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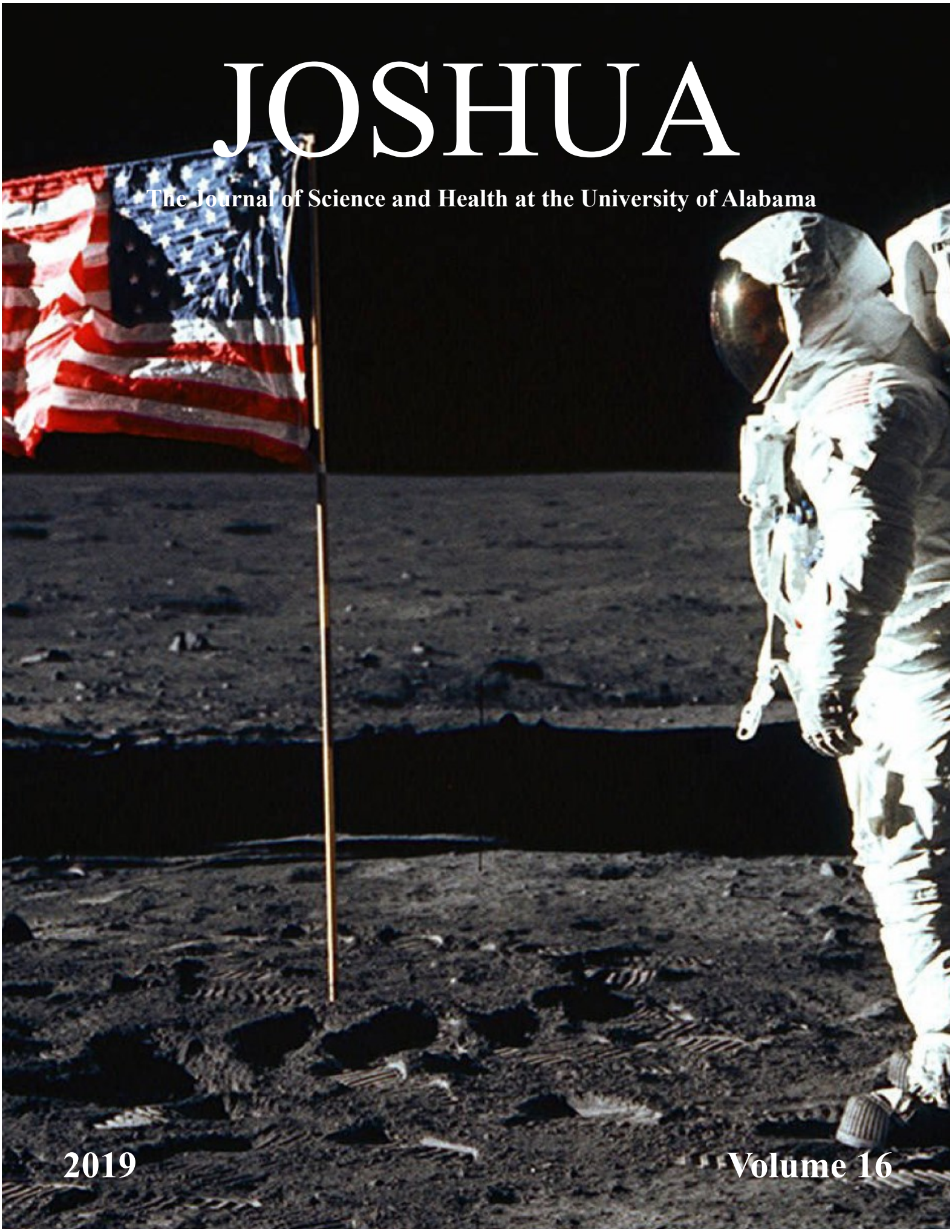

2019 Volume 16

About the Cover:

On July 20th, 1969 the first humans landed on the moon. This cover was selected to commemorate the 50th anniversary of Apollo 11. Astronaut Edwin E. "Buzz" Aldrin Jr. is pictured beside the United States flag. His footprints represent a feat accomplished by the United States but dedicated to mankind. This image can be found at NASA.gov.

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Electrospinning of Cellulose Acetate Nanofibers: Process Optimization

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Cellulose acetate (CA) is the acetate ester of cellulose and produced from cellulose via the process of acetylation. Currently, electrospinning has become a widely used technique to produce CA nanofibers for potential applications such as filtration, medical dressing and food packaging. Being biodegradable and biocompatible, CA nanofibers bring additional advantages for these applications, e.g., high surface area, high porosity, and light weight. The quality of the CA nanofibers, which can be characterized by the prevalence of defects on the fibers, pore size, and fiber diameter, directly affects its performance. Fiber quality is, in turn, directly determined by the electrospinning process parameters. Therefore, in this project, we aimed to investigate the effect of electrospinning parameters, including CA concentration, voltage, and spinning distance, on the electrospinnability of CA nanofibers and fiber diameter, using process optimization principles and response surface methodology. Certain process parameters, including solvent (acetone), needle diameter (gauge 22, inner diameter 0.413 mm), temperature (20 °C), and feed rate (2 mL/h), were kept constant throughout the experiment. Preliminary experiments were conducted to determine the extreme conditions of each parameter and define a working boundary. Then, trials of electrospinning CA nanofibers were conducted following a 3-factor, 3-level Box-Behnken design within the predetermined range. CA nanofibers were characterized by scanning electron microscope (SEM) for their morphology and SEM images were analyzed using the ImageJ software for their mean diameter. The mean fiber diameters fell into the range from 404 to 1346 nm, and increased with CA concentration. The fiber diameter was less affected by the other two parameters, i.e., voltage and spinning distance.

Introduction

Presently, electrospinning has become a highly popular technique to fabricate micro- and nanofibers, because of its versatility, simplicity, and scalability [1]. Electropsun nanofibers may find a large variety of applications, such as wound dressings, cell scaffoldings, drug delivery platforms, tissue engineering, environmental filtration and so forth [2]. To date, nanofibers from various biopolymers, including polysaccharides, proteins, and DNA have been successfully by the electrospinning technique.

Cellulose acetate (CA) is the acetate ester of cellulose produced from cellulose via the process of acetylation (Figure 1). Being biodegradable and biocompatible, CA nanofibers can bring additional advantages for practical applications, e.g., high surface area, high porosity, and light weight. CA has been electrospun into microscale and nanoscale fibers using solvents such as N,N-Dimethylformamide [3], acetone and N,N-Dimethylacetamide (2:1 w/w) [4], acetic acid and water (17% w/w) [5], and DCM and methanol (9:1 v/v) [6].

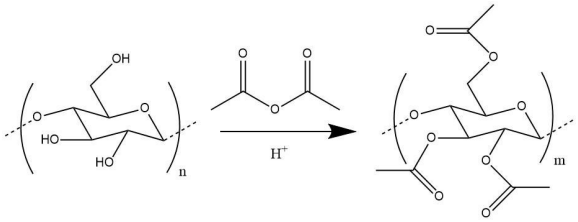

Figure 1: Synthesis of cellulose acetate from cellulose through acetylation and partial hydrolysis.

The morphology of the resulting nanofibers directly affects their possible applications as well as the level at which they are able to function. The morphology of nanofibers is determined by the parameters used while they are electrospun. Therefore, it becomes imperative to know how modifying electrospinning parameters alters the morphology of the resulting nanofibers. In this study, we seek to unveil these effects through the principles of process optimization.

Due to CA's high solubility in acetone, acetone was chosen as the solo solvent in our procedure. It was able to dissolve CA at room temperature via magnetic spinning in a relatively short amount of time. Preliminary tests were done to determine the ranges of parameters, including CA concentration, applied voltage, and spinning distance, to test. Re-

sponse surface methodology with Box-Behnken design was used, because in Box-Behnken design, all design points fall within the predetermined operational ranges. This study will provide tremendously important information on the electrospinning parameters and diameter prediction of fabricating CA nanofibers.

Materials and Methods

Materials

Cellulose acetate (MW ~100,000 Da; acetyl content ~ 39.7 wt%) and acetone were purchased from VWR International (Radnor, PA, USA).

Electrospinning

The preparation of spinning dope involved dissolving the appropriate amount of CA in acetone by stirring at room temperature (20 °C). The spinning dope was then loaded into a 10 mL syringe (Becton, Dickinson and Company, Franklin Lakes, NJ, USA) with a 22 gauge blunt needle (Hamilton Company, Reno, NV, USA) as the spinneret. The electrospinning setup comprised a higher voltage generator (ES30P, Gamma High Voltage Research, Inc., Ormond Beach, FL, USA), a syringe pump (NE-300, New Era Pump Systems, Inc., Farmingdale, NY, USA), and a grounded aluminum foil (Figure 2). Electrospinning runs were conducted at a constant ambient temperature (20°C) in a fume hood with no air flow. The fibrous mat deposited on the aluminum foil was then collected for further analysis.

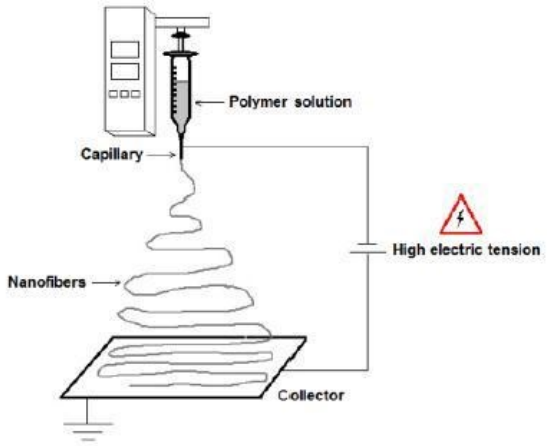

Figure 2: Schematic drawing of the electrospinning setup used in this study [7].

Design of experiments

In order to establish a quantitative relationship between fiber diameter and spinning parameters, a 3-factor, 3-level Box Behnken design (Table 1) was created using Minitab 18 (Minitab, Inc., State College, PA, USA). Three variables were included in the model: CA concentration (9 to 15 %, w/v), voltage (8 to 16 kV), and spinning distance (6 to 14 cm). The design contained 15 experiments, including 12 unique combinations and 3 replications of the center point (Table 1). Feed rate was kept constant at 2 mL/h.

Scanning electron microscopy (SEM)

Observation of electrospun fibers was performed using a JEOL 7000 FE scanning electron microscope (Jeol USA, Inc., Peabody, MA, USA) at an accelerating voltage of 20kV Images were analyzed using the ImageJ software (National Institute of Health, Bethesda, MD, USA). Three images were used for each fiber sample and ten different segments were randomly measured to obtain an average diameter.

Results and Discussion

Electrospinnability

Electrospinnability (ability to form fibers via electrospinning) of the spinning dopes was evaluated visually during the electrospinning process and from the SEM images. It is worthwhile to note that in preliminary tests, we found that mass concentrations outside of the range of 9%-15% (w/v) were unsuccessful in creating nanofibers via electrospinning. Solutions with a CA concentration below 9% (w/v) were unable to produce continuous jet and fibers. Comparatively, a solution with a CA concentration above 15% (w/v) was ill suited for electrospinning, because its high viscosity combined with the high evaporation rate of acetone caused the needle tip to clog quickly and prevented a steady stream. Fiber samples from each experimental run were observed using scanning electron microscopy (Figure 3) and evaluated according to their spinning behavior and fiber morphology (Table 1).

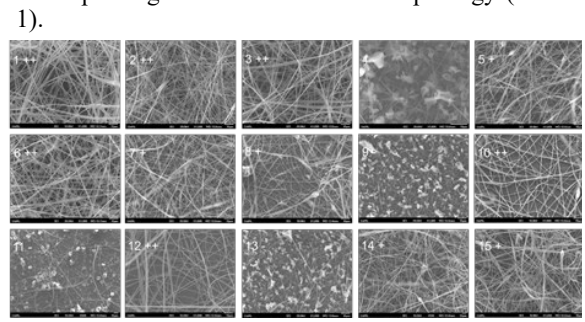

Figure 3: Scanning electron micrographs of CA fibers from experimental runs. Scale bar represents 10 µm in all figures. Fibers were evaluated and classified into good fibers (++), fair fibers (+), and poor fibers (−).

Run Order	CA Concentration (%, w/w)	Distance (cm)	Voltage (kV)	Diameter (nm)	SD	Fiber evaluation
1	15	6	12	1346	812	++
2	12	6	16	488	221	++
3	15	10	16	823	519	++
4	9	6	12	452	236	-
5	12	10	12	801	382	+
6	15	10	8	749	336	++
7	12	10	12	666	449	+
8	12	14	8	977	464	+
9	9	10	8	404	171	-
10	12	14	16	1104	531	++
11	9	14	12	562	400	-
12	15	14	12	1149	523	++
13	9	10	16	478	337	-
14	12	6	8	756	470	+
15	12	10	12	653	403	+

Table 1: Design of experiments and results. Fiber evaluated as good fibers (++), fair fibers (+), and poor fibers (−).

