexual undertones, as well as others that overlap with the subject on a minimal scale.

In the American culture, the topic of sex has only begun to become normalized with the sexual revolution of the 1960s. In such a short span of time, sex still remains a taboo subject—however it is one that people experience and discuss as if looking between the fingers that cover their eyes. With the gravity of its sensationalness, hentai somehow became the representative image of anime. Again, this is not the reality, and there are numerous members of the subculture that do not take part in this section of the culture. This graphic, stereotypical image, however inaccurate, is still the *only* image in some peoples' mind who have no further information on the subculture. For those who take offense to the topic of sex, such an image is enough to turn off the desire to learn more and give the culture a fighting chance. With such an image ingrained in a mind, anyone who associates themselves with the culture becomes subject to all the assumptions that the culture is plagued with.

*Nerdy Image*

Some of the participants stated they believe one component of the stigma is due to the *type* of people within the culture. Much like stereotypes, the characteristics of a small group of people belonging to the same group are enough to create a representative image for the entire population of the group. When asked where she thinks the stigma she faces stems from, Dacey replied,

> For a while when I was in High School, I didn't tell anyone I liked anime because I was scared that someone was going to be like, "She likes to watch anime porn!" There was a guy in High School and he was flat-out like, "Fuck yeah I watch anime porn" and automatically any person that was into anime liked anime porn.

Such an experience is a perfect example of the kind of tokenism that keeps the participants of the culture feeling ostracized from society as well as what allows outsides to ostracize them.

*Stigma Management Techniques*

As many studies have found, those in a lower and stigmatized position in society tend to employ different methods to manage their stigma. In this particular study, the researcher found the participants to use the methods of identity management, avoidance, the strength in numbers philosophy as well as brushing it off. The data showed that some participants made use of multiple techniques.

*Identity Management*

Many studies have found that a common practice in managing stigma is to manage the identity one puts out in the world. Stigma comes from a person's perceived lowered status in society. In order to effectively manage the stigmatized identity, one is essentially managing the ability of the outside world to see the attribute that causes their stigma. In this case, all participants spoke on employing one or more techniques of managing stigma. Five participants spoke on the identity management method. Similar to some of the other methods that will be discussed, this method can be executed in various ways. The extent of information management, among other things, includes managing the type of conversations one has with both members of the culture and outsiders. When asked how interactions between himself with members of the culture differ from interactions with those who don't participate in the culture, Bruno replied,

> I'll ask a question in general, and if they say yes or no, I'll go from there. If they say yes, I'll ask what anime's they watch, and if they say no, I'm like, "Why?"

With this statement, Bruno demonstrates himself changing the conversation according to whether or not the person he is interacting with participates in the culture. Another participant, Kennedy, when asked how she interacts with people who respond negatively to her consumptions, she responded,

Usually with people like that, there's no way to change their mind about it, because at that point, they've already established the stigma that it's weird; but maybe I won't talk to them about it, or around them.

*Avoidance*

The second most commonly reported method, at four of ten participants, was avoidance. In relevance to this study, avoidance is the deliberate action of avoiding people that the participants feel may react negatively to news of their consumptions. When asked how the participants cope with the stigma, the first participant to mention use of this method, Courtney states,

I hang out with people who also enjoy [anime culture] so that minimizes it; just getting away from people who I know are going to say something negative, or who have said something negative about it—just don't bring it up and choose to hang out with people that I know like it.

Here the participant states that keeping those around her limited to those with more positive views of the culture "minimizes" the stigma she faces. This statement seemed to encase the sentiment of other participants employing the same method.

*The Strength in Numbers Philosophy*

Other than the intended findings related to stigma and stigma management, I found that this subculture had a much more in-depth sense of community than originally thought. Another method of coping with the stigma is through use of the social security net that the community provides. As previously mentioned, participants within the culture sometimes use their love of anime and manga as a bonding bridge to connect with other people. In this same realm of social interaction, the members of the group can use these bonds and mutual interests to support themselves and assure themselves that they are not so strange after all. When asked how

they respond to people who feel negatively about their consumptions, Katrina responded,

Well as a kid it bothered me and made me feel weird, even in high school. As I've gotten older, and I've noticed this with my friends too, we're just like "Who cares?" You get to the point where you're like, "Obviously I like it, and it's not that weird if a ton of other people like it; I'm not some weirdo!"

Some participants stated they are presently facing more neutral rather than negative reactions for their consumptions. However, four out of ten participants stated they faced more stigma while in their youth. Of this sample group, many also stated that this was the reason they did not have a deeper level of dedication to the culture. In other words, the participants encountered their first anime on their own, either through TV or some other way, but then realized that it was not a common consumption—in some cases others who were more open about the consumption were severely chastised. Next, the need to keep the consumption hidden hindered the participants' abilities to find more anime, as well as find others who also participate in the culture.

As previously mentioned, for most participants, the early years of their participation were kept hidden. This being the case, their participation in the culture was strictly an individual hobby. However, coming to college and finding others who participate allowed for a sense of community to develop. There are plenty of popular conventions that some participants said they go to solely to make friends and be exposed to new anime. The interactions with those who also participate are described as being very different than with those who do not. Some participants reported feeling as though they could relate to others they find to share their consumptions more than those who don't, even if they feel the culture is not a big part of their life.

## CONCLUSION

Anime culture is still a fairly new one, with its popularity continuously growing with every new anime and manga series produced. According to the participants of the study, members of the culture enter into it because of their appreciation for art style, Japanese culture, along with their desire for complex and unpredictable story

lines. So why is it that a culture full of things to be appreciated receives unfounded negative assumptions and stigma from outsiders of the culture? This research has found three main contributors to anime culture's stigmatized image: cultural differences, the hentai assumption, as well as "nerd tokenism."

Initially, it was my belief that the participants within anime culture would have faced harsh amounts of stigma for their consumptions. Instead, I found that for the most part, the participants faced mostly neutral reactions. However, for those that have experienced the effects of the stigma their consumptions bear, this research has provided several strategies to cope with it: identity management, avoidance, and finding security in the growing population of the culture.

The contributions of this research study include breaking down the causes of stigma for a specific subculture, as well as bringing to light the stigma management methods employed by some of its participants. In this study, I found the participants used some of the standardized techniques of stigma management, such as identity management, as well as some unique techniques like using the anime community to find the confidence to brush off negative responses and to boost their own social lives. It was this ability that is the most interesting, however, because essentially the participants are recreating a positive image of themselves and of others from an identity that was initially stigmatized. In the future, I hope to improve the study by reaching out to a larger number of participants and asking more in-depth questions about the environmental conditions when they faced the harsher amounts of stigma.

## REFERENCES

Cross, T. L., Coleman, L. J., & Terhaar-Yonkers, M. (2014). The Social Cognition of Gifted Adolescents in Schools: Managing the Stigma of Giftedness. *Journal for The Education Of The Gifted*, 37(1), 30-39.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago: Aldine Pub.

Goffman, E. (1963). *Stigma: Notes on the Management of Spoiled Identity*. New York, NY: Simon & Schuster.

Hentai. (n.d.). Dictionary.com's 21st Century Lexicon. Retrieved August 30, 2016 from Dictionary.com website http://www.dictionary.com/browse/hentai

Kamise, Y. (2013). Occupational stigma and coping strategies of women engaged in the commercial sex industry: A study on the perception of "kyaba-cula hostesses" in japan. *Sex Roles, 69*(1-2), 42-57. doi:http://dx.doi.org/10.1007/s11199-013-0293-0

Schwalbe, M. L., & Mason-Schrock, D. (1996). Identity Work as Group Process. *Advances in Group Processes, 13*, 113-147.

# INTEGRATION OF A SUPERCONTINUUM LASER WITH A HYPERSPECTRAL IMAGING SYSTEM

by SHANE W. SMITH

## ABSTRACT

*Supercontinuum lasers are broad-band lasers, as opposed to single or narrow-band lasers, allowing the examination of various media for optical characterization at multiple wavelengths. A hyperspectral imaging system (HIS) is an instrument with a camera and spectrometer, which generates 3D data cubes containing both spectral (frequency or wavelength) and spatial (picture-like) information. When combined with a hyperspectral imaging system, a supercontinuum laser (SCL) can be used as a light source for generating images and spectra for the analysis of materials and media. Before any light source can effectively be used, it must be characterized and normalized.*

*The purpose of this research is to investigate 1D spectral and 2D spatial profiles of the supercontinuum laser using the HIS in the Hyperspectral Optical Property Instrumentation Laboratory (HOPI Lab) at TAMU-CC. To characterize the laser with the hyperspectral imaging, two sets of experiments were conducted in reflection mode. In the first set of experiments, the laser power setting was kept constant, and camera integration time was altered. The second set of experiments involved capturing hyperspectral data cubes of the laser beam at altering laser power settings, but constant camera integration time.*

*The laser spectral profiles showed similar trends with varying camera integration times; however, changes in the gradient of the line joining two dominant local peaks were observed, particularly at maximum laser power setting. Gradient change was not as prominent at lower laser power settings. As the laser power intensity and camera integration times were increased, spreading of the spatial 2D laser beam profile was also observed. Due to a large number of photons reaching the imager, the data was saturated at high laser power settings and long camera integration times. Filters suitable for the wavelength range of the laser must be utilized to avoid saturation and still obtain useful signals using the laser and HIS.*

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## INTRODUCTION

The goal of this research is to characterize a supercontinuum laser (SCL) beam spatially and spectrally using different hardware and software settings to determine the optimum combination of parameter values for consistent and quality image acquisition.