Continuous fibers were formed using 12% and 15% (w/v) CA solutions. As seen in runs 3, 5, 7-9, 12, 14, and 15-17 in Figure 3, nanofibers created using these solutions had little to no beading, no matter the voltage and/or the spinning distance used. As CA concentration increased, the amount of beading decreased, and therefore, the quality of fibers increased. Nanofibers spun from the 9% (w/v) CA solution demonstrated a large amount of beading, as seen in runs 6, 11, 13, and 15 in Figure 3. All fibers resulting from this concentration, no matter the spinning distance and voltage, were of low quality. Furthermore, 9% (w/v) CA solution produced the least amount of fibers in the same amount of time compared to the 12 and 15% (w/v) CA solutions. It required the most amount of time to create a nanofibrous mat that covered the aluminum foil collector completely. These two facts demonstrated the poor spinnability of the 9% (w/v) CA solution.

While the 9% (w/v) CA solution had the lowest level of spinnability, there was a common additional layer of difficulty shared by each of the three mass concentrations. In all experimental runs, extremely viscous balls of fluid gradually accumulated at the tip of the needle. This was due to the fast evaporation of acetone, further accelerated by the drawing of the spinning jet towards the grounded target. As the solvent evaporated, the spinning dope became viscous, making it difficult to stretch and elongate. Periodically during the run, the viscous fluid buildup needed to be cleared from the tip in order to enable electrospinning to continue. Despite removing the fluid buildup on the outside of the needle, if a run continued long enough, the solution inside the needle tip would completely solidify, cut off the stream, and end the run. Therefore, the time period of fiber collection in this procedure had to be relatively short. We believe that this played a key role in the relatively large variation in fiber diameters seen in the resultant nanofibers. This will be discussed in more detail in the next section.

Fiber diameter

The fiber diameters were measured and are listed in Table 1. The mean diameters of the nanofibers produced in this procedure ranged from 404 to 1346 nm. Regression analysis did not result in a reliable predictive model using second-order equations. Again, this was probably due to the instability of the electrospinning process and large variations in fiber diameters. Contour plots in Figure 4 indicate that the fiber diameter is very responsive to CA concentration as compared to its independence on the voltage and spinning distance used. As CA concentration increased, the diameter of the resulting fibers increased (Figure 4a & 4b). Comparatively, Figure 4c shows that altering the voltage and spinning distance did not have a distinct effect on the diameter of the nanofibers. This was unexpected because many previous studied found that fiber diameter was affected by both the voltage and spinning distance [ref: Kong Ziegler 2013 Carbohydrate Polymers].

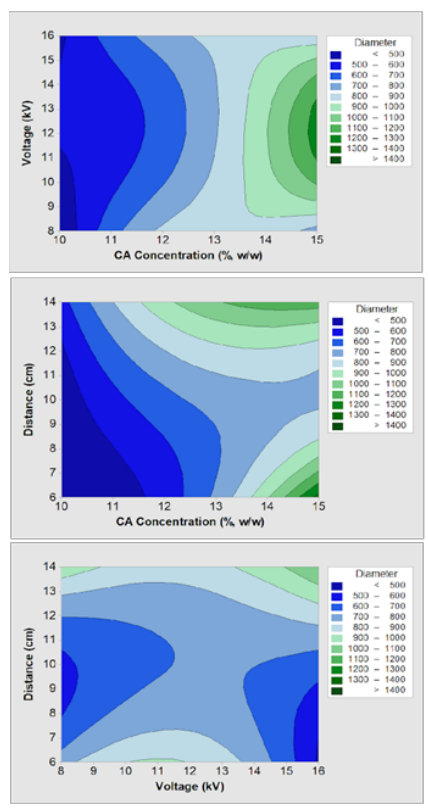

Figure 4: Contour plots of CA fiber diameter as a function of electrospinning parameters.

Conclusion

The optimization of parameters for the electrospinning of CA nanofibers was investigated in this study. The mean fiber diameters ranged from 404 to 1346 nm, and increased with CA concentration. The voltage applied and spinning distance had little impact on fiber diameter. It was found that the best quality nanofibers with little to no beading were produced by solutions with a 15% (w/v) CA concentration, and that solutions spun with a mass concentration below 12% (w/v) produced unusable low quality fibers with too much beading. However, even though solutions with 15% (w/v) CA concentration produced fibers with little to no beading, due to viscous fluid buildup, they did not produce nanofibers with uniform diameters. The large variation in diameter would make them less desirable for many applications. In order for these nanofibers to function at their ideal capacity, it is necessary for them to be more consistent in their size and morphology than the nanofibers created in this procedure. For future attempts in creating CA nanofibers via electrospinning, using a solution less prone to evaporation may produce more uniform nanofibers.

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Review of Treatment and Prevention of Dementia

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This review presents findings related to treatment and prevention of dementia, focusing on literature published recently. Dementia is an advanced stage of cognitive decline marked by symptoms such as memory loss. It has multiple causes and risk factors, many of which are related to other chronic diseases. National and local organizations have set goals for improving the health of Americans that include improving dementia diagnoses and outcomes. The prevalence of dementia may also be decreasing. The dietary patterns of older adults are discussed in relation to diets known to improve dementia risk and outcomes. Lifestyle factors that may compound the effect of diet are also discussed. Educational programs are an important tool for implementing interventions to improve prevention, care, and outcomes of dementia. Recommendations are given for designing future programs.

Introduction

Dementia is an advanced stage of cognitive decline marked by the loss of at least two executive cognitive functions, like memory and awareness, that can result from multiple causes. It often follows a diagnosis of mild cognitive impairment (MCI), which indicates an earlier stage of cognitive decline, and it most common form is known as Alzheimer's disease (AD) [4]. Dementia is a large burden on society, decreasing quality of life for both patients and caretakers while accruing large healthcare costs [3]. Educating affected and at-risk populations about dietary and lifestyle interventions is an important strategy for preventing and treating this disease, and these often overlap with interventions that address other chronic diseases like cardiovascular disease (CVD), diabetes, and obesity [2].

Analysis of Studies

At a national level, Healthy People 2020 (HP2020) has set goals concerning Alzheimer's and other dementias as well as goals addressing their risk factors. They aim to reduce the gap between individuals who are diagnosed with dementia and those who know, or whose caregiver knows, that they have been diagnosed; and they aim to keep adults with dementia from avoidable hospitalization. HP2020 has also set goals addressing risk factors for dementia like physical activity, diet, tobacco use, and related chronic diseases [22]. In the HP2020 Midcourse Review, no progress is shown on its two goals for AD and other dementias. However, progress has been made on the related topics of heart disease and stroke, diabetes, obesity, physical activity, and older adults [10]. Some progress is being made toward national health objectives, and some of the most important risk factors for dementia are being addressed at a national level.

Along with the risk factors already mentioned, loneliness is associated with a significant increase in risk for dementia, while having a higher number of close friends, being married, being satisfied with life, and attaining a higher education level are all associated with a decreased risk [15, 6, 21]. According to the Institute of Health Equity, more social determinants of health that increase the risk for dementia or its risk factors include a history of depression, poor health behaviors of parents, lower parental socioeconomic status, poor childhood housing conditions, low household income, abuse of or addiction to certain medications, job insecurity or unemployment, and more [7]. Dementia rates show low disparities across demographics. According to The Aging, Demographics, and Memory Study, increased age is the greatest demographic risk factor for dementia. Presence of one or two alleles of the APOE gene also increased risk for AD. Sex and race were not found to be related to dementia risk [14]. The prevalence of dementia has likely decreased in recent times. Matthews, et al. report comparisons between data collected on adults over 65 in the UK from 1989 to 1994 and from 2008 to 2011, showing that prevalence decreased from 8.3% to 6.5%, by 1.8%, between the two time periods [9]. Christensen, et al. reports data on two Danish cohorts, one born in 1905 and evaluated in 1998 and one born in 1915 and evaluated in 2010. The second cohort had significantly higher scores of cognitive ability, despite being older, which signified lower cognitive decline [5]. While these data have limited applicability to the United States, they suggest a decreasing trend in the prevalence of dementia.

Diet

Diet stands out as an important modifiable risk factor to prevent or delay the onset of disease. The epidemiological link between cognitive decline and other chronic diseases suggests that a dietary pattern suited for related chronic diseases may also combat cognitive decline. In fact, the Mediterranean (Med) diet and the DASH (Dietary Approaches to Stop Hypertension) diet, both supported by the Academy of Nutrition and Dietetics for reducing the risk of other chronic diseases including CVD, have also shown efficacy as treatments for combating cognitive decline [18]. The MIND (Mediterranean-DASH diet Intervention for Neurodegenerative Delay) diet, a modified combination of the DASH and Med diet that emphasizes leafy greens and berries, has been tested with similar outcomes, and may be more effective than either the Med or DASH diets [12, 13]. Furthermore, one avenue for the advancement of dietary interventions is the investigation of particular components of a diet that have been associated with incidence of dementia. Findings may lead to modification of current recommended dietary patterns, and some progress has been made in this endeavor. For example, a study conducted on 276 adults over the age of 50 found that a higher intake of white rice was associated with a higher risk for MCI, while intake of whole grains, nuts, fruits, vegetables, and dairy were associated with a lower risk [8].

In contrast, a study of adults in Chicago over the age of 65 concluded that high vegetable intake was associated with a slower rate of cognitive decline over the course of the study, while fruit intake was not [11]. A meta-analysis comparing data on dietary omega-3 fatty acids and AD or dementia risk found no protection based on the essential fatty acids alone, but significant dose-dependent protection from fish consumption on AD risk [20]. These findings support the recommendations of the Med, DASH, and MIND diets while suggesting that increased fish in the MIND and DASH diets and decreased emphasis on fruit in the DASH and Med diets could be beneficial. Another important avenue for the improvement of dietary interventions is the comparison of recommendations to the current eating habits of the target population. In the Health ABC Study, a study of adults aged 70-79, participants were grouped based on diet characteristics. Of 2582 participants and six dietary patterns, only 14.5% of participants ate a diet characterized by healthy foods [1]. The healthy foods dietary pattern most closely resembled the DASH diet, and was associated with the greatest survival rate and quality of life. All dietary patterns, however, were lower in vegetables than recommended by the Med, DASH, and MIND diets, specifically dark green and dark yellow vegetables; all met fruit and nut recommendations. All kind), refined grains, and sweets and desserts from any of the three reference diets.

These findings show that following a brain-healthy diet may require significant diet modification for most older adults, while also suggesting that, given high adherence, dietary interventions have the potential to drastically change the effect of an individual's diet on their health. To follow a MIND-style diet, the average study participant would need to increase their leafy green and other vegetable consumption; decrease fruit, dairy, refined grains, red meat, and poultry; shift their fruit choices to include mostly berries; and use olive oil as their main cooking oil. These or similar recommendations may apply to older adults in general.

Lifestyle

Modifiable risk factors other than diet also play a role in determining dementia risk. A study of Swedish adults over age 60 who were without dementia at baseline investigated the effect of various types of daily activities. All participants ate based on the Nordic Prudent Diet, and lifestyle factors were assessed in terms of supporting the diet's effects. The study found that diet adherence and an active lifestyle independently improved cognitive assessment scores by similar amounts, and that the combination was more effective than either diet or lifestyle alone. Components of an active lifestyle included various physical, mental, and social activities [17]. Moreover, while the inverse association between physical activity and cognitive decline has been consistently shown, mental and social activity have a less clear relationship with the risk for cognitive decline [2].

Education Programs

Many of the education programs that have been evaluated for AD and dementia focus on caregivers, who facilitate the diet of affected individuals with diminished independence. One such program focused on preventing unintentional weight loss, often seen in AD patients, by educating caregivers on relevant topics, including strategies to address common difficulties. Participants were recruited from hospitals and educational programming was given in-person in small groups. The program was found to be effective for improving change over time in weight status and for decreasing cognitive decline over the course of the study. Both outcomes were likely due to improved nutritional status, which is an important determinant in the risk for cognitive decline. Caregivers reported an increased ability and level of confidence in dealing with AD-related issues due to the educational program [16]. Another study instead focused on optimizing an internet-based education program for use by older adults. To enhance accessibility for seniors, the program's designers favored images and videos over text where possible and used short, simple sentences where text was necessary. The program included .

information on dietary and lifestyle prevention of MCI, tips for healthy cooking and shopping on a budget, methods for tracking subjective experience and biochemical markers, and more. Study participants included a range of health experts with geriatric experience, IT professionals, caregivers, and older adults. Participants were asked to explore and evaluate the educational tool, resulting in multiple improvements to areas like terminology and font, image, and video size [19]. This program meets unique needs because, as a web-based tool, it is accessible to a wider audience and has the potential to be highly cost- and time-effective. Furthermore, by including tips for healthy eating on a budget, it aims to reduce health disparities based on socioeconomic status.