Identifying and implementing appropriate hardware to interface the SCL with the hyperspectral imaging system (HIS) for high quality images have also been investigated in this work.

*Problem Statement*

Supercontinuum lasers are broad-band lasers as opposed to single or narrow-band lasers, thus allowing the examination of various media for optical characterization in engineering and scientific applications at multiple wavelengths [1],[2]. Both traditional and supercontinuum lasers are subjects of continuing basic and applied research [3]-[6]. Due to the high laser power rates at various wavelengths, and particularly the peak wavelength, as well as the issues regarding the delivery and capture of the laser beam spot that required hardware interfacing and integration, there has been a challenge in the acquisition of hyperspectral images under uniform illumination from the SCL. The purpose of this research was to investigate methods to increase the quality of images acquired with the SCL and hyperspectral imaging camera. For quality imaging, uniform illumination of samples are significant. The research involved characterization of the supercontinuum laser beam spot to investigate the optimum hardware parameters for the SCL and hyperspectral imaging for capturing quality images.

*Background*

Hyperspectral imaging (HSI) involves the tools and skills for the acquisition and analysis of data cubes through a hyperspectral imaging system and hardware that interfaces to a computer, which then allows data capture through a software tool [7]. Computer-controlled data acquisition and viewing offers the extraction of multiple image frames at different wave bands from hyperspectral data cubes. Hyperspectral imaging is a fast-growing field in the optics and photonics industry. Its application in the field of remote sensing for spatial/spectral imaging and analysis has allowed researchers to identify then differentiate various specimens or materials from the collected data cubes [7]-[12]. The hyperspectral imaging system used in this study is a benchtop system consisting of a 14-bit camera that responds to wavelengths within 400-1000 nm, a spectrophotometer that separates white light into wavebands within this spectral region, and a

horizontal moving stage that allows spatial data to be stitched from spectral frames [13]. A motorized vertical stage has been developed and added to the system by previous undergraduate researchers in the HOPI Lab to allow semi-automated focusing through a computer controlled software interface.

In previous studies, a broadband halogen light bulb had been used as the illuminator for the hyperspectral imaging system. In reflection mode, the illuminator is on the same surface as the sample viewed by the camera lens, collecting diffusely reflected light from a sample surface after the incident light interacts with the sample [13]. This is a relatively low-powered light source and has been demonstrated to produce results that are not visually uniform across the imaged frame as its spectral response appears to fluctuate at different intensity levels [13]. SLC will replace the current light source with a more uniform white broadband light source suitable for imaging smaller areas of samples.

Supercontinuum laser has multiple wavebands that can be separated through hyperspectral imaging at narrow bandwidths, as mentioned before. Supercontinuum lasers are part of technology that is still developing due the nature of broadband laser generation [10], [14], [15]. The SCL used in this research is commissioned for spectral bandwidth of 420-2400 nm. The supercontinuum light is coupled to a nonlinear device and transferred to the site of interest via a fiber optic cable which is the best fit for this research since no outside irradiation can dampen the results. The use of SCL will enable the researchers in the HOPI Lab to observe materials at different frequencies of the electromagnetic spectrum, exposing their properties at the related wavelengths [16].

## EQUIPMENT

In this section, instruments used in the experiments are explained.

*Supercontinuum Laser*

The supercontinuum laser used in the experiments (Leukos SM-100) is a Class IV laser that produces a non-pulsating beam pattern. The beam is generated from an aperture connected to a fiber optic cable whose output consists of broadband of light between 420 nm and 2400 nm. The pulse repetition rate is listed as 125

**FIGURE 1.**

Hyperspectral image system with supercontinuum laser in reflection mode
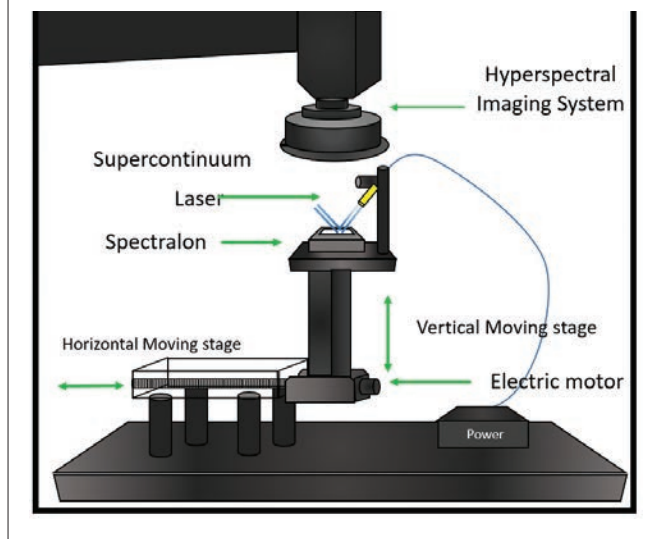
kHz with a peak at 1064 nm. Special safety goggles are used in all experiments specially designed to reduce the laser power that could potentially reach the eye, particularly at the peak wavelength of the laser.

*Hyperspectral Imaging System*

The Hyperspectral Imaging System in the HOPI Lab was acquired from Headwall Photonics (Hyperspec™ VNIR P-Series Imaging Spectrometer, Headwall Photonics, Fitchburg, MA) and further developed in the lab for computer-controlled focusing capability. The HIS has been used in multiple research areas using an LED ring light [13],[17],[18]. The camera possesses a silicon-based imager which responds to light energy within 400 nm and 1000 nm, hence limiting the data analysis range to 420 nm to 1000 nm. The camera's silicon-based imager's efficiency is low, producing low-contrast 2D images, or noisy spectral response, around 400 and 1000 nm fringe wavebands requiring data normalization to enhance small changes that can be captured in the hyperspectral data cubes. One way to adjust data quality is through controlling the amount of photons that reaches the imager by changing the camera's integration time that determines the imager's exposure time to photons.

The data acquisition system can be seen in Figure 1.

## METHODS

Data acquisition, as well as data viewing and analysis are explained in this section.

*Data Acquisition*

Hyperspectral data cubes were acquired with the bench-top hyperspectral imaging system with the SCL shining on the top surface of the sample in reflection mode. The hyperspectral imaging camera was first adjusted for focus using a standard which includes a set of accurately separated fine bars and numbers to assess the clarity of the images that are taken. The focusing process is necessary, since different samples can be at different heights and therefore distance from the camera, affecting the clarity of the image that falls on the imager. Focusing was achieved by adjusting the vertical stage the standard is placed on until the standard image appears clearest.

The next step involved imaging two different reference panels that were to be used to normalize the data later on. The first reference panel was an optically homogenous gray panel. The second reference panel was Spectralon© standard with high reflectivity in the measured wavebands. Additionally, dark images were also collected by turning the SCL off. The purpose of the dark images was to assess the HIS's dark noise without any input light. After focusing and collecting the dark images, SCL beam spot is captured with different camera integration time and laser power settings.

The first set of experiments were conducted at six camera integration times (50, 100, 150, 200, 250, 300 ms), which were repeated for multiple laser power settings (3000, 3500, 4000, 4500, 5000, 5500, 5600 au). Then the experiments were repeated at fixed integration times and changing laser power settings. It is noted here that 5600 au is the maximum laser power setting recommended by the manufacturer of the SCL to ensure maximum laser bandwidth generation; however, since the hyperspectral imaging in the HOPI Lab is sensitive to the lower range of the spectrum, the experiments were also expected to reveal the need, or the lack thereof, for the use of maximum laser power level.

All experiments were conducted in a dark-room environment to avoid any stray light entering the hyperspectral imaging system beyond the controlled illuminator, which, in this case, was the supercontinuum laser.

**FIGURE 2.**

Selecting region of interest in captured images. Red box represents a 10 x 10 window (in pixels) where spectra are extracted, and average spectrum is computed.



*Data Viewing and Analysis*

After the hyperspectral data cubes were collected, the spatial and spectral data were extracted, viewed and analyzed using software tools such as ENVI 5.1, MATLAB R2015 and MS Excel 2013.