Recommendations

Educational programs are a potentially effective method to treat and prevent dementia and cognitive decline. More research should be conducted to optimize the delivery and accessibility of information and to determine the optimal range and depth of information to be provided. Online educational tools may be ideal for maximizing availability, although front-end investment may present a barrier to their creation. In contrast, in-person education sessions by health experts could require less initial investment and therefore be more feasible for moderate- or small-scale efforts, while also allowing for direct patient-expert interaction and personalization of recommendations. Programs intended for at-risk or diagnosed individuals should include information for healthy weight management in terms of both underweight and overweight individuals, as well as information on a healthy dietary pattern, physical activity, tobacco use, and more. Budgeting information may be appropriate for low socioeconomic status communities. Particular attention should be given to presentation of information due to diminished senses and abilities among older adults, especially those experiencing cognitive decline. Caregiver-focused educational programs should include similar information along with strategies for dealing with common difficulties experienced by AD and dementia patients.

Conclusion

Reducing the prevalence and incidence of AD and other dementias should be a high priority for national and state health agencies. Addressing this disease requires a broad view of dietary and lifestyle factors that can be either protective or detrimental. These factors also have the potential to improve quality of life for those who are already experiencing cognitive decline or dementia. The findings presented suggest following a brain-healthy diet similar to the diets discussed in combination with physical activity. Educational programs may be a key tool in this endeavor and should be optimized by future research.

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Stereotypes, Biases, and Intimate Partner Violence: African American Females in the Courtroom

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Negative stereotypes are fixed, widely held, and oversimplified images of a person that have the potential to impact juror decision making. This study examined the impact of victim race on juror decision making and attitudes in a case of alleged intimate partner violence (IPV). Mock jurors read a vignette in which victim race was manipulated. Participants (N= 184) rendered a verdict, answered several attitudinal questions (i.e. "How likely would you be to call the police if you witnessed an IPV incident?") and completed the Symbolic Racism Scale. Data suggests that participant racial biases did not impact their perceptions of the case or ultimate decision making. production.

Introduction

Biases and Stereotypes

Stereotypes and biases are negative connotations associated with African Americans that are commonly held by Caucasians [17]. Stereotypes may cause Caucasians to view African Americans less favorably, and it is important to examine if biases are present in juror decision making. Stereotypes, typically associated with African American women, have been examined in past research. Gillum, (2007) examined the beliefs held by African American men regarding the "jezebel" (sexual temptress) and "matriarch" stereotypes of African American women. In this survey of African American men, 48% of respondents endorsed the jezebel stereotype and 71% endorsed the matriarch stereotype, which is associated with anger and dominance [5]. These common stereotypes are important to understand because they have the potential to affect African American women involved in the criminal justice system.

Sutton (2013) examined racial biases specifically within the courtroom by observing African American and Latino males who were convicted of a felony. Sutton hypothesized that convicted African Americans and Latinos would receive more severe sentences than Caucasians. Results suggested that the odds of African American defendants receiving the next- most severe sentence were nearly 26% higher than an average Caucasian defendant. Sutton (2013) surmised that racial biases and stereotypes may have impacted defendant sentencing.

Biases were measured by symbolic racism, a belief system combining the ideas that racial discrimination is no longer a serious obstacle [9]. Symbolic racism consists of the opinions that the disadvantages African Americans face are due to their own unwillingness to take responsibility and the special attention given to them is unjustified [9].

Intimate Partner Violence

Intimate partner violence (IPV) is physical violence, sexual violence, and psychological aggression by a current or former partner [2]. Domestic violence cases and factors that may have impacted juror sentencing decisions have been explored by Henning and Feder (2005). Researchers examined a multitude of cases involving IPV and looked at both the legal (e.g. weapon use and injuries of the victim) and extralegal (e.g. socioeconomic status and race) factors pertaining to the case. Data suggested that legal factors played less of a role in sentencing than extralegal factors although legal factors still impacted decision making [8]. For example, if a defendant was Caucasian from a higher socioeconomic status, prosecutors were more likely to drop the case. Further, minorities were less likely to get released on their own recognizance than Caucasian defendants. Gender also influenced IPV cases as female accusers were more likely to be treated leniently or have the charged dropped [8]. This study suggests that race and gender are important factors when sentencing IPV cases.

Research in domestic violence cases has been investigated by Maeder, Mossiere, and Cheung (2013), where participants were asked to read mock cases and act as jurors. The researchers manipulated the race of the defendant in domestic abuse case involving interracial couples. The researchers hypothesized that race would not influence the verdict, but that gender differences would affect sentencing. The jurors' attitudes toward females affected the decision, and the jury found the defendant in interracial couples guilty more often than same-race couples [11]. These findings indicate racial biases may be present when convicting a defendant.

Theoretical Orientation

The Chivalry Hypothesis states that women are generally treated better in the criminal justice system than men because they are viewed as weak, frail,

and irrational [7]. Within this theoretical framework, the Selective Chivalry Hypothesis states that Caucasian women are treated more leniently in the criminal justice system than African American women [3]. This leniency can be due to the stereotypes that are associated with African American women that Caucasian women do not face. Finally, the Typicality thesis states that women are treated better in the criminal justice system, but only when their offense is consistent with stereotypes of female offenders [3]. For example, females who violate the gentle, mothering stereotype by committing in violent or assaultive behavior would be treated with less leniency. These three theories contribute to the hypothesis that women, especially African American women, are treated more punitively in the criminal justice system because of the stereotypes that are associated with them in society.

Limitations of Previous Research

While past research provides a solid base understanding of biases' influence on courtroom decisions, further research is necessary to understand how racial biases can affect African American female victims. African American defendants face a 26% higher chance of receiving a more severe sentence than Caucasian defendants in the same situations [14]. This shows that race does play a factor in sentencing defendants, but there is limited research regarding African American women as victims specifically. Researchers have examined race [14], gender roles [13], and intimate partner violence [8] as individual variables. However, there is a gap in research as to how all of these factors come together and impact African American women. Biases can lead to unfair trials within the courtroom concerning gender and race. Finally, there is also more research on biases and stereotypes on African American males than females, stressing the importance of studies focusing on African American women's experiences [14].

Current Study

This study contributed to part of a larger study conducted by Cox and Stanziani (2017) investigating the intersectionality of race, gender, and juror decision making in domestic violence cases. Researchers in this larger study manipulated the race of both the defendant and the victim. The current study focused on the race of the victim only, while the defendant's race remained constant. The independent variables of this study were race and biases, whereas the dependent variable was the verdict given by participants.

Attitudinal statements about the crime were observed in relation to independent variables for the purpose of examining other potential factors that may have influenced verdict. The present work assessed three hypotheses for race and biases' potential impact on IPV trail outcomes:

1.Race will impact the verdict. Specifically, a defendant who abused an African American victim will be more likely to be found not guilty, when compared to a defendant who abused a Caucasian victim;

2. Participant race biases will play a role in verdict. Therefore, the more symbolic racism, the less punitive they will be towards the defendant when the victim is African American;

3. There will be an interaction between the impact of participant biases and victim race on verdict. Specifically, participants who show more symbolic racism on the Symbolic Racism 2000 Scale will be less likely to convict the defendant when the victim in African American.

Materials and Methods

Participants

Participants (N=184) were recruited from Amazon's Mechanical Turk (MTurk; http://www.mturk.com). MTurk is an online forum that allows for a more representative sample of the U.S. population, compared to undergraduate students. Data derived from MTurk is generally considered reliable and generalizable [1]. Participants were compensated ($1.00) for participating in this research. The ideal sample size, calculated using a p-value of .05 through G*Power [4] was 176 to obtain medium effect size for each hypothesis.

Participant inclusion criteria were based on eligibility to sit on a jury in the United States: being a U.S. citizen, 18 years of age or older, and the ability to speak the English language fluently.

Demographic Questionnaire

A series of questions were presented to participants regarding age, gender, sexual orientation, racial background, religious affiliation, socioeconomic status, and past involvement in an abusive relationship. Demographics were not included in the analysis, but observed in order to look at possible reasons, other than the independent variables, influencing decisions for guilty or not guilty verdicts.

Vignettes

Participants were randomly assigned to read one of two vignettes describing a criminal IPV case. To protect the true nature of the study, participants only read one case. Vignettes manipulated the names of the defendants and victims to alter the race within the vignette.

The vignette described a situation in which the police responded to a call regarding a domestic disturbance involving a married couple that had a verbal and physical disagreement which ended before police arrived on the scene.

The female victim was found bleeding from the head and the male defendant had fled the scene. The victim reported that the defendant slapped her, resulting in her slipping and hitting her head on the stove. The victim was taken to the hospital, and a doctor testifies about her injuries and medical treatment.

The vignette, used in previous research [10], remained the same for all conditions, with the exception of the race manipulation. The two experimental conditions were: African American female victim and Caucasian female victim.

Dependent Variables

After reading the assigned vignette, the participant was prompted to label the defendant "guilty" or "not guilty." Participants then answered nine questions measuring different attitudes of the crime, victim, and defendant. These questions examined possible factors underlying the participants' verdict selection. Using a Likert-type scale (ranging from 0-100), questions assessed how aggressive they perceived the incident to be, whether or not they would call police, what sentence the defendant deserves, and how frequently they believe this type of incident occurs.

Comprehension Check

Participants were given questions pertaining to the race of the victim and the crime committed in the vignette. Comprehension checks were used to make sure participants gave their full attention to the vignettes and were aware of what occurred in the mock situation.

Symbolic Racism 2000 Scale (Henry & Sears, 2002)

Participants then completed eight questions from Henry and Sears's (2002) Symbolic Racism 2000 Scale (SRS) assessing the extent to which they endorse ideas characteristic of the Symbolic Racism belief system. Each question was answered using a Likert-type scale ranging from 1-4 (1=strongly agree, 4= strongly disagree). These questions pertained to racial tension in the United States, the responsibility of the hardships African American face, and discrimination. For example: "It's really a matter of some people not trying hard enough; if Blacks would only try harder they could be just as well off as whites" [9]. Each item on the scale was converted to a 0-1 scale and provided a scale item comparison, then the scores were summed [9]. The scores represent a dimensional construct with lower SRS scores suggesting more symbolic racism, and a high SRS score representing less symbolic racism. Thus, no arbitrary cut-point indicating "racism" will be used. The Symbolic Racism 2000 Scale has been previously tested to have high reliability (α=.79) [16].

Procedures

Participants completed the study on their own time and in an environment of their choice. After participants logged into their MTurk account on their computer, they selected the study and a brief description appeared. After being instructed to click the link presented, participants were randomly assigned one vignette to read. After reading the vignette, participants were asked to give a verdict (guilty, not guilty), complete attitudinal statements, comprehension checks, the Symbolic Racism 2000 Scale, and demographic questions. After the questions were completed, participants were debriefed about the full purpose of the study and had the option to withdraw their data from analyses.

Results

Victim Race

Concerning the race of the victim and the dichotomous verdict of the case, within the Caucasian condition participants rendered a guilty verdict 74.15% of the time whereas participants within the African American condition rendered a guilty verdict 75.78% of the time. A chi-square test determined the relationship between defendant race and participant verdict was not significant ($\chi^2(1, n = 184) = .07, p = .80$).

When examining participant's attitudinal statements, independent t-tests yielded partially significant differences between the two conditions. Specifically, participants were more likely to call the police when the victim was Caucasian compared to when the victim was African American, $t(182)=-2.317$, $p=.022$. When participants were asked about sentencing decisions, an independent t-test found no differences between participants in the Caucasian victim condition and participants in the African American victim condition, $t(182)=.85$, $p=.40$. Regarding attitudes concerning how violent the act of aggression was, an independent t-test indicated no significant difference between participants in the Caucasian condition and participants in the African American Condition, $t(181) =- 1.1$, $p=.27$. See Table 1 for the means and standard deviations of the Caucasian victim condition. See Table 2 for the means and standard deviations of the African American condition.

Caucasian Victim Condition

Attitudinal Statement	Mean	Standard Deviation
Call the Police	82.24	26.83
Sentencing Decisions	2.25	2.92
Level of Violence	63.66	23.66

Table 1: DESCRIPTION

African American Victim Condition

Attitudinal Statement	Mean	Standard Deviation
Call the Police	72.66	29.06
Sentencing Decisions	2.65	3.52
Level of Violence	59.87	22.89

Table 2: DESCRIPTION

Symbolic Racism Scale

Inherently, participants are likely to have predisposed biases regarding race [5]. However, participant's racial biases (measured by SRS) did not significantly predict verdict decision (χ^2 (1) = 1.037, p = .308). Participant racism predicted sentencing decision punitiveness, with lower levels of racism predicting more severe sentencing decisions (b = -1.354, R^2 = .052, F(1, 148) = 8.124, p = .005).