Data normalization was achieved through the software tools ENVI 5.1 and MS Excel 2013. Normalization involved dividing the original image by the lowest intensity measured after the dark image was subtracted from each using Equation (1).

$$I_n = \frac{I - I_d}{I_l - I_d}, \quad .................................................. (1)$$

In this equation $I$ is the measured image (raw data with laser beam on), $I_d$ is the dark image obtained with all lights off, $I_l$ is the lowest intensity image obtained with the lowest camera integration time (in this case 50 ms), and $I_n$ is the normalized image. Normalizing the data in ENVI involved selecting the spatial region of interest from the hyperspectral images as shown in Figure 2. The spectral data corresponding to the selected area were then extracted.

## DATA AND RESULTS

In this section, the data collected from with the supercontinuum laser using the hyperspectral imaging system are presented with associated results.

*2D Spatial Representation of Laser Beam*

The 2D SCL beam profiles were obtained using the ENVI 5.1 software tool by representing the hyperspectral images as an RGB image. In RGB images, only three bands are used with a true color filter to represent what the human eye perceives as a colored image. The hyperspectral imaging system generates 811 bands, or

spectral data points, resulting in 811 image frames. The results of experiments with changing camera integration times from 50 ms to 300 ms, and constant laser power settings at 3000, 4000, 5000 and 5600 au are shown in Figure 3. In Figure 3, the laser is incident on the Spectralon© standard, which is over 99% reflective in the spectral range of the camera. Black represents low intensity ranges or the background, whereas white and various bright colors represent highest pixel intensity values from areas illuminated by the laser beam spot. The laser beam spot appears oval instead of circular because the beam hits the surface of the standard at an oblique angle, and the horizontal and vertical size of each pixel is not square due to the selected incremental distance covered by the horizontal moving stage which can change 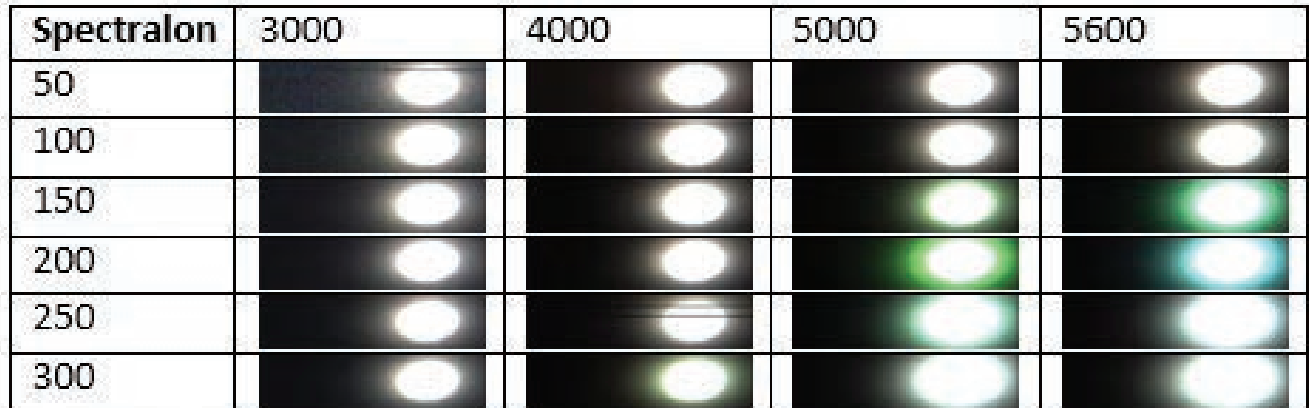the aspect ratio of the images. Figure 3. 2D RGB supercontinuum laser beam profiles at increasing camera integration times from 50 ms to 300 ms, and at four SCL power settings of 3000, 4000, 5000 and 5600 au. In this experiment, the SCL beam was incident on a Spectralon© standard reference.

The experiments were repeated using an optically homogenous photograph-quality gray panel which had about 18% reflectance in the wavelength range of the camera. Figure 4 shows the corresponding beam profiles on gray reference panel with the same experimental settings for images as in Figure 3.

In Figure 3 qualitative analysis of SCL beam profiles on Spectralon© show beam spreading in both horizontal and vertical direction above SCL power setting of 3000 au. At 4000 au, the beam spreading becomes apparent after camera integration time is increased beyond 250 ms. At 5000 au, beam profiles demonstrate spread after 150 ms of integration time. Similar results are obtained for laser power setting of 5600 au although the beam profile, particularly at 150 ms, appears larger in 5600 au setting than at 5000 au setting.

In Figure 4, beam spreading is not observed. This is expected because gray panel does not reflect as highly as Spectralon© does.

*Spectral Representation of Laser Beam*

Figures 5 and 6 show the average raw (original, non-normalized) and normalized spectra from laser power settings of 3000, 3500, 4000, 4500, 5000, and 5500 au at five camera integration times from 100 to 300 ms. Spectra acquired at 50 ms are not shown, as these

FIGURE 3.

2D RGB supercontinuum laser beam profiles at increasing camera integration times from 50 ms to 300 ms, and at four SCL power settings of 3000, 4000, 5000 and 5600 au. In this experiment, the SCL beam was incident on a Spectralon© standard reference.



FIGURE 3.

2D RGB supercontinuum laser beam profiles at increasing camera integration times from 50 ms to 300 ms, and at four SCL power settings of 3000, 4000, 5000 and 5600 au using a gray reference standard on which the SCL beam was incident.
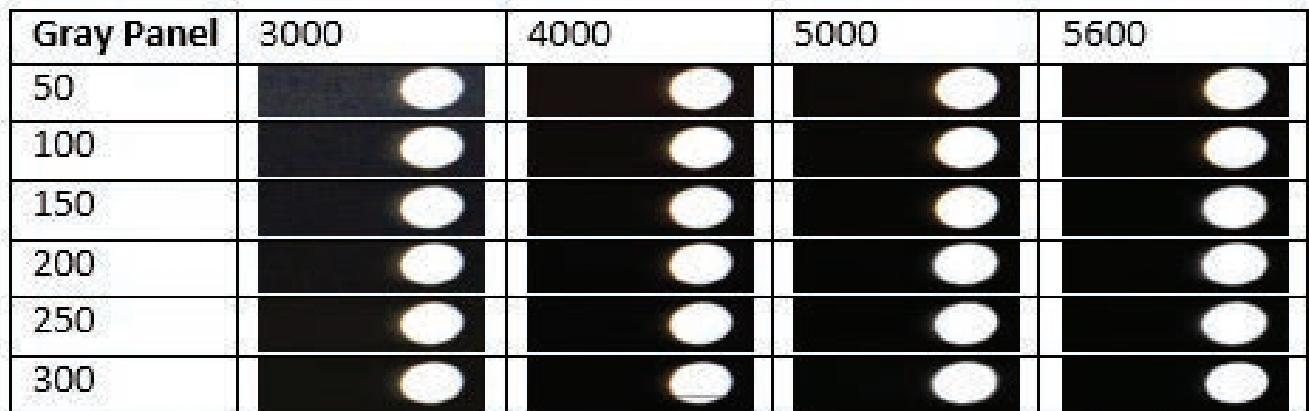
spectra are used as a reference in the normalization process.

Figures 5 and 6 show that spectra are greatly correlated at fixed laser power settings. Shifts in two dominant local peaks can be observed among spectra obtained at different laser power settings. Similarly, higher reflected laser intensity is apparent in spectra from Spectralon© compared to those obtained from the gray panel.

It is also apparent that within each fixed laser power setting, the gradient of the two dominant local peaks also show changes as the camera integration time increases. Both results suggest non-linear response of the SCL/HIS at different laser power levels and camera integration times.

SCL beam spectra obtained from Spectralon© show saturation at SCL power settings of 5000 au and beyond when camera integration times exceed 300 ms. These results suggest that for highly reflective materials, hyperspectral imaging system's integration time should not be set at more than 300 ms when laser power settings are high, more specifically, 5000 au or above.

FIGURE 5.
Raw (original) average spectra (left column) and normalized average spectra (right column) obtained from Spectralon© at increasing laser power settings and camera integration times.

## FIGURE 5. (cont.)

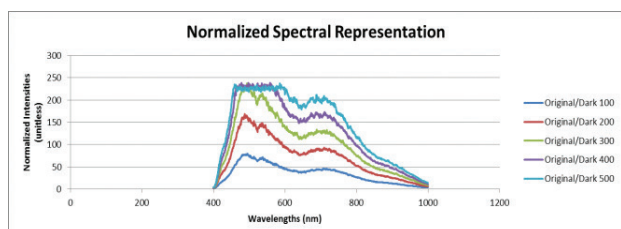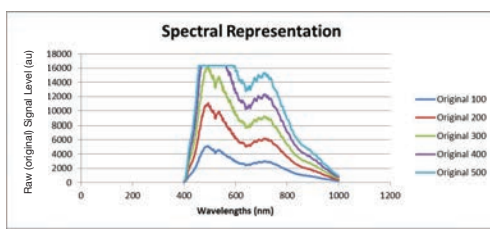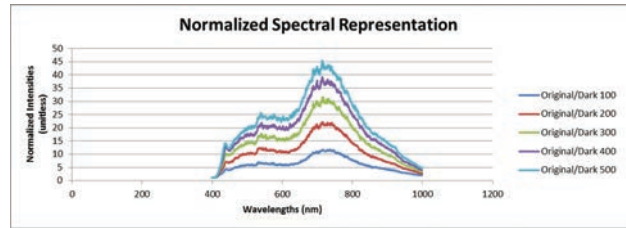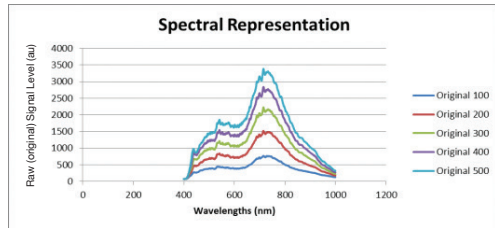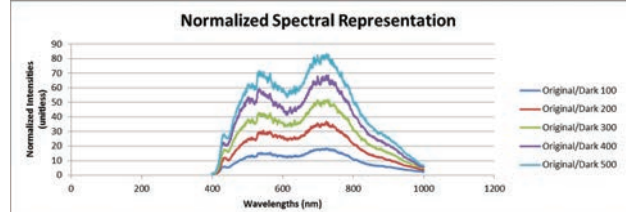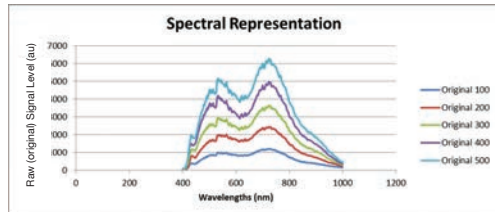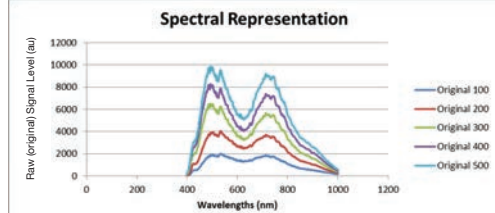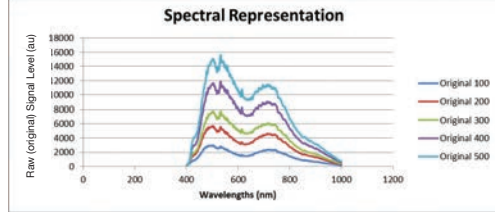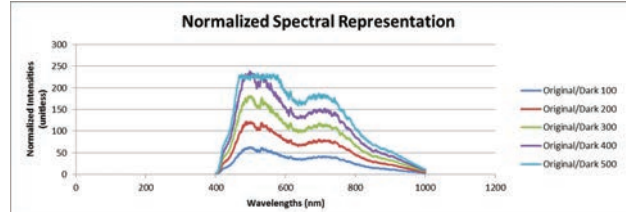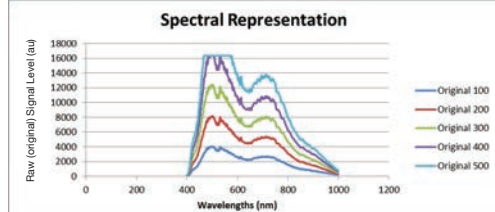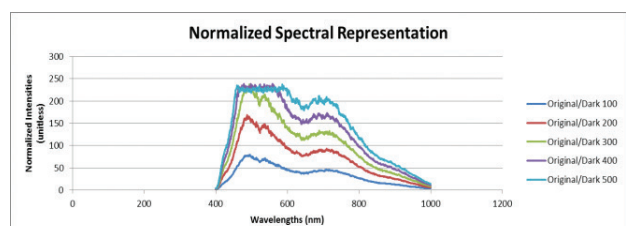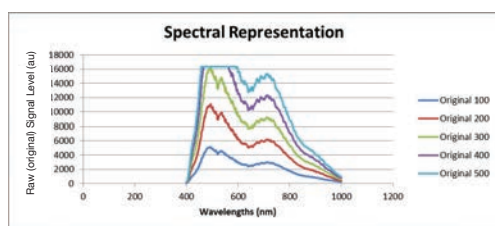| Super-continuum Laser Power Setting (au) | Raw Spectral Response from Gray Panel | Normalized Spectral Response from Gray Panel |
|---|---|---|
| 3000 | | |
| 3500 | | |
| 4000 | | |
| 4500 | | |
| 5000 | | |
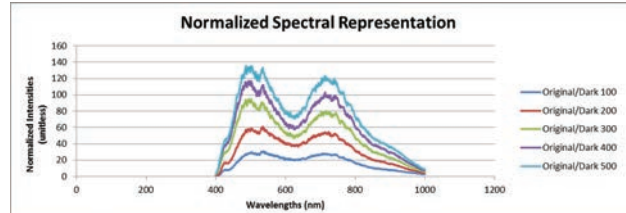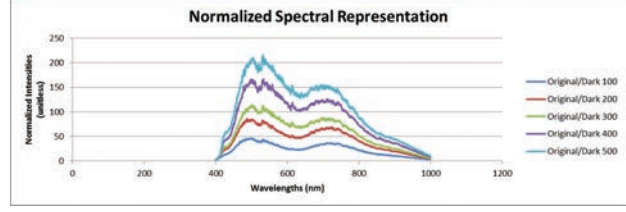


## FIGURE 6.
Raw (original) average spectra and normalized average spectra at different laser power settings with increasing camera integration times using the gray panel.

| 5500 | | |
|---|---|---|

## SUMMARY AND CONCLUSION

The purpose of this research was to characterize the spatial and spectral properties of the supercontinuum laser with the hyperspectral imaging system and determine optimum system parameter settings to obtain high-quality data using the SCL as a light source.

The 2D beam profiles demonstrate spatial spreading with increased number of photons reaching the camera imaging sensor. This spreading is more obvious in images obtained from the highly-reflective Spectralon©. In spectral profiles, the gradient of the line joining the two most prominent local peaks change at different settings. This change was more prominent when the laser power setting was higher than 5000 au for the highly-reflective Spectralon©.

Spatial and spectral profiles obtained from hyperspectral data cubes demonstrate that the supercontinuum laser is a suitable light source for the hyperspectral imaging system at higher laser power settings from 4000-5500 au, as long as the hyperspectral imaging camera integration time is set to a level that will not cause saturation in the data. It has been observed that the higher the laser power setting the lower the noise level. Similarly, the higher the integration time, the lower the noise in the signals. The optimum laser power setting and camera integration time is therefore the highest possible combination of the two that does not cause saturation in the data.

We conclude that laser power setting and camera integration time should be kept constant across all experiments to ensure consistent experimental results that can be compared within and across experiments. The data must also be normalized to remove multi-system variations. The optical properties of the analyzed sample should be kept in mind before starting experiments to ensure laser power setting and integration time do not need to be changed during experiments.

Future work involves the use of the laser as a light source to image different samples and materials of interest in multiple applications. For the available hyperspectral imaging system, maximum laser power setting does not appear to be necessary, although it is recommended by the manufacturer. As a solution to saturation problems, filters can be used to prevent saturation of data at high power and integration time settings.

## ACKNOWLEDGEMENT

## REFERENCES

[1] Chen, Y. C., Winful, H. G., and Liu, J. M. (1985). Sub-harmonic bifurcations and irregular pulsing behavior of modulated semiconductor lasers. *Applied Physics Letters*, *47*(3), 208.

[2] Chodos, A., and Ouellette, J. (2005). "Einstein Predicts Stimulated Emission" APS News *American Physical Social Sites*; Web. 25 Feb.2016.

[3] Fu, D., Holtom, G., Freudiger, C., Zhang, X., and Xie, X. S. (2013). Hyperspectral imaging with stimulated Raman scattering by chirped femtosecond lasers. *The Journal of Physical Chemistry B*, *117*(16), 4634-4640.

[4] Matthews, M. (2015). Simulating laser-material interactions. (cover story). *Laser Focus World*, *51*(8), 33-38.

[5] Mihalcea, R. M., Baer, D. S., and Hanson, R. K. (1998). A diode-laser absorption sensor system for combustion emission measurements. *Measurement Science and Technology*, *9*(3), 327.