Participants' SRS scores did not predict whether they would call the police (b=.143, R^2=.020, F(1, 148)=3.05, p=.083). However, participants' SRS scores did significantly predict their attitudes regarding the seriousness of IPV in general (b=.26, R^2=.07, F(1, 148)=10.76, p=.001). Participants' SRS scores significantly predicted attitudes regarding how violent the act of IPV was, (b=.17, R^2=.03, F(1, 148)=4.06, p=.046), with lower levels of racism (i.e., higher SRS scores) predicting higher attitude ratings.

Race and Biases

A one-way ANCOVA examined the impact of the relationship between victim race and biases on verdict while controlling for participant SRS score. Results were not significant (F(1, 145) = 3.638, p = .058).

Discussion

The current study examined the impact of victim race on juror decision making and attitudes in a case of alleged intimate partner violence (IPV). To further understand how juror biases may impact courtroom decisions, the present study manipulated the race of a female IPV victim and measured participant "jurors" racial biases. Various attitudinal statements were assessed to determine if race influenced how the jurors felt about the level of violence of the crime, the likelihood of calling the police, and the prison sentence for the defendant. In general, this data suggests participant racial biases did not impact their perceptions of the case or ultimate decision making.

Victim Race

Victim race (Caucasian, African American) was manipulated to examine its impact on participant verdict or perceptions. Results suggest no significant difference between the Caucasian and African American groups. This could suggest that other factors, such as gender, may have outweighed race. Specifically, participants may have attended more to the gender demographic than to the race demographic. This could possibly be accredited to the Chivalry Hypothesis, and the theory that women receive protective treatment within the criminal justice system [7].

Participant responses to attitudinal statements to provide a more nuanced understanding of their decision making process. Specifically, participants rated the extent to which they perceived the IPV incident to be violent. Similar to the race and verdict outcome, there were no differences between groups. This may be attributed to the fact that domestic violence is seen as violent regardless of race [15]. Since race did not have any effect, gender may outweigh race in this case.

However, when participants were asked about the likelihood that they would contact police if they witnessed a similar incident, results suggest they were more likely to call the police when the female victim was Caucasian than if she were African American. This suggests that there was a racial bias in favor of Caucasian females when participants considered police involvement. Past research has shown that a typical stereotype of an African American female is "the matriarch," whereas she is viewed as physically dominant and overly aggressive [5]. If the participants within this study held that belief to be true, even if unwittingly, it may have influenced their decreased likelihood to contact police.

Participants were also asked to provide an appropriate sentence for the defendant, within a specified time frame (1-20 years). There were no differences between groups for selected sentences. Past research has shown that race can impact verdict, but IPV cases may be perceived differently. Sutton (2013) examined the racial disadvantages within the courtroom regarding criminal males. He found differences in sentence severity when examining Caucasian and African American criminals, suggesting the odds of an African American were 26% more likely to receive a harsh sentence than Caucasian defendants. Although there is robust research to suggest the differential treatment of African American men within the criminal justice system, our data suggests African American females who are victims of IPV are not treated

differently than Caucasian females.

Symbolic Racism Scale

Additionally, racial biases of the participates, as measured by the SRS, were examined in relation to verdict selection outcomes. Results indicate participant's symbolic racism endorsement did not significantly predict their verdict selections. Specifically, whether participants scored high or low on the SRS, their likelihood of rendering a guilty verdict did not differ between the Caucasian and African American groups. Although participants SRS score did not influence sentencing, it did impact various attitudinal statements.

Regarding the attitudinal statement assessing perceptions of how violent the act of aggression was, participants who scored high on the SRS (portraying lower levels of racism) regarded the incident as more violent. Again, biases regarding African American woman may have impacted this result, with higher biases relating low attitude towards violence of the crime. Several commonly-held stereotypes characterize African American women as sexual temptresses and matriarchs [5]. Higher endorsement of these stereotypes would be associated with decreased likelihood of perceiving IPV committed against an African American woman as violent.

However, participants SRS scores did not predict their expressed likelihood of contacting the police between Caucasian and African American victims. Sentencing disparities also did not relate to higher or lower SRS scores. This replicates previous findings, such as Shernock and Russell's (2012) study indicating race did not impact restraining orders nor discretion of the prosecution.

Race and Biases Outcome

Examining the impact of race on participant's likelihood to call police yielded no results between the two conditions (Caucasian, African American). Interactions between race of the victim of the alleged IPV case presented in the vignette combined with the potential biases of participants (SRS scores) did not significantly impact whether participants rendered a guilty or not guilty verdict. Race alone did not impact verdict nor did biases.

Limitations and Future Research

Although this study further examined the impact of juror biases on decision making and attitudes, important limitations may have impacted observed outcomes. One limitation to consider is data collection through MTurk. Some researchers have cautioned about weaknesses of MTurk such as participant's attention, cognitive ability, and language comprehen sion [6]. Therefore, MTurk data collection is a limitation in this study due to the differences in participant's attention.

Furthermore, several questions asked about participant's attitudes regarding the alleged IPV case as well as the SRS. Collecting self-report data on such attitudes includes the risk of participants not answering questions truthfully in order to seem more "politically correct." Although language was used to protect the true nature of the study, SRS questions are very face valid and participants may have attempted to answer in a way they felt was socially acceptable.

Future research may explore the race of potential jurors, and potential biases towards jurors' own race. Within this study, we do not know if the race of our participants impacted the results of their biases toward African American or Caucasian victims of IPV. Participant gender could also impact results, and research may further explore whether one gender favors another when making decisions. This study examined only the race of the female victim in an IPV case, but many other factors can be explored to further the understanding of juror's decision making and attitudes towards victims in cases of IPV.

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Atomic Spacing of Graphene and Manufacturing Atomically-Sharp Tunneling Tips

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Scanning Tunneling Microscopy (STM) was used to observe atomic arrangements on the surface of Highly Oriented Pyrolytic Graphite (HOPG). A proportional integral derivative feedback loop was carefully tuned to display the arrangements of atoms on a surface by controlling the height of an atomically-sharp probe tip as it was scanned across the surface. By analyzing a line scan of the measured topography using a Fourier transform, the average spacing between carbon atoms was determined to be 225 pm. Three techniques were used for making tunneling tips: a mechanical cutting process and both single-step and three-step electro-chemical etching processes. Probe manufacturing success was gauged by comparing the contrast of topography images of the HOPG surface. The best quality image had a Root-Mean Square (RMS) value of 0.02 nm. Lower RMS values indicated higher-quality images. An image with an RMS value 0.11 nm resulted in less image contrast. Chemically etching the tips yielded smaller RMS values. Interestingly, a single-step electro-chemical etching process provided the best results, rather than applying additional etching steps that are outlined in the literature.

Introduction

Since 1986, Scanning Tunneling Microscopy (STM) has changed mankind's perception of matter. Today, scientists can not only measure distances billions of lightyears away to the most distant galaxy, they can also measure extremely small distances on the opposite end of the measurement spectrum. Through STM, scientists measure atomic arrangements on the scale of nanometers. Many STM experiments are performed in a vacuum environment and often in cryogenic temperatures [10]. Under these conditions, image contrast is superb, allowing measurements of nanometer sized samples. In this work, arrangements of carbon atoms on the surface of HOPG (grade ZYH) samples is investigated under ambient conditions. To replicate STM measurements under ambient conditions, both the surface under study (graphite) and the probe used to make measurements with atomic resolution, must be chemically-inert and pristine throughout the course of the experiment. A platinum-iridium (Pt-Ir) wire is carefully manufactured to make probe tips. These Pt-Ir tips are used in the microscope as the source of tunneling electrons into the sample. Tunneling [4] is the phenomenon that is used to make observations of atomic arrangements on the HOPG surface. To achieve atomic resolution, the tunneling tips must have a single protruding atom that is the main source of electrons. The electrons tunnel into empty orbital states that belong to the atoms on the HOPG surface [10].

We applied three techniques to make probe tips: manually cutting the wire with Erem Magic Cutters 612N [4] and chemically etching the wire through both single-step and three-step, electrochemical processes [5]. In this experiment, we analyze and compare the techniques for manufacturing tunneling tips.

Data taken with each type of prepared tip helps to compare which technique is best for achieving atomic resolution. Chemically etching the tip with the three-step process [5] is believed to be the best method for manufacturing usable tunneling tips, but in this experiment, the experimenters concluded that all three steps were not necessary for producing a usable tip. A refinement of step one in the electro-chemical etching process was sufficient to make a suitable tunneling tip (FIG. 1).

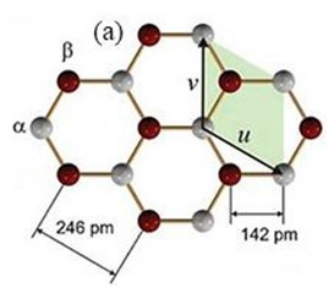


FIG. 1: (a) A model of atomic spacing from [7].

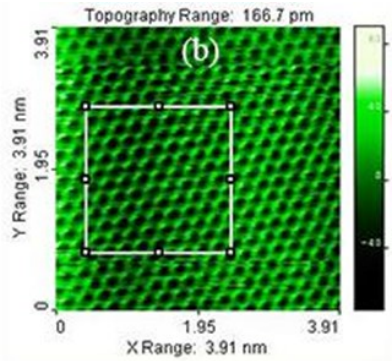


Figure 1: (b) Raw data taken with the chemically etched tip that went through the refined process.

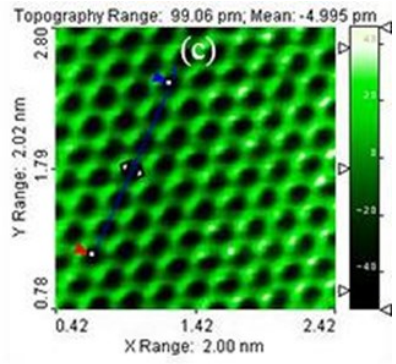


Figure 1: (c) A 2 nm x 2 nm zoom in of the raw data. The line in this picture correlates to a line scan in part (d)

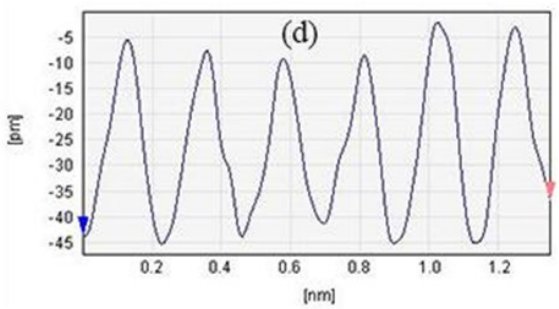


Figure 1: (d) Where an RMS value of approximately 0.0174 nm is calculated . This is a graph of height vs. distance.

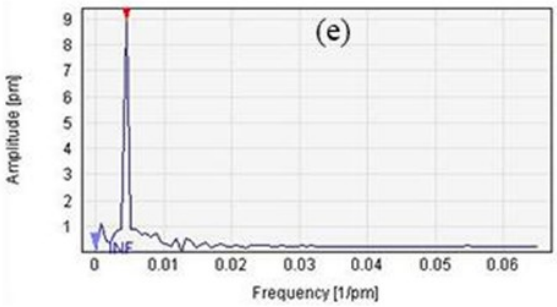


Figure 1: (e) The Fourier transform of the line scan in part (d). The Fourier transform in part (e) plots amplitude against frequency.

Materials and Methods

The evidence for achieving atomic resolution can be seen in Figure 2. A line scan of a 250 nm x 250 nm image of a HOPG surface was the first data to be measured by the microscope. This data shows that it is possible to measure distances in the nanometer and picometer range. The dark step in the lower right corner was measured to be approximately one nanometer. Measurements like the one in Figure 2 led the original inventors to believe that some of the tiniest entities in existence could be measured using STM [1]. Although some STM instruments involve elaborate vacuum systems and cryogenics, this experiment involved using the STM under ambient conditions operating at room temperature and atmospheric pressure [8].

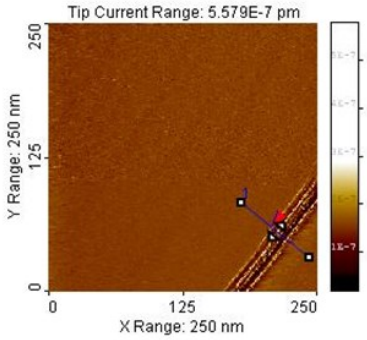


Figure 2: Continued on next page

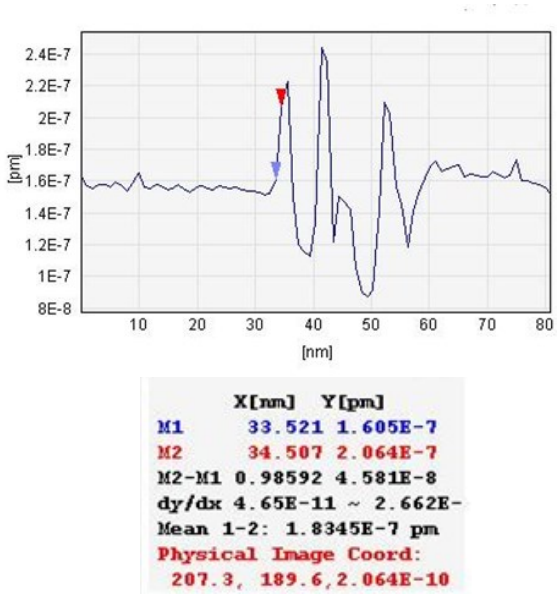


Figure 2: Nanometer size step with data confirms the STM's ability to measure nanometer and sub-nanometer sized steps and spacing.