[6] Wu, K., Veitch, P., Munch, J., & Ottaway, D. (2014). Suppression of self-pulsing in Tm:YAlO lasers via current feedback. *Applied Physics B: Lasers & Optics*, *114*(3), 415-419. doi:10.1007/s00340-013-5535-x

[7] Smith, R. B. (2012). Introduction to Hyperspectral Imaging. *Microimages, Inc.*.

[8] Yuen, P. W. T. and Richardson, M. (2010). An introduction to hyperspectral imaging and its application for security, surveillance and target acquisition. *The Imaging Science Journal, 58*(5), 241-254.

[9] Martin, G. and Plaza, A. (2012) Spatial-Spectral Preprocessing Prior to Endmember Identification and Unmixing of Remotely Sensed Hyperspectral Data. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing,* vol. 5, 380-395.

[10] Kaasalainen, S., Lindroos, T., and Hyyppä, J. (2007). Toward hyperspectral lidar: Measurement of spectral backscatter intensity with a supercontinuum

laser source. *Geoscience and Remote Sensing Letters, IEEE, 4*(2), 211-215.

[11] Schuerger, A. C., Capelle, G. A., Di Benedetto, J. A., Mao, C., Thai, C. N., Evans, M. D., and Stryjewski, E. C. (2003). Comparison of two hyperspectral imaging and two laser-induced fluorescence instruments for the detection of zinc stress and chlorophyll concentration in Bahia grass (Paspalum notatum Flugge.). *Remote sensing of environment*, *84*(4), 572-588.

[12] Chen, Y., Nasrabadi, N. M., Tran, T. D. (2011). Hyperspectral Image Classification Using Dictionary-Based Sparse Representation. *IEEE Transactions on Geoscience and Remote Sensing*, *49*(10), 3973-3985.

[13] Mehrubeoglu, M. (2012). Spectral Characterization of a Hyperspectral Imaging System Using Optical Standards. *Proc. 2012 IEEE International Conference on Imaging Systems and Techniques*, 136-129. doi:10.1109/IST.2012.6295579

[14] Gražulevičiūtė, I., Skeivytė, M., Keblytė, E., Galinis, J., Tamošauskas, G., and Dubietis, A. (2015). Supercontinuum generation in YAG and sapphire with picosecond laser pulses. *Lithuanian Journal Of Physics*, *55*(2), 110-116.

[15] Hundertmark, H., Kracht, D., Wandt, D., and Fallnich, C. (2003) Supercontinuum generation with 200 pJ laser pulses in an extruded SF6 fiber at 1560 nm. *University of Bath. Claverton down, Bath.* Revised Nov. 13. 2003. Web. Accessed Feb. 26. 2016.

[16] *Supercontinuum* Generation, *Encyclopedia of Laser Physics and Technology*. 04 Apr. 2016. https://www.rp-photonics.com/supercontinuum_generation.html

[17] Mehrubeoglu, M., Smith, D. K., Smith, S. W., Strychar, K., and McLauchlan, L. (2013). Investigating coral hyperspectral properties across coral species and coral state using hyperspectral imaging. *Proceedings of SPIE*, vol. 8870, 88700M.

[18] Mehrübeoglu, M., Nicula, C., Trombley, C., Smith, S. W., Smith, Shanks, S. E., and Zimba, P. V. (2015). Mapping pigment distribution in mud samples through hyperspectral imaging. *Proc. SPIE 9611, Imaging Spectrometry XX,* 961106. doi:10.1117/12.2190059.

## APPENDIX

Acronyms

au or a.u. – arbitrary units

HSI – Hyperspectral imaging

HIS – Hypers

SCL – Supercontinuum Laser

# HUB OF THE CLASSROOM OR JUST A PLACE TO STORE BOOKS?: AN ANALYSIS OF ELEMENTARY CLASSROOM LIBRARIES

by STEPHANIE TIET

## ABSTRACT

*The purpose of this study was to take a closer look at classroom libraries to find out how teachers in two South Texas schools set up and utilize their libraries. Thirteen teachers responded to a Classroom Library Survey, which asked them to self-report details of their libraries, such as the number, genre and level of books, library organization and set up, and how their libraries are used. Following the survey, the researcher visited seven of the thirteen teachers' classroom libraries after school hours, and used a Classroom Library Checklist to report on the actual content of the libraries. The findings revealed some inconsistencies between the surveys and checklist data. The results of this study will help pre-service teachers and in-service teachers create classroom libraries that will enhance daily literacy instruction.*

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## INTRODUCTION

Shoulders hunched over books, lively conservations about a funny character, and friendly book recommendations are activities that one might see in a classroom library. Classroom libraries are important because they can be tools to foster voluntary reading. According to Applebee, Langer, and Mullis (1988), classrooms that showcase well-designed libraries have children who "interact more with books, demonstrate more positive attitudes toward reading, choose reading as a leisure time activity, spend more time reading, and exhibit higher levels of reading achievement" (as cited in Fractor, Woodruff, Martinez, & Teale, 1993, p. 480). However, teachers are not given an instruction manual that details how to create a well-designed classroom library, such as what size it should be, how it should be organized, or how to involve students in its creation. Thus, classroom libraries vary from classroom to classroom, as some may be larger, more organized, or used by students more than others. With so many different forms of classroom libraries out there, how can pre-service and in-service teachers know how to set up an effective classroom library? The purpose of the study was to take a closer look at classroom libraries and find out how teachers in South Texas set up and utilize their libraries.

## LITERATURE REVIEW

*More than a Just a Bookshelf*

A classroom library is much more than a place to store books. It is "an effective instructional tool" that provides students with "the necessary tools and strategies" they need to improve their reading (Catapano, Fleming, & Elias, 2009, p. 71). Diller (2003) points out that the classroom library should not be a quiet place and recommends that teachers encourage students to engage with the area through the following activities: creating a poster to showcase a favorite author, participating in literature circles, reading to stuffed animals, and writing book reviews. Catapano et al. (2009) suggest introducing students to text selection strategies such as using the "five finger rule" to select a book at their independent reading levels by skimming book covers and illustrations as well as being aware of the font size and the number of words on a page. Hartley (2008) adds that "students [can] monitor and support their own reading [by] using strategies like predicting, asking questions, rereading for meaning, and making connections" (p. 74). Another way teachers can utilize the classroom library as an instructional tool is by teaching students to care for their library by assigning relevant jobs (Catapano et al., 2009; Pytash, 2012). These jobs might include "book doctors," "reshelvers, bin checkers, and book reviewers that can be rotated among students and will help reduce the time required for the teacher to spend on the managing the classroom library" (p. 69). In addition to instituting jobs, Diller (2003) recommends that students who have these jobs regularly share their observations with the rest of the class (as cited in Catapano et al., 2009). Fractor et al. (1993) advise allowing students to name the classroom library. For instance, one teacher's kindergarteners named their library "The Book Nook" which allowed them to feel as if it was their own personal library (Fractor et al., 1993). Students can also be involved in the process of choosing books for their library by voting on new ones that should be added (Catapano et al., 2009; Hartley, 2008; Pytash, 2012). Opening the classroom library to students is imperative because it builds a sense of community in the classroom, serves as an instructional tool, and offers a sense of ownership.

*Components of a Complete Classroom Library*

Simply placing books on bookshelves does not make an effective classroom library. According to Young and Moss (2006), "having great books in the classroom is not enough to entice students to read them" (p. 211). To launch a library, Young and Moss recommend that the area of the classroom where the library is housed must be inviting, easily accessible, and cozy. The library needs to have enough space to fit several children (Fractor et al., 1993). This way, students will be able to engage in meaningful conversations about what they are reading, thus creating a "community of readers" (Fractor, et al., 1993, p. 478). Furthermore, Fractor et al. (1993) suggest that the library have "boundaries [that] set apart the library area from the rest of the classroom" to give students the nestled atmosphere they need to enjoy their books (p. 478). While the size of the classroom library is important, Catapano et al. (2009) declare that it is the "decoration and organization of the library that make all the difference" (p. 63). Teachers might use pillows, stuffed animals, rugs, bean bags, chairs, posters, and book jackets for decorations. These artifacts create a warm, bookstore-like ambiance. Shelving books with their spines facing out might save space (Fractor et al., 1993); however, displaying books with their "covers visible [allows] for easy selection" (Catapano et al., 2009, p. 66). Additionally, teachers might consider devising a list of rules and procedures to ensure that the library will be used efficiently, such as implementing an easy check-out system and return bins for the books.

There are several ways to categorize books in classroom libraries, although most who have written about the topic advise that books be grouped together by topics and genres and organized into bins that are labeled or color-coded (Catapano et al., 2009; Sanacore, 1995). Fountas and Pinnell (2001) also propose "organizing [books] by…theme, author, series, and special features (e.g., awards, class favorite, books they have read aloud)" because this "teach[es] students 'how to think about books'" (as cited in Catapano et al., 2009, p. 67). Moreover, Catapano et al. (2009) stress including "books that are culturally relevant to the lives of students in the classroom [and have] characters similar in age to students in the classroom who share experiences they have had can be critical for generating interest

and fostering self-to-text connections" (p. 61). Brassell (1999) recommends featuring books in students' home languages, as well as magazines, newspapers, and books that the students themselves have written. Multicultural books and nonfiction books are also a must have in the library according to Lao (2005) and Young and Moss (2006). The point here is to build a classroom library that contains a wide variety of texts that are relevant to the children who reside in that classroom.

*The Powerful Rewards of a Classroom Library*

Students reap rewards by using books that are at their fingertips. Young and Moss (2006) state that "students who have ready access to books in their classrooms have better attitudes about reading, reading achievement, and comprehension than their peers with less access to books in the classroom" (p. 207). Pytash (2012) found that "access to the classroom library began to change the students' perceptions of themselves as literate members of their community" (p. 33). Moreover, Anderson, Wilson, and Fielding (1988) note a correlation between standardized reading test scores and the amount of reading students do (as cited in Young and Moss, 2006). They specify that nonfiction books in the classroom library help "expose students to text types found on standardized tests," which helps students score higher (Young, Moss, & Cornwell, 2007, p. 2). Perhaps the greatest and most powerful reward that ensues from a classroom library is that students are exposed to many different kinds of texts.

*Out of the Paycheck and into the Classroom Library*

So where do classroom library books come from? As one can imagine, teachers spend a lot of money out of their own pockets to purchase books (Lao, 2005). School libraries are better funded; however, there is usually little money available for purchasing books for classroom libraries (Young & Moss, 2006). Lao also mentions that teachers spend their own money for the following reasons: to provide a wide variety of books in the classroom, to put books in the hands of students who do not have access to them at home, and to meet students' specific interests and reading levels. Teachers are not the only ones who spend their own money. According to Catapano, Fleming, & Elias (2009), pre-service teachers also start collecting books for their classroom libraries long before they finish their teacher preparation programs. Motivated teachers who understand the importance of students' access to books and want to grow their classroom libraries give the gift of literacy to their students each year by spending their own money on books.

## METHODS

This study employed a mixed methods design, in which both quantitative and qualitative data are collected simultaneously in order to "provide a comprehensive analysis of the research problem" (Creswell, 2014). The researcher used collected data from survey responses (quantitative data) and the classroom library checklists (quantitative and qualitative data) to determine the ways in which teachers in a small South Texas school district house and use their classroom libraries.

## PARTICIPANTS

*Survey Participants*

A survey was sent to 45 teachers who are employed at two schools in a small South Texas school district. These two schools were chosen because the researcher had volunteered as a tutor in both and had developed working relationships with the principals of both schools and several of the teachers. The researcher visited with the teachers in both schools after school hours to provide them with information about the study, the survey, and the classroom library visits. Thirteen teachers responded to the survey, resulting in a 28.8% response rate. All respondents are female and have taught in the classroom for several years (See Table 1 for the demographic information of teachers responding to the survey). Seven teach at a primary school (School A) that serves approximately 480 pre-kindergarteners, kindergarteners, and first graders, and six participants teach at an elementary school (School B) that serves approximately 498 second, third, and fourth graders.

*Classroom library visit participants.*

Of the thirteen teachers who responded to the survey, nine teachers supplied their emails and agreed to allow the researcher to visit their classroom libraries. The researcher contacted these teachers via email to set up dates and times for visits and seven teachers responded (see Table 2 for the demographic information of teachers participating in classroom library visits).

**TABLE 1.**
Demographics and percentages of the classroom library survey respondents.

| Characteristic | Number | Percentage |
|---|---|---|
| Gender | | |
| Female | 13 | 100 |
| Male | 0 | 0 |
| Number of Years Taught | | |
| First year | 0 | 0 |
| 2-5 years | 2 | 15 |
| 6-10 years | 3 | 23 |
| 11-15 years | 3 | 23 |
| 16-20 years | 1 | 8 |
| More than 20 years | 4 | 31 |
| Grade(s) Taught | | |
| K | 4 | 31 |
| 1 | 3 | 23 |
| 2 | 2 | 15 |
| 3 | 0 | 0 |
| 4 | 4 | 31 |
| Content Taught | | |
| Reading | 2 | 15 |
| Language Arts | 3 | 23 |
| Math | 1 | 8 |
| Science | 0 | 0 |
| Social Studies | 0 | 0 |
| Art | 0 | 0 |
| Music | 0 | 0 |
| English | 0 | 0 |
| All subjects | 7 | 54 |

**TABLE 2.**
Schools, grade level, and content taught of the seven teachers from the classroom library visits.

| Teachers | School | Grade Level | Content Taught |
|---|---|---|---|
| 1 | A | 1 | All subjects |
| 2 | A | K | All subjects |
| 3 | A | 1 | All subjects |
| 4 | B | 4 | Reading |
| 5 | B | 4 | Reading |
| 6 | B | 2 | English Language Arts |
| 7 | B | 2 | All subjects |

## DATA COLLECTION

*Survey.*

The Classroom Library Survey was developed by Drs. Bethanie Pletcher and Christie Warren and was piloted during this study (see Appendix A). Three experts in the field of reading instruction reviewed the survey for content validity, and several changes were made based on their recommendations. The survey asked teachers to consider the materials in their classroom libraries, such as the quantity and types of books available. Furthermore, the teachers were asked to consider the organization and general use of their libraries. An email with a link to the electronic survey was sent to the teachers, and they completed the survey online through Qualtrics, an electronic survey tool.

*Classroom library visits.*

The last question of the survey invited teachers to type in their email addresses if they were interested in allowing the researcher to visit their classroom libraries. The researcher visited seven classrooms after school hours and used a checklist to make notes about the classroom libraries (see Appendix B). The checklist includes the same items teachers were asked to consider on the electronic survey. Moreover, the checklist allowed the researcher to confirm some of the survey results. The researcher also received verbal consent from those teachers to take photos of their classroom libraries to consider later when adding to the checklist notes.

## DATA ANALYSIS

The researcher gathered survey responses from Qualtrics, an online survey program, and reviewed the results. Next, the checklists and notes from the classroom library visits were numbered and matched with corresponding photographs. Then, the data from the checklists was coded similar to that of the survey responses and recorded into a new set of tables. Lastly, the researcher compared the survey responses and checklists and looked for similarities and differences.

*Ethical Considerations*

Participation in the electronic survey was voluntary. An information page was attached to the survey detailing the scope of the study as well as consent information. All information collected from the survey and classroom visits was confidential. The teachers' names, names of

**TABLE 3.**
Results of the classroom library survey concerning the physical features of the teachers' classroom libraries.

| Survey Questions | Number | Percentage |
|---|---|---|
| Designated Space for Library | | |
| Yes | 12 | 92 |
| No | 1 | 8 |
| Enough Space for Three to Four Students | | |
| Yes | 10 | 77 |
| No | 3 | 23 |

**TABLE 4.**
Researcher's checklist results regarding the physical features of the visited classroom libraries.

| Checklist Criteria | Teachers | | | | | | |
|---|---|---|---|---|---|---|---|
| | School A | | | School B | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Designated Space for Library | Yes | Yes | Yes | No | No | Yes | Yes |
| Enough Space for 3-4 Students | Yes | Yes | Yes | No | No | Yes | Yes |

schools, and the name of the district are not mentioned in this report. Participation in this study did not affect the teachers' professional standings with their district or schools in any way.

*Trustworthiness*

Two types of data have been collected for this study to ensure its trustworthiness. Data collected from the classroom library visits was compared to the survey results. The researcher also asked a faculty mentor to view the classroom library checklist information in relation to the survey data as a form of peer review.

## RESULTS

*Physical Features of the Classroom Libraries*

Lao (2005) maintains that well-designed classroom libraries encourage students to read on their own, so the physical features of libraries are crucial in drawing in readers and most importantly, making them want to stay and read. Classrooms need to have a designated space for the library. According to Fractor et al. (1993), this means that it should be private and separate from the rest of the classroom. Looking at the Classroom Library Survey results, as seen in Table 3, twelve out of thirteen teachers reported that they have a designated space for their library in their classroom. These survey results, however, did not reflect what was found in the Classroom Library Visit Checklist. Of the seven classrooms visited, two did not have a designated space specifically for their libraries (see Table 4). The other five classrooms had libraries that were a focal point of the classroom and contained colorful rugs, lamps, chairs, pillows, stuffed animals, and shelves. Some classrooms

even included more decorative items like bean bags and rocking chairs. These items helped to carve out a space that was separated from the rest of the classroom. Additionally, by using such items in the classroom library, the teachers made the library attractive and relaxing. This was not seen in the other two classrooms where bookshelves were placed in various places in the classroom and, as a result, there was not a centralized place for a classroom library.