One of the main aspects of the STM process is manufacturing tunneling tips for the experiment because STM requires a fine tip to scan a metal surface. For this experiment, a platinum-iridium alloy wire was used for tip construction. The first tip used was mechanically cut [6]. Figure 3.b. shows an optical microscope image of a mechanically cut tip. To make this tip, a pair of flat-nose pliers was used for gripping a piece of Pt-Ir wire that was approximately 4 mm long. While holding the wire firmly, a pair of Erem Magic Cutters 612N was held at the most oblique angle possible relative to the flat-nose pliers. The cutters were closed on the wire at the instant that the wire was pulled away, such that the end of the wire was pulled/ripped off [6]. Cutting, or ripping, the Pt-Ir wire in this manner provided measurable results. The observed data was chiefly atomic arrangements on HOPG samples. Before measuring the data from each HOPG sample, a small piece of Scotch tape was applied to the surface of the sample to remove the top layer; this resulted in a pristine layer on the sample by removing some of the impurities of the surface. This method can be used to exfoliate a single layer of graphite atoms called graphene, (this was the subject of the 2010 Nobel prize in physics [9]). The sample holder was driven slowly to within a tunneling distance of a few tens of nanometers by an inertial motor within the STM apparatus. The inertial motor moved the sample holder by a fraction of a micrometer per each advance during the final approach mechanism [7]. Tunnel current and image parameters were controlled through Nanosurf software that also provided a means of changing tip voltage, scan velocity, and Proportional Integral Derivative (PID) feedback gain parameters [7].

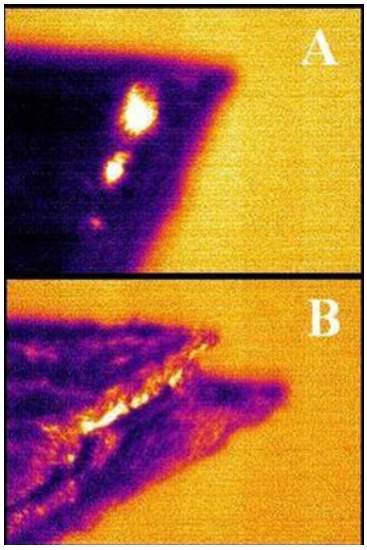


Figure 3: (a) The original wire before a cut or etching has been made. (b) The wire cut with Erem Magic Cutter 612N.

The next tip manufacturing process utilized was a chemical etching process. The apparatus included a variac (variable autotransformer) for regulating AC Voltage, .25 mm diameter Pt-Ir wire, a 150 ml, 1.5 M solution of $CaCl_2$ in 150 ml deionized water, and a graphite counter electrode. The variac was connected to the Pt-Ir wire which was held in the solution by a metal alligator clip with the counter electrode approximately 3 cm deeper than the wire. The AC voltage was varied from 25 V – 40 V [5]. In this experiment, it was found that the best tip was made by changing the voltage during this step. A starting value of 35 V was used and after approximately 90 sec, the voltage was increased to 40 V. Without the increase, a burly starn (spherical boss) was formed on the end of the tip as shown in Figure 3c. Increasing the voltage resulted in a loss of the burley starn at the end and a visible sharpening as shown in Figure 3d.

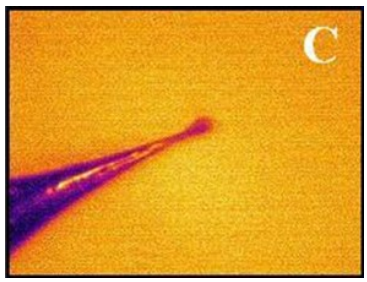


Figure 3: (c) The first stage of the etching process.

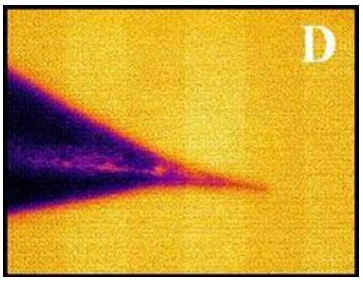


Figure 3: (d) A picture of the tip after the final etching; this is the finished product.

In the original electro-chemical process, after the first stage, the new tips had a thinner, droplet-shaped burley starn at the end [5]. The burley starn was removed in stage 2. In stage 2, the tip was bent at a 90º angle approximately 2-3 mm above the tip point and inserted into a second chemical solution using a similar setup including a graphite counter-electrode. The second solution was 25 ml deionized water, and 200 ml of 98% H_2SO_4. In this stage, a more complex waveform was applied to the tip. The waveform was a rectangular wave at a frequency of 4 kHz, with a duty cycle of 16%, at +10 V in the "on" state and -0.5 V for the "off" state. This waveform was applied for approximately 5-10 minutes to make the burley starn fall off while leaving behind an etched point. Then to prevent further etching, a DC voltage of -1.1 V was applied. For polishing the etched tip, the complex waveform was applied for an additional 10 sec to the process. The final stage consisted of dipping the tip back in the sulfuric acid and applying -1.1 V DC to the tip for two minutes to remove a layer of oxide formed during the previous stages [5]. After this, the Pt-Ir wire was straightened and placed in the STM. The wire was washed with deionized water after each stage.

Results

Image size, time per line, data points per line, current, gain, and tip voltage were varied in the Nanosurf software that controlled the STM. The optimum parameter to achieve atomic resolution was scanning 256 points per line at approximately 0.2 sec per line. A gain control, proportional (P-gain) and integral (I-gain), was used to determine feedback strength and reduce noise in the images. The best images had a setpoint current of one nanoamp and 100 mV tip voltage, a P-gain of 900, an I-gain of 200, and a D-gain of zero (Figure 1(b)). A setpoint current of one nanoamp means that 10^{10} electrons are flowing between the tip and sample each second. The tunneling tip was the only variable changed in this comparison study. The HOPG sample, the electronics, external vibrations, the transducer, and thermal drifts were constant throughout the experiment.

The single-step chemically etched tip produced much better results than those that were mechanically cut. In Figure 4, images (a), (b), and (c), taken with mechanically cut tips, were compared to image (d). Image (d) was taken with the chemically etched tip that went through the refined electro-chemical process.

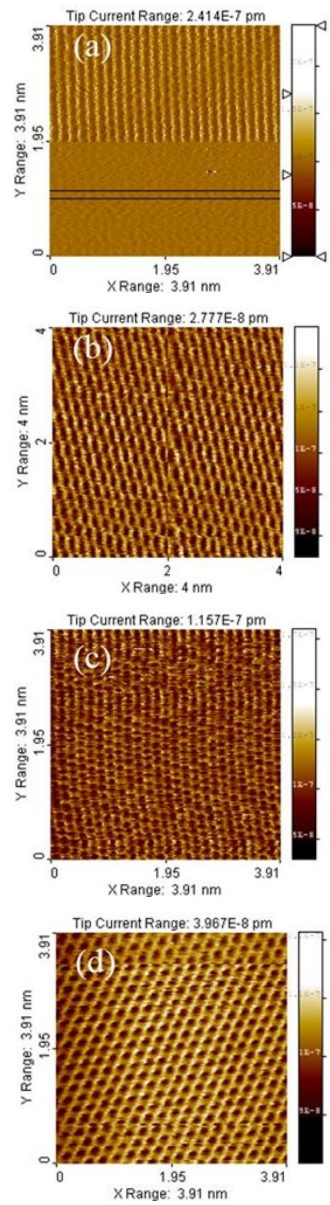
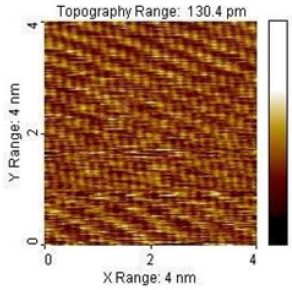


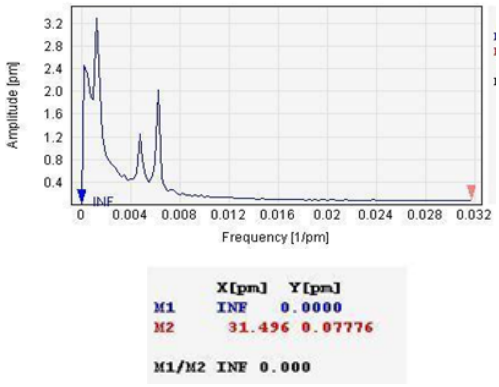
Figure 4: (a) Data taken with one of the first mechanically cut tips. (b) and (c) show how data improved with more practice in mechanically cutting the tips. (d) data taken with the chemically etched tip that went through the refined electro-chemical process.

Data taken with tips that were manufactured through all three stages of the electro-chemical process did not yield significant results (Figure 5). The data with the best contrast (Figure 1) was taken with a tip that went through the refined process; however, the same results could not be replicated afterwards. The stark contrast between the roughness of Figure 5(d) and smoothness of Figure 1(d) was immediately noticeable. In Figure 1(a), β atoms, which are the voids in Figure 1(c), are spaced approximately 246 pm apart. According to the Fourier transform in Figure 1 (e), the spacing calculated in the data from this experiment was approximately 225 pm. The RMS value obtained from the raw data in Figure 1b. is approximately 0.02 nm which supports the conclusion that a smaller RMS value leads to better contrast in the picture.

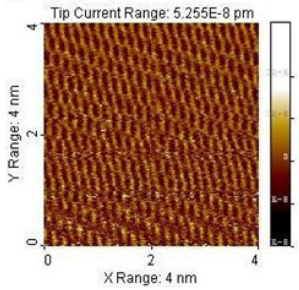
(a)



(b)



(c)



(d)

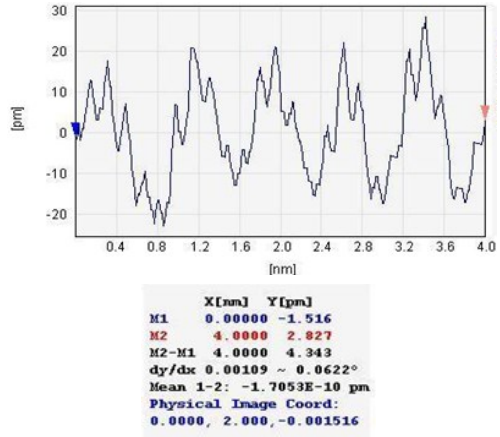


Figure 5: Data taken with a tip that was manufactured through all three steps of the electro-chemical etching process. This data can be compared to Figure 1: (a) Raw data taken with a chemically etched tip that went through all three steps of the electro-chemical process. (b) Amplitude vs frequency graph. It can be compared to Figure 1(e). (c) Tip current range image. (d) Line scan from Figure 5(a) and can be compared to Figure 1(d). The tunneling tip that went through the refined process yielded a more significant result than tips that went through all stages of the electro-chemical process.

Conclusions

The analysis of cutting Pt-Ir tips for STM was ultimately a combination of both mechanical and chemical cutting techniques. The experiment was conducted in a laboratory that was subject to various sources of error out of the control of the experimenters. For example, external vibrations and thermal drifts in and outside of the laboratory resulted in the STM distorting the image in the scanning process. The parameters, mainly the P-gain and I-gain, were fined tuned to control the noise. The direct measurement of atom spacing on the graphene surface was quite remarkable in itself (Figures 1(a), 1(c), and 1(d)). For reference, that is one of the smallest measurements that exists (approximately 0.000000000225 meters, or 225 picometers ~ .225 nanometers). During the original electro-chemical process, it is possible that errors were made in manufacturing the electric circuits especially when creating the complex pulse circuit mentioned in the methods and material section [5]. For example, the timing of the +10 V AC pulse could have been off by a few microseconds. The square wave

pulse could have been more, or less, than +10 V AC as well. Furthermore, observing a burley starn drop-off during the second-stage when the tip is bent approximately 90º was extremely hard and required a large lens to magnify the event since the burley starn is microscopic.

In the future, it would be interesting to see if the refined electro-chemical process could be replicated to provide a more economical and less complicated tip manufacturing process. It would also be interesting to chemically etch tips using different chemical solutions and investigate whether tips for STM could be produced more rapidly.