Additionally, a classroom library should have enough space for at least three or four students to gather (Fractor et al., 1993). As shown in Table 3, ten teachers indicated on the survey that their classroom libraries permitted room for this number of students. The survey results somewhat matched what was discovered during the classroom library visits. The same teachers who did not have a designated space for their library also did not have a designated place for students to gather near the classroom's books. The set-up and decor of the classroom library is crucial in creating a place for students to gather (Fractor et al., 1993; Lao, 2005), and a majority of the teachers have taken that into consideration.

*Organization of the Classroom Libraries*

Having an organized classroom library can help students easily and quickly locate books. According to Catapano et al. (2009), "books can be grouped in various ways, depending on the developmental level of the students in the classroom" (p. 66). The survey asked the teachers to take a close look at their libraries and identify how their books were grouped: by genre, reading level, author, and/or topic. Seven teachers indicated that they categorized their books by genre or topic. Five other

**TABLE 5.**
Researcher's checklist results regarding the organization of the visited classroom libraries.

| Checklist Criteria | Teachers | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | School A | | | School B | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| How Books are Organized | | | | | | | |
| Genre | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Reading Level | ✔ | | ✔ | | | | |
| Author | ✔ | | ✔ | | | | |
| Topic | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ |
| Shelves or Tubs are Labeled | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Book Covers Displayed Forward * | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

NOTE: A majority of the book covers in all of the teachers' classrooms were displayed facing forward in tubs/bins.

**TABLE 6.**
Results of the classroom library survey concerning the organization of the teachers' classroom libraries.

| Survey Questions | Number | Percentage |
| --- | --- | --- |
| Books Organized By * | | |
| Genre | 3 | 25 |
| Reading Level | 0 | 0 |
| Author | 0 | 0 |
| Topic | 4 | 33 |
| Other | 5 | 42 |
| All the above | 3 | 25 |
| Genre, author, and topic | 1 | 8 |
| Genre, level, topic | 1 | 8 |
| Shelves or Tubs in Library are Labeled | | |
| Yes | 9 | 69 |
| No | 4 | 4 |
| Significant Number of Books Displayed with Covers Facing Forward | | |
| Yes | 10 | 77 |
| No | 3 | 23 |

NOTE: *There are only twelve participants who responded to this question.

teachers responded to the question by saying that they organized their books by using a combination of genre, topic, and author categories. The varied responses from the survey were somewhat consistent with what the researcher recorded in the Classroom Library Visit Checklist in that a majority of the seven teachers visited organized their books by genre and topic (see Table 5).

Another measure to ensure that a classroom library is organized for students is to physically organize the above categories for easy selection. "Stead (2002) recommends using separate baskets, shelves, or tubs to hold books groups by various topics" (as cited in Young & Moss, 2006, p. 211). In addition, teachers might clearly label the tubs or shelves to help students select texts. As shown in Table 6, 69% of the teachers surveyed reported that their shelves or tubs are clearly labeled. These results supported what the researcher observed during the classroom library visits, as all seven teachers had their shelves or tubs labeled (see Table 5). Some of the teachers used easy-to-read labels that featured playful clipart that corresponded with the bin's content.

Displaying books with their covers facing forward is important because it captures the students' attention and entices them to choose something to read (Fractor et al., 1993; Hartley, 2008; Young

et al., 2007). According to the Classroom Library Survey results, ten teachers responded that they displayed a significant number of books with covers facing forward. Indeed, during visits to classroom libraries, the researcher observed that the books in all seven of the classroom libraries were displayed in this manner. This matched 100% of the teachers' responses to this question on the survey (see Table 6). The results indicated that a majority of teachers see the importance of organizing the classroom library, thereby making it easier for children to access books.

*A Variety of Texts at Students' Fingertips*

Another consideration for teachers as they build their classroom libraries is featuring a variety of texts that will meet students' interests and encourage them to read new books. The survey asked participants to identify the kinds of reading materials available in their classroom libraries (see Table 7). During visits, the researcher found that a majority of the teachers' libraries contained

### TABLE 7.
Results of the classroom library survey concerning the information about the texts in the teachers' classroom libraries.

| Survey Questions | Number | Percentage |
|---|---|---|
| Kinds of Reading Material | | |
| Picture Storybooks | 9 | 69 |
| Chapter books | 3 | 23 |
| Magazines | 0 | 0 |
| Big Books | 0 | 0 |
| Other reference materials | 1 | 8 |
| Reading Materials Matches the Content Taught | | |
| Yes | 13 | 100 |
| No | 0 | 0 |
| Library Contains Books at Different Reading Levels | | |
| Yes | 13 | 100 |
| No | 0 | 0 |
| Number of Books in Library | | |
| 10-50 | 1 | 8 |
| 50-100 | 2 | 15 |
| 100-200 | 2 | 15 |
| 200-500 | 2 | 15 |
| 500-1000 | 3 | 23 |
| 1000 or more | 3 | 23 |
| Percentage of Books Published within the Last Ten Years | | |
| 0 to 10% | 1 | 8 |
| 11 to 25% | 0 | 0 |
| 26 to 50% | 6 | 46 |
| 51 to 75% | 4 | 31 |
| 76% to 100% | 2 | 15 |
| Reading Material in Good Condition | | |
| Yes | 13 | 100 |
| No | 0 | 0 |

### TABLE 8.
Researcher's checklist results regarding the available texts in the visited classroom libraries.

| Checklist Criteria | Teachers | | | | | | |
|---|---|---|---|---|---|---|---|
| | School A | | | School B | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Kinds of Books | | | | | | | |
| Picture Storybooks | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Chapter Books | | | | ✔ | ✔ | ✔ | ✔ |
| Magazines | ✔ | | ✔ | ✔ | | ✔ | ✔ |
| Big Books | ✔ | | | | | | |
| Other reference materials | ✔ | | | ✔ | ✔ | ✔ | |
| Genres of Books | | | | | | | |
| Realistic Fiction | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Fantasy | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Historical Fiction | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Nonfiction | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Poetry | ✔ | | ✔ | | ✔ | ✔ | ✔ |
| Other | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ |
| Books at Different Grade Levels | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Reading Material Matches Content | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Approximate Number of Books | 800-1,000 | 300-500 | 1,000+ | 900-1,000 | 800-1,000 | 800-1,000 | 1,000+ |
| New vs Old Books | | | | | | | |
| New | 30 | 15 | 40 | 20 | 30 | 20 | 45 |
| Old | 70 | 85 | 60 | 80 | 70 | 80 | 55 |

different reading levels to meet the needs of all students. All in all, the study revealed that the teachers' classroom libraries had a variety of texts to assist them in meeting the needs and interests of their students.

*Quantity and Quality of Texts*

The survey also asked the teachers to report the approximate number of books they have in their classroom libraries, as well as their overall condition. Teachers indicated on the survey that their libraries held anywhere from ten to over one thousand books. After counting books in seven of these libraries, the researcher estimated that the libraries held anywhere from 300 to 1000+ books. Interestingly, "Allington and Cunningham (2002) suggest that primary-grade classrooms should have between 700 and 750 titles and upper-grade classrooms should have 400 titles" (as cited

a variety of texts, such as picture storybooks, chapter books, magazines, and other reference materials. Moreover, the researcher examined the genres of books readily available in the seven classroom libraries. Refer to Table 8 for the genres featured in these classroom libraries. Furthermore, the survey and checklist results indicated that all of the libraries contained books that matched the content they taught, as well as books at

in Lao, 2005, p. 180). Based on the number of books collected from the survey and checklist, more than half of the classroom libraries meet these requirements.

Although the amount of books teachers have in their classroom libraries is important, the condition and relevance of those books is equally important. The inclusion of new and relevant texts in the library sparks reading in classrooms because books that represent current topics or trends might appeal to students more than books that were written years ago. A teacher from Lao's (2005) study declared, "I feel that I need good texts as models for my students for good reading and writing. New books are always coming out that appeal to the interest of the readers and writers in my room" (p. 185). When teachers were asked on the survey what percentage of their books were published within the last ten years, the majority reported that 0% to 50% of their books were published within the last ten years. While visiting the classrooms, the researcher estimated the percentage of books that were new and old. This assessment revealed that a majority of the teachers' books were old. Furthermore, all thirteen teachers reported on the survey that their books were in good condition; however classroom visits indicated inconsistent results for books considered old and new.

*The Library is Open*

When asked if their students know how to use their classroom libraries, 85% of the teachers indicated that their students do. Catapano et al. (2009) stressed that students should learn how to use the library so they can build a sense of ownership of it and understand responsibility. The survey also questioned how often the students use their classroom libraries, and 85% of the teachers reported that their students use them once or twice per day. It is interesting to note that two of the teachers responded that their students use the library once or twice per month and once or twice per week. All thirteen teachers surveyed indicated that they allowed regular blocks of time for their students to read the material in the classroom library. A classroom library is more than a bookshelf, so by involving students in the library, they are not only learning but are becoming a part of a community of readers.