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Examining the Effectiveness of the Buzzy to Decrease Pain in Children Receiving an Immunization

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In healthcare settings, children often fear needles and the pain associated with them. Different interventions aim to reduce this fear and pain. Buzzy is a bee-shape, battery-operated vibrating device with an attachable ice packet to provide cooling effect. The vibration and cooling sensation stimulate the nerves between the injection site (i.e., upper arm or thigh) and the brain. This stimulation can help minimize a child's pain and anxiety. The purpose of this study is to examine the effectiveness of the Buzzy in reducing children's pain when receiving injections during doctor visits. In the study, 100 children, ages 4 to 12, who were receiving an injection were randomly placed in either the Buzzy intervention group or a control group. For the participants in the Buzzy group, a Buzzy device was placed on the child's arm between the brain and site of injection. The control group received standard care (i.e., no psychosocial intervention). Prior to the injection, parents completed a demographic questionnaire. During the injection, a research assistant rated the child's pain using observation scales. After the injection, the child was asked to rate his or her pain level during the injection using an analogue scale of faces and parents rated their child's perceived pain level using an observation scale. Results from the children, parents, and research assistants showed there were no differences in recorded pain levels between the two groups. For parental reports of their children's pain, there was significantly higher scores of pain reported by parents of girl participants compared to parents of boy participants (p =.003). Furthermore, children between 4 and 7 verbalized their pain more frequently and complained the pain was of a higher severity when compared to the older children, ages 8 to 12. In this study, the Buzzy was not effective in reducing pain in children receiving an injection.

Introduction

Children are often required to undergo routine injections such as immunizations and blood draws, to establish long-term physical health and wellness [20]. However, the pain associated with these routine procedures can have a lasting negative impact on a child's psychosocial state [12]. Fear of needles, including blood draws and injections, is one of the most common specific fears amongst children [13]. Early experiences, such as immunizations as an infant, have been correlated with more pain and anxiety during subsequent healthcare encounters later in life. [12]. Additionally, children that develop needle phobias in early childhood tend to associate fear and anxiety with all healthcare professionals and experiences [3]. Hence, healthcare professionals need to address the impact early painful events, such as receiving an injection, can have on children's ability to cope with future painful experiences. Studies have shown that parents' childhood fear of the pain associated with injections may lead them to refuse vaccinations for their own children. [12]. Many pharmacological interventions have been approved to help ease pain during an injection, including topical anesthetic creams, topical anesthetic sprays, and jet-injected lidocaine (j-tip) [7,17,18]. However, each of these interventions can take up valuable time and staffing resources in a healthcare setting.

There are non-pharmacological interventions that can be used to ease the pain of injections that do not take up limited time and resources. These methods, including comfort-holding from parents, introducing a distraction, and thermomechanical interventions such as the Buzzy, can have lasting impacts on a child's relationship with both needles and healthcare experiences.

Buzzy is a non-pharmacological intervention that utilizes the gate-theory to block off the pain that a child would feel during an injection [5]. Gate-theory states that pain travels from the initial site to the brain through gates which must be open for nerves to propagate the signals along the nervous system [19]. If a gate higher on the pathway than where the pain originates from is blocked, the brain would theoretically not feel the original source of the pain. Buzzy accomplishes this by using a combination of vibrations and cold sensations from an ice pack which is placed between the source of pain and the brain. [19].

There are few studies that assess the effectiveness of the Buzzy intervention on pediatric patients undergoing an injection. One study showed that during a routine TDaP vaccination, 73% of seven-year -olds reported less pain with the Buzzy than without [16]. Another study found that adult patients who received the Buzzy during an IV insertion had a less painful experience than those without the Buzzy[1]. However, there is no comprehensive study that looks

at the effectiveness of the Buzzy across a wide age-range of children and with a variety of administered injections. The purpose of this study was to evaluate the Buzzy's impact on reducing pain associated with routine injections in pediatric patients ages 4 to 12. It was hypothesized that children who receive the Buzzy intervention would report less pain and have less perceived pain during injections. It was also hypothesized that parents and guardians of children who receive the Buzzy intervention would report a higher satisfaction with their healthcare professionals.

Materials and Methods

Participants

One hundred parent-child dyads were enlisted in the study following institutional review board approval. The children were visiting the Pediatric Clinic at the University Medical Center in Tuscaloosa, Alabama to receive an injection. The children's ages ranged between 4 and 12 years of age (M=6.98; SD=2.45). The children's ages were distributed with 58.2% (n=57) between the ages of 4-7 and 41.8% (n=41) between the ages of 8-12. 51% of the participants were male (n=51) and 47% of the participants were female (n=47). The following ethnicity distribution was observed: 26% Caucasian (n=26), 53% African American (n=53), 10% Hispanic (n=10), 1% Asian (n=1), and 5% other (n=5). The families were predominantly lower in socioeconomic status.

Procedure

A member of the research team approached prospective participants in the waiting area to receive parents' consent for their child to participate in the study. Inclusion criteria were English-speaking children between the ages of 4 and 12 who were receiving an injection via the arm or thigh. Exclusion criteria included children with neurodevelopmental or language delays that would impede their ability to self-report, children who have skin wounds in the treatment area (e.g., exposed skin or abrasions that would be irritated by the Buzzy device), children who had been administered an analgesic within the last 4 hours, and children with sensory processing disorders.

Participants were randomly placed into either the Buzzy group (n=49) or the control group (n=51) using random sample numbers generated by a computer software program, randomizer.org. Following the random assignment, parents completed a demographic questionnaire while waiting for the nurse to prepare the injection. The study was conducted in patient exam rooms after the children were triaged (i.e., blood pressure, weight, temperature, and height measured) and visited by the doctor and/or nurse. During the injection, a non-observing researcher either provided minimal distraction (i.e., talking, asking questions) or implemented the Buzzy distraction.

In the Buzzy group, a researcher utilized the Buzzy. Once in place, the vibrations were turned on, and the device was held in place for 30 to 60 seconds. The nurse then administered the injection close to the bottom end of the Buzzy. The Buzzy was removed from the arm after the injection. In the control group, the children received standard care without the Buzzy and received minimal distraction (i.e., talking or asking questions) during the injection.

Background/Demographic Questionnaire

This questionnaire gathered information of parents' ethnicity, age, marital status, education level, and occupation and the children's age, ethnicity, gender, and medical history.

FACES Pain Rating Scale [21]

The FACES pain rating scale assessed children's self-reported level of pain during the injection. The FACES scale has been found to be reliable and valid for children ages 3 and above [21]. After the injection, children were shown a scale of faces, fluctuating from no hurt, very happy (0) to hurts as much as you can imagine (5). The researcher pointed and explained each of the faces to the participant (i.e., face zero was smiling because they had no hurt, face three hurts some, and face five hurts as much as you can imagine). The researcher then asked the children, "Which face shows how much hurt you had during your injection?"

FACES Pain Scale-Revised (FPS-R) [9]

The FPS-R is an assessment of children's level of pain during injections using a scale from 0 to 5. FPS-R was utilized by both the parent and the observer researcher (e.g., a different researcher than the one holding the Buzzy and assessing the child's self-reported pain). The FPS-R has been found to be a valid and reliable tool for assessing pain and is frequently used as a pain assessment tool for children [9]. After the injection, the parent and observer researcher were shown six faces with a description stating the first face represents no pain (0) and the last face represents very much pain (5). Parents and the researcher were each asked to circle the face which represented the child's level of pain they observed during the injection.

Behavioral Observation Pain Scale (BOPS)

The BOPS was used by the observer researcher to assess the child's level of pain during the injection. The BOPS is a valid and reliable tool for assessing children's pain [8]. It assessed pain using the three variables of facial expression, vocalization, and body movements, which are indicative of pain in children. The researcher was shown a description of behaviors for each score for each variable and was asked to pick the closest descriptor of the child's behavior. The observer researcher then scored the child on these three variables, immediately after the injec

tion, on a scale of 0 to 2, with higher scores suggesting more pain-associated behaviors. Total pain scores were obtained by adding the child's score from each variable; possible scores ranged from 0 to 6, with higher scores indicating more pain. A score above 2 suggests the child is in pain [8].

Parent Satisfaction

The parent satisfaction questionnaire is a self-report of parent satisfaction with the injection. After the injection, the parent was asked to rate the following questions: "How satisfied were you with the outcome of the procedure?" and "How satisfied were you with the child's behaviors during the injection?" on a scale of 0 (not at all) to 5 (very much).

Analysis

This study examined the effectiveness of the Buzzy intervention in reducing pain in children receiving injections. Descriptive information was obtained through frequency and distribution analyses. Independent samples t-tests were conducted to compare each groups' reported pain levels.

Results

Children's Pain

The children's pain was measured through a self-report assessment (i.e., FACES), a behavioral observation measure (i.e., FPS-R) completed by the parent, and two behavioral observation measures (i.e., FPS-R & BOPS) completed by an observer researcher. Independent samples *t*-test was used to compare the differences in self-reported pain and observed pain during the injection between the experimental group and the control group No significant differences were found between the group utilizing the Buzzy and the group receiving standard care on the child's self-reported pain ($p = 0.92$), parent observation of pain ($p = 0.67$), or research assistant observed pain ($p = 0.81$), using the FPS-R. In addition, no significant differences were found between groups on the BOPS utilized by the researcher observer ($p = 0.60$). These findings suggest the Buzzy intervention did not decrease children's pain while undergoing injections when compared to a control group.

Parent Satisfaction

To assess parents' satisfaction with the use of the Buzzy versus standard care, the parents were asked to answer: 1) "How satisfied were you with the outcome of the injection?" and 2) "How satisfied were you with your child's behavior during the injection?", with a score of 5 suggesting very satisfied. Independent samples *t*-test was used to examine differences between control group and experimental group satisfaction scores. No significant difference was found for either satisfaction with the outcome of the injection ($p = 0.72$) or satisfaction with child's behaviors ($p = 0.98$). These findings suggest the Buzzy did not increase parent satisfaction with injection procedures.

Gender Differences

Gender differences in reports of injection pain have previously been found [4]. This study also explored gender differences. An independent samples *t*-test was used to examine differences between gender on self-reported pain (i.e., FACES) and parents' reports of pain behaviors (i.e., FSP-R). No significant difference was found for self-reported pain by the children between genders ($p = 0.24$). However, there was a significant difference between genders on parents' reports of pain. Parents reported girls ($m = 5.53$, $sd = 3.64$) displayed significantly more pain than boys, ($m = 3.56$, $sd = 3.64$, $t(95) = 2.61$, $p = 0.01$).

Age Differences

The current study also explored the possibility of age differences in pain during injections. Children were grouped into two age cohorts, either 4 to 7 or 8 to 12. Independent samples *t*-test was used to examine age differences relating to pain. Parents did not report a significant difference between ages on pain ($p = 0.18$). However, there was a significant difference between ages on children's self-reported pain and the observed pain by the observer researcher (i.e., FSP-R). Younger children, between the ages of 4 and 7, self-reported significantly more pain experienced during the injection ($m = 4.32$, $sd = 4.42$) compared to older children, ages 8 to 12, ($m = 2.15$, $sd = 2.62$, $t(95) = 2.77$, $p = 0.007$). The observer researcher observed significantly more pain was experienced by the younger children ($m = 4.32$, $sd = 4.42$) than the older children ($m = 3.1$, $sd = 2.83$, $t(95) = 2.81$, $p = 0.006$). These findings suggest younger children may display and report more pain than older children when receiving an injection.

Discussion

The purpose of this study was to examine the Buzzy's effectiveness on decreasing pain during injections. It was hypothesized that children who received the Buzzy intervention would self-report less pain than children in the control group, but that was not observed. There was no significant difference in self-reported pain between the control group and the Buzzy group. Additionally, indications of pain level were consistent between the child, parent, and researcher, which further suggests that the Buzzy was not effective at reducing pain during an injection. These results were unexpected considering previous studies have shown a reduction in pain levels during similar needle-involved experiences, such as IV insertions [16, 14].

There have been no other studies that support the findings that Buzzy is ineffective at reducing pain during needle sticks. However, none of the previous

studies looked at intramuscular (IM) injections. The studies that support Buzzy's effectiveness were all for peripheral needle sticks, such as IV placements and lab draws. Further research must be conducted to evaluate Buzzy's effectiveness on IM injections versus peripheral needle sticks due to the different sensations that occur.

It was also hypothesized that parents of children in the Buzzy group would report higher satisfaction with their child's care than parents of children in the control group. Again, our findings did not support this hypothesis since there was no significant difference between parent satisfaction amongst the control group and the Buzzy group. These results could be due to parents being normalized to a child's behavior during an injection and, therefore, rating a high satisfaction with the control group. One study that examined the use of J-tip combined with the Buzzy found that parent satisfaction was higher with pain management interventions than without, but this study does not examine parent satisfaction with the Buzzy alone [11]. However, a different r study found that parent satisfaction was not increased with the use of the Buzzy versus without, supporting findings from this study [15]. Thus, more research must be done to conclude that the Buzzy is ineffective at increasing parental satisfaction with care during immunizations.

One secondary finding of this study is that younger children, between the ages of 4 and 7, self-reported and were perceived to experience more pain during injections than older children, ages 8 to 12. Parents feel similar sensations of pain and anxiety as their children when watching their child undergo a pain-inducing experience, such as injections [12]. Therefore, the pain that the parent felt while watching their child receive an injection may have influenced their scoring of their child's pain, resulting in a higher score due to parental bias.

There have not been any studies that examine the differences in pain levels between younger and older children, so these results cannot be supported via existing literature. Further research will need to be conducted on pain perception in various age groups to support these findings.

Another secondary finding was related to gender. Gender differences were found in parent-observed pain. Parents observed and reported higher levels of pain in girls than boys. A previous study of children 3-12 years showed gender differences in self-reported pain, with females reporting significantly more pain than males [6]. In another study, girls were rated as experiencing more pain than boys during bone marrow aspirations [10]. These results could be tied to societal gender norms, specifically the expectation that males should show little pain while girls should be more sensitive.

Limitations

Limitations include a lack of generalizability to other pediatric units and a small sample size. Since data was only collected at one pediatric office, the ability to generalize the findings to other pediatric settings may be limited. Additionally, a larger sample size would have been more representative of the population.

Another limitation is variability in the number of injections children received. Since this factor was not controlled, some participants received a single injection while others received multiple. A child receiving more injections could have reported pain differently than those receive one. If the study were to be replicated, a control for the number of injections should be implemented. Lastly, the study included five research observers who assessed pain using the behavioral observation scales. The use of multiple observers increases the potential for variability among scoring. This could have potentially influenced the outcome, and future studies should take measures to minimize observational bias.

Conclusion

Although previous studies suggest the effectiveness of the Buzzy in children receiving IV's and blood withdrawals, this study did not find significant benefits in utilizing the Buzzy during intramuscular injections. In addition, it was found that younger children and girls display more pain. Such findings could imply that parents and healthcare providers should be aware that these groups may be more vulnerable to pain associated with injections and require greater support during such procedures. Secondary findings from this study show that younger children experienced more pain with injections than did older children, and that parents tend to perceive their female children as experiencing more pain during injections than male children. Future studies should be conducted to compare Buzzy's effectiveness to other nonpharmacological pain relief options such as visual aid blocks (i.e. virtual reality goggles). Additionally, more research must be done to assess pain differences in younger versus older children, as well as discrepancies in parental perception of pain in male versus female children.

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Inhibitory Effect of Tea on the *in vitro* Enzymatic Digestion of Starch

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Previous studies of phenolic compounds have demonstrated their ability to decrease the rate of starch hydrolysis by inhibiting digestive enzymes for starch. A major implication of such inhibition is a slowed rate of starch digestion into glucose, which thereby reduces a sudden rise in blood glucose level after a starchy meal. Tea, rich in phenolic compounds, has been widely reported for its beneficial health effects. Accordingly, this study explored the inhibitory abilities of four types of tea, i.e., green tea, oolong tea, black tea, and white tea, on the in vitro enzymatic digestion of potato starch (PS) and high-amylose maize starch (HAMS). The in vitro digestion was carried out in simulated intestinal fluids and the reducing sugar content released from digestion was measured at 1 h and 2 h using the 3,5-dinitrosalicylic acid assay. Total phenolic content (TPC) in the teas was determined using the phenolic-binding Fast Blue BB assay. Results showed that the TPCs in green tea and oolong tea were significantly ($P<0.05$) higher than those in black tea and white tea. Yet, all teas demonstrated significant inhibitory effect on the digestion of both starches. No significant difference in the inhibition was found among these teas, except that green tea showed higher inhibition on HAMS digestion at 2 h. It was also noticed that both starches were digested to the same extent after 2 h of digestion, but at different rates. At 1 h, the extent of HAMS digestion was significantly higher than that of the PS, possibly due to its higher content of amylose, which is more soluble than amylopectin and thus more accessible by the digestive enzymes. In conclusion, our results suggested that tea, regardless of its type, can slow down enzymatic digestion of starch and therefore imply a potential benefit for controlling postprandial hyperglycemia.

Introduction

Starch is a polysaccharide comprising of a large number of glucose units linked by α-glycosidic bonds. Depending on how the glucose molecules are linked together, two types of polymers exist in starch, i.e., amylose and amylopectin. Amylose is strictly linear, while amylopectin contains linear chains and branches. Found in large amounts in staple foods, e.g., wheat, maize (corn), rice, and potatoes, starch is the most common dietary carbohydrate and serves as a major source of energy in human diets. In the gastrointestinal tract (GIT), starch is digested by a series of enzymes into glucose for absorption. The kinetics of starch digestion and that of glucose release/absorption as the energy source for the body determine the nutritional quality of starch. Rapid starch digestion may cause postprandial hyperglycemia and hyperinsulinemia cycle, which is involved in a series of metabolic diseases including metabolic syndrome, obesity, type 2 diabetes, and cardiovascular diseases. Starch in certain foods, especially heavily processed foods (e.g. refined flour), can be rapidly digested, which will raise the blood glucose level quickly. On the contrary, certain starch portions, e.g., slowly digestible starch and resistant starch, are slowly digested or even indigestible, and cause a slower and steadier rise in blood glucose level.

While the structure of starch greatly dictates its rate of digestion, another critical factor is the activity of α-amylase in the GIT, which is one of major enzymes responsible for starch digestion. It is present in the mouth as salivary α-amylase and in the small intestine as pancreatic α-amylase [1]. Recent studies have demonstrated the ability of phenolic compounds, a large class of plant secondary metabolites, to inhibit the activity of α-amylase and thus slow the rate of starch digestion. A natural and abundant source of phenolic compounds is tea, which is also known to confer other health benefits such as antioxidant properties.

Previous studies that examined the effect of tea polyphenols on starch digestion showed inconsistent results. For instance, Sun, Gidley, and Warren (2018) [2] showed that tea polyphenols inhibited pancreatic α-amylase activity, and Kwon et al. (2008) [3] reported that black, green, and oolong tea had a mild inhibitory effect (ranging from 35 to 40 percentage inhibition) on pancreatic α-amylase. On the contrary, Yang and Kong (2016) [4] found the same teas to enhance the enzymatic activity. This study, however, also found that high concentrations of isolated tea polyphenols mildly inhibited α-amylase activity.

Despite the invaluable foundation set by previous studies, discrepancies clearly exist regarding the effect of tea and tea polyphenols on α-amylase activity and starch digestion. Therefore, this study was to further investigate the topic with a multifaceted approach to assess the effects of different teas, more

specifically, green (GT), black (BT), oolong (OT), and white (WT) teas, on the digestion of two types of starch, i.e., potato starch (PS) and high-amylose maize starch (HAMS). The total phenolic content in the teas were determined for possible correlation with their inhibitory effects. The two starches with different amylose contents (approximately 25% and 80% (w/w) in PS and HAMS, respectively) were used to assess the possible consequence of differing amylose content in starch.

Materials and Methods

Materials

High amylose maize starch (HAMS; Gelose 80) was kindly provided by Ingredion (Bridgewater, NJ, USA). Potato starch (PS), maltose, and 3,5-dinitrosalicylic acid, urea, lipase, porcine pancreatin, and porcine bile extract were purchased from Sigma-Aldrich, Inc. (St. Louis, MO, USA). Potassium sodium tartrate tetrahydrate, sodium phosphate monobasic, sodium phosphate dibasic, sodium chloride, sodium bicarbonate were purchased from VWR chemicals, LLC (VWR chemicals, Solon, OH, USA). English breakfast black tea (BT) and green tea (GT) (Twinings©) were purchased from a local grocery store. White tea and oolong tea were from grocery stores in Anxi and Anji (Fujian, China), respectively.

Brewing of tea samples

Four types of tea leaves (1.0 g) were brewed with 40.0 mL of boiling deionized (DI) water for 20 min, cooled to the room temperature (20 °C), filtered with Whiteman No. 4 filter paper, and labeled as GT, BT, OT, and WT, respectively.

Determination of total phenolic content

The fast blue salts BB assay was adopted to determine the total phenolic content in the brewed tea samples according to Lester et al [5]. In detail, 1.0 mL of 100-fold diluted tea samples was mixed with 1.0 mL of 0.1% (w/v) Fast blue BB for 30 s, followed by adding 0.1 mL of 5.0% (w/v) NaOH. The mixture was stirred with a vortex mixer and incubated for 90 min under light at room temperature (20 °C). After that, absorbance was measured at 420 nm using a Mettler Toledo UV5Bio UV-vis spectrophotometer (Mettler Toledo, Columbus, OH, USA). Gallic acid standard solutions were used to establish the standard curve and results were expressed as milligram of gallic acid equivalents (GAE) per gram of dried weight of the tea samples.

Pancreatin in vitro digestion

Two types of starch, PS and HAMS, were subject to in vitro digestion with and without the presence of brewed teas according to the method outlined by Flores et al [6]. Specifically, 1.0 mL of each tea sample was added with 0.5 g of starch sample in a 50 mL test tube, followed by adding 6.0 mL of simulated intestinal fluid and 3.0 mL of bile fluid. The compositions of simulated digestive juices were shown in Table 1. As a control, 1.0 mL of DI water was added instead of brewed tea. In order to account for the interference in absorbance measurements by particles other than sugar (e.g., digestive fluid components and tea residuals), a blank that contained neither starch nor tea was used. The digestion trials were conducted in an orbital shaking water bath at 37 °C with a shaking speed of 160 rpm for 2 h to simulate the motion and temperature of human intestinal digestion. At 1 h and 2h of digestion, 0.5 mL aliquots were collected and immediately placed in a boiling water bath for 10 min to deactivate the enzymes and halt the reaction.

Simulated intestinal juice	Bile juice
500 mL DI water	500 mL DI water
7.012 g NaCl	5.259 g NaCl
0.564 g KCl	0.376 g KCl
3.388 g $NaHCO_3$	5.785 g $NaHCO_3$
80.0 mg KH_2PO_4	0.25 g Urea
50.0 mg $MgCl_2$	15.0 g Bile salts
0.1 g Urea	
9.0 g Pancreatin	
1.5 g Lipase	

Table 1: Compositions of simulated digestive juices.

After the reaction was terminated, each sample was centrifuged at 2700 g for 3 min and the supernatant was then diluted to a proper concentration. The reducing sugar content was then determined using the 3, 5-dinitrosalicylic (DNS) colorimetric assay [7]. For the assay, 0.2 mL of the diluted samples was combined with 0.1 mL of DNS reagent. This solution was heated in a boiling water bath for 8 min, and allowed to cool to room temperature (20 °C). DI water (0.9 mL) was then added to each sample for further dilution. Absorbance was measured at 540 nm using a Mettler Toledo UV5Bio UV-vis spectrophotometer. Absorbance readings were subtracted by the reading of the blank sample to eliminate the interference of foreign particles on light scattering. The standard curve was established using maltose standard solutions and the results were reported as maltose equivalent (mM).

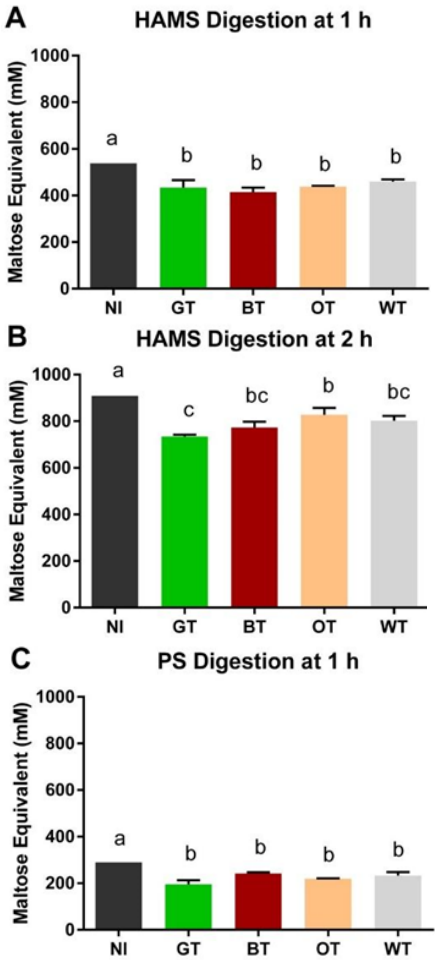
Statistical Analysis

All experiments were conducted in duplicates. Data were analyzed by one-way analysis of variance (one-way ANOVA) followed by Tukey multiple comparison test using the GraphPad Prism soft-

ware (San Diego, CA). The letters a, b, and c indicate statistically significant differences, $P < 0.05$ (a > b > c).