*Stocking the Classroom Library*

Many of the teachers who participated in this study reported that their classroom library holds hundreds of books. So the question is, how do they acquire them? According to the survey, six teachers (46%) attained their books from bookstores, public libraries, the school library, and garage/rummage sales. According to Lao (2005), most of the books featured in classroom libraries are bought by the teachers themselves. There are several reasons teachers use their own money to buy books for their students, such as meeting students' specific needs, updating the reading materials, and supporting classroom instruction. Perhaps a more significant reason teachers spend their own money is because they understand the importance of reading practice. In Lao's (2005) study, one teacher revealed, "I wanted [my students] to understand that I wasn't just 'preaching' about the importance of books but I wanted them to actually see that I thought it was so important that they read that I was willing to spend my own money to get them adequate reading material" (p. 187).

## DISCUSSION

The classroom library is more than just a compilation of books that are stored on shelves and in bins that take up space in classrooms. Here, students engage in meaningful conversations over books, discover new books, and share books with peers. This study prompted thirteen teachers to take a closer look at their libraries and will help them and other teachers consider several aspects of classroom libraries, such as the setup, organization, and text variety. Teachers who do not have classroom libraries can also learn of their importance and how students might benefit from having access to them. This study also revealed that teachers customize their libraries to meet the needs of their students. A kindergarten classroom library in School A for instance, only featured picture storybooks, while a fourth grade classroom in School B had an assortment of texts, such as chapter books, magazines, reference materials, and picture storybooks. After visiting several classrooms, it was clear that the teachers understand that having an inviting classroom library encourages students to "book-shop." Some of the teachers emulated bookstores by decorating their libraries with colorful rugs, stuffed animals, and comfortable chairs. They also used the bookstore technique of showcasing books by facing their covers forward to catch students' attention.

Moreover, pre-service teachers, like the researcher, can begin developing a critical eye for how to build and maintain a complete classroom library. Both pre-service and in-service teachers will be encouraged to work toward growing their classroom libraries by collecting an assortment of texts, including different types of reading materials and various genres and topics. Additionally, the researcher can take the knowledge learned from the study and provide teachers in field-based settings with information about creating a complete classroom library that can be used to motivate students to read and support classroom instruction.

## LIMITATIONS

This study has several limitations. The researcher collected data from a small sample of teachers at two schools located in one school district. Furthermore, all teachers who participated in the study have classroom libraries. It is possible that teachers who did not respond to the survey do not have classroom libraries. The Classroom Library Survey is a self-reporting instrument, so inaccurate responses were possible. The researcher was only able to visit seven of the thirteen teachers' classrooms, which yielded fewer results for analysis between the survey and the classroom library visits. Moreover, due to time constraints, the classroom library visits were brief, which did not allow for exact counts of books.

## CONCLUSION

After surveying teachers and physically stepping into their classrooms, I gained a deep understanding of the importance of classroom libraries. Classroom libraries can help to instill a love of reading in students, broaden their interests, and improve their reading skills. Furthermore, I have developed a critical eye for studying these libraries and gained confidence in my ability to build a complete and effective library in my own future classroom. Learning how teachers in South Texas set up and maintain their classroom libraries revealed that, despite being in the same school district, each teacher had a unique classroom library that fit the needs of their students. Although there were a few inconclusive results between the Classroom Library Survey and the Classroom Library Checklist, it was clear that the teachers value their libraries. They have

invested money and time to build attractive and cozy spaces where children can gather to share the joys of reading.

## REFERENCES

Brassell, D. (1999). Creating a culturally sensitive classroom library. *The Reading Teacher, 52*(6), 651-652.

Catapano, S., Fleming, J., & Elias, M. (2009). Building an effective classroom library. *Journal of Language and Literacy Education, 5*(1), 59-73.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Los Angeles, CA: Sage.

Diller, D. (2003). *Literacy work stations: Making centers work.* Portland, MA: Stenhouse Publishers.

Fractor, J. S., Woodruff, M.C., Martinez, & M.G., Teale, W.H. (1993). Let's not miss opportunities to voluntary reading: Classroom libraries in the elementary school. *The Reading Teacher, 46*(6), 476-484.

Hartley, J. (2008). You should read this book!. *Educational Leadership, 65*(6), 73.

Lao, C. (2005). Why teachers buy books for their students. *Reading Horizons, 45*(3), 176-193.

Martinez, M., & Teale, W. H. (1988). Reading in a kindergarten classroom library. *The Reading Teacher, 41*(6), p. 568-572.

Pytash, K. E. (2012). Ain't nothing wrong with reading books: Creating a classroom library at an alternative school. *Young Adult Library Services,* (4), 31-35.

Sanacore, J. (1995). What to look for in whole language content area classrooms. *Journal of Adolescent and Adult Literacy, 39*(3), 240-243.

Young, T. A., & Moss, B. (2006). Nonfiction in the classroom library: A literacy necessity. *Childhood Education, 82*(4), 207-212.

Young, T. A., Moss, B., & Cornwell, L. (2007). The classroom library: A place for nonfiction, nonfiction in its place. *Reading Horizons, 48*(1), 1-18.

## APPENDIX A

*Classroom Library Survey*

What grade level(s) do you teach?

What content do you teach?

How many years have you been a classroom teacher?

There is a designated space in my classroom for a classroom library that students use.

How many books are there in your classroom library?

I have the following kinds of reading materials in my classroom library.

Where do you get books for your classroom library?

My books are organized by…(genre, reading level, author, topic, other)

Most of the reading material in my classroom matches the content that I teach.

My classroom library contains books written at different reading levels.

The shelves or tubs in my classroom library are clearly labeled.

My students know how to use my classroom library.

What percentage of your books was published within the last ten years?

Do you have books that are culturally relevant to your student population?

There are a significant number of books displayed with the covers facing forward.

Most of the reading materials in my classroom library are in good condition.

How frequently do students use your classroom library?

There is an organized system for children to check out reading materials from my classroom library.

There is enough space for three to four students to gather comfortably in my classroom library.

My students have regular blocks of time to read the reading material in my classroom library.

## APPENDIX B

*Classroom Library Checklist*

| | | |
|---|---|---|
| Designated space for library in the classroom | Yes | No |
| Approximate number of books | | |
| Kinds of books | _____ traditional fiction storybooks | |
| | _____ historical fiction books | |
| | _____ poetry collections | |
| | _____ books with only factual information, but not biography or autobiography | |
| | _____ reference books | |
| | _____ magazines | |
| | _____ newspapers | |
| How books are organized | _____ genre | |
| | _____ reading level | |
| | _____ author | |
| | _____ topic | |
| Reading material matches the content taught | % yes | |
| Books at different grade levels | Yes | No |
| Shelves or tubs are clearly labeled | Yes | No |
| New vs. old books | % new | % old |
| Books displayed with covers facing forward | Yes | No |
| Enough space for three or four students to gather in the classroom library | Yes | No |

# TEXAS A&M UNIVERSITY-CORPUS CHRISTI
# A BRIEF HISTORY

Texas A&M University–Corpus Christi began in 1947 as the University of Corpus Christi (UCC) which was affiliated with the Baptist General Convention of Texas. In 1970, Hurricane Celia causes more than $1,000,000 dollars in damage to the campus. In 1971, the Baptist General Convention of Texas sold UCC to the state of Texas and the Texas Legislature authorizes the Texas A&I University System to establish a state-supported upper-level institution of higher education in Corpus Christi. In 1973, Texas A&I University at Corpus Christi opens its doors on 4 September 1973 to 969 students as an upper-level institution of higher education. In 1977, the Texas Legislature changes the name of the University to Corpus Christi State University. In 1989, Corpus Christi State University joins the Texas A&M University System. In 1993, the Texas A&M University System Board of Regents renames the institution Texas A&M University–Corpus Christi and a year later it becomes a four-year comprehensive university and enrollment increases to 5,000 students. In 2004, the Board of Regents approves the College of Nursing and Health Sciences which opened in 2005. In 2005, Dr. Flavius Killebrew becomes President/CEO and initiates Momentum 2015, a ten year plan to establish Texas A&M University–Corpus Christi as the flagship university of South Texas. Today the University has over 10,000 students.

Today Texas A&M University–Corpus Christi is not only a proud member of the Texas A&M University System but it is also the premier public university in the region and is currently the only university in the United States to be situated on an island. Texas A&M University–Corpus Christi is currently a member of the Southland Conference under the NCAA division I.

All information on this page can be found at http://www.tamucc.edu.

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