Results and Discussion

In order to evaluate the inhibitory effect of the four different teas on *in vitro* enzymatic starch digestion, two types of starch, i.e., PS and HAMS, which vary in their amylose content, were subject to simulated *in vitro* digestion with and without the presence of teas. The extent of starch enzymatic digestion after 1 and 2 h was measured by the amount of digestion product, primarily reducing sugars, released from digestion and expressed as maltose equivalent (Figure 1). Samples without tea served as a control that demonstrated the base starch digestion. All four teas, when compared to this control, displayed significantly ($P<0.05$) lower values of reducing sugar in the digestion of both starch types. An exception was noted for OT in PS digestion at 2 h. These results suggested that tea has an inhibitory effect on the digestion of starch by α-amylase.



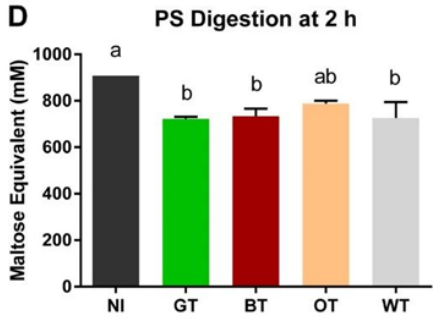


Figure 1: Extent of HAMS and PS digested, expressed as maltose equivalent, with and without the presence of teas after 1 h and 2 h of digestion.

The digestion of HAMS and PS proceeded to approximately the same extent by 2 h, but the digestion at 1 h was significantly lower for PS. This difference may be explained by the higher amylopectin content of PS. Compared with amylose, amylopectin molecules are much bulkier, highly branched and more densely packed in molecular arrangement. These properties make amylopectin more difficult to hydrate and be accessed by enzymes in the aqueous phase. Hence, the presence of more amylopectin in PS could have delayed the binding of α-amylase and its substrates, and thus lower the enzymatic digestion rate in PS.

Measurements for the total phenolic content of the teas demonstrate significant difference ($P<0.05$), except for between GT and OT (Figure 2). GT and OT contained the highest total phenolic content, while WT had the lowest. However, comparison of inhibitory ability on α-amylolysis showed no significant difference among the four teas (Figure 3). Furthermore, the inhibitory percentage ranged from 8.87% to 20.45% at 2 h of digestion. The lower limit indicates a particularly mild inhibitory effect. The inhibitory ability of the teas did not increase with their total phenolic content. Firstly, one possible reason is the diversity of phenolic compounds and their variance in inhibitory ability. Phenolic compounds are a large group of compounds derived from a phenol, and even within the same sub-group of phenolic compounds, their inhibitory effect may vary. For instance, the inhibitory effect of tannins [8] and proanthocyanins [9] both increased with molecular weight and degree of polymerization. The total phenolic content determined cannot reveal the structural diversity of all phenolic compounds in the teas. Secondly, it may also be attributed to other components in tea. For example, caffeine was reported to enhance α-amylase activity [10], while ions have been shown to generate varying effects on α-amylase activity. For instance, Aghajari, Feller, Gerday, and Haser (2002) [11] reported chloride ions to enhance α-amylase activity, while nitrate

ions had no significant effect. In relation to this theme, the content of chloride and nitrate ions in GT, BT, and WT have been found to vary significantly [12]. Accordingly, it is reasonable to speculate that the mild inhibitory effect exhibited in this experiment are a net result of the inhibitory effect of tea polyphenols and the augmenting effects of other tea components, such as caffeine and ions. Since the composition of the other components may differ among the teas, their compounding effects could also explain the lack of correlation between total phenolic content and inhibition percentage.

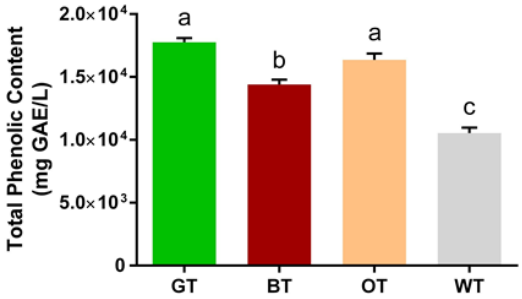
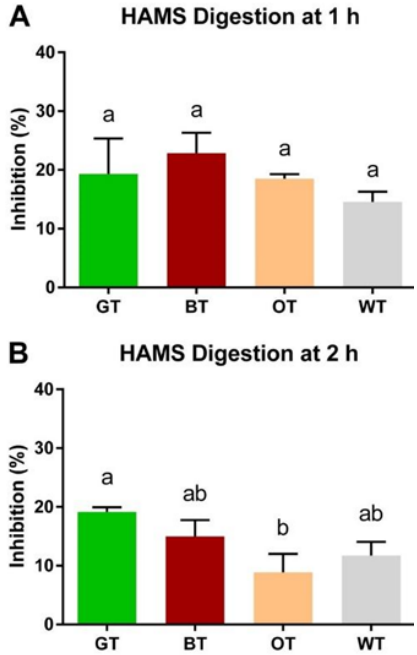


Figure 2: Total phenolic content, expressed as mg of GAE per liter of tea, in the four teas.



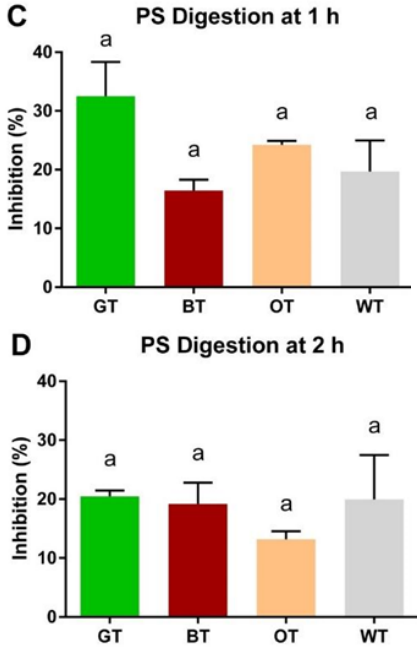


Figure 3: Percent inhibition of teas on HAMS and PS digestion after 1 h and 2 h of digestion.

Conclusion

The inhibitory effect of four types of teas, including green tea, black tea, oolong tea, and white tea, on the enzymatic digestion of potato starch and high amylose maize starch was evaluated using simulated *in vitro* digestion. All teas, regardless of type, were able to significantly decrease the extent of starch digestion by α-amylase. While the extent of digestion in both starches was the same at 2 h, the slower digestion of PS at 1 h may be a result of its high amylopectin content. The total phenolic contents in the teas were significantly different, expect for green and oolong teas, but could not predict the inhibition ability of the teas, which showed no significant difference. It was possibly due to the structural diversity of phenolic compounds and the presence of other compounds, such as caffeine and ions, that could alter enzymatic activity. Despite the interference of those other components, the net results of including tea in *in vitro* starch digestion by α-amylase appear to exhibit potential as a means of delaying starch digestion, glucose release and absorption and possibly preventing postprandial hyperglycemia.

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The Impact of Non-Qualifying Traumas on PTSD Research and Treatment Options

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The aim of this study was to determine whether the rate of Post-Traumatic Stress (PTS) symptomatology expressed by individuals with traumas not covered by Criterion A of the *Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) diagnostic criteria for Post-Traumatic Stress Disorder (PTSD) was significantly different from individuals whose traumas qualify them for a PTSD diagnosis. The data used in this research came from the Coping Power study conducted by Dr. John Lochman. The UCLA PTSD Index for DSM-IV, Life Experiences Survey, and Personal Demographic form gauged PTS symptomology, assessed the nature of the traumas, and investigated environmental factors in a cross-sectional study of adults. Participants were divided into three groups based on their answers to the PTSD Index: Non-traumatized, qualifying traumatized (QT), and non-qualifying traumatized (NQT). The QT and NQT groups' symptom endorsement rates were compared by item and Criterion Cluster. Based on numerous 1-way ANOVAs, individuals do not experience qualifying levels of symptom impairment or distress, though Independent Samples T-tests show insignificant itemized differences in certain Criteria and items that may call for further research. This result illuminates the potential for further study of specialized treatment programs for non-qualifying traumas and/or interitem reliability of the measures used.*

Introduction

Despite changing definitions in decades past, the Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria for trauma and Post-Traumatic Stress Disorder (PTSD) still fails to recognize all divisions of trauma [2]. Diagnoses such as Acute Stress Disorder (ASD), Subthreshold/Partial PTSD, and Complex PTSD (CPTSD) catch individual cases that align with the common PTSD category; still, many events do not qualify under the psychiatric standard. Individuals suffering from trauma symptoms are unable to receive proper treatment due to the subclinical nature of their traumas. This inattention leaves many at risk of issues resulting from untreated trauma symptoms, such as poor treatment engagement, increased substance abuse and suicidal ideation risks, poverty, chronic illness, and premature death [10]. Lack of acknowledgement and support compounds the distress and impairment caused by the initial sub-trauma [8]. This present research, in conjunction with the larger body of literature surrounding subthreshold forms of PTSD, aims to determine whether a significant population expresses clinically relevant rates of distress or impairment as a result of traumas not qualified by the DSM-5,potentially highlighting a significant need for treatment services in such a population..

Current DSM Trauma Criteria

The current DSM-5 diagnostic trauma criteria are split into Categories A through H, with Criterion A referring solely to the nature and circumstances surrounding the trauma [13]. For anyone age six and older, direct experience or witness to actual/threatened death, sexual violence, or serious injury fits Criterion A. Those who learn of some violent or accidental traumatic event occurring to a dear family member or friend also fit the updated criteria, as do those who are repeatedly exposed to extreme details of traumatic events, particularly in the workplace.

DSM Symptom Criteria

Criteria B through E categorize Post-Traumatic Stress (PTS) symptoms into re-experiencing, avoidance, negative thoughts or feelings that begin or worsen following a trauma, and trauma-related reactivity that begins or worsens following a trauma. Criterion B can include nightmares, flashbacks, emotional distress after exposure to traumatic reminders, and physical reactivity after exposure to traumatic reminders. Criterion C includes avoidance of trauma-related thoughts or feelings or any trauma-related reminders. Criterion D includes inability to recall key features of the trauma, as well as overly negative thoughts and assumptions about oneself or the world, an exaggerated blame of self or others for causing the trauma, negative or flat affect, a decreased interest in activities, feelings of isolation, and difficulty experiencing positive affect. Criterion E lists irritability or aggression, risky/destructive behavior, hypervigilance, a heightened startle reaction, difficulty concentrating and/or sleeping as behavioral symptoms.

Changes from DSM-IV to DSM-5

These criteria for traumatic events differ from those standardized by the earlier DSM-IV; unexpected death of a family member or friend due to natural causes is no longer included, nor is Criterion A_2's response of fear, hopelessness, or horror [1]. The updated criteria leave a gap in trauma event qualification. Though these events are neither violent nor "accidental," the shock has a notable effect on the bereaved. Parental death has been recorded resulting in an increased risk of PTSD during the first two years following the event [11]. Regardless of the circumstances surrounding the death of the loved one—relationship, attachment style, cumulative traumas, etc.—the individual's trauma is not clinically relevant according to the DSM-5 [7].

Changing DSM criteria are not the only contributors to diagnostic exclusion. Other events that do not qualify for a PTSD diagnosis include: miscarriage, violent or accidental death of a public figure/celebrity, separation from caregivers by Child Protective Services or parental incarceration, etc. Similar to concepts in Doka's presentation on disenfranchised grief, lack of support for those involved causes unique problems: unacknowledged loss, nonexistent social support, and an inability to participate in the healing process [6]. Additional issues arise for those dealing with cumulative traumas, especially when said traumas are non-qualifying. Maladaptive coping, impaired functioning, and other adverse symptoms that "are typically assessed in response to only one qualifying Criterion-A traumatic event" often develop [8].

Alternative Diagnoses: Other Specified Trauma or Stressor-Related Disorders

While deliberating the DSM-5 criteria, Criterion A was retained for the sake of "discontinuity between the [affected individual's] pre- and posttraumatic sense of themselves, their world, and their future" [7]. Alternatives are available under the umbrella term "Other Specified Trauma- or Stressor-Related Disorder" for individuals below DSM standards that still experience this discontinuity. Subthreshold/Partial PTSD applies to individuals "meeting the DSM-IV criterion for re-experiencing and either the DSM-IV criterion for avoidance or the DSM-IV criterion for hyperarousal," [17] and applied to 29% of traumatized participants in a 2014 study [16]. Another option for those with recent trauma is Acute Stress Disorder (ASD), in which "anxiety and behavioral disturbances [...] develop within a month of exposure to extreme trauma, with symptoms that begin during or shortly following the trauma" [5]. Those experiencing cumulative traumas may be diagnosed with CPTSD. While an expansion of stressor-related illnesses is an improvement, none of these diagnoses cover circumstances in which trauma fails to meet criteria while significant symptoms still plague the individual.

Effects of Misdiagnosis

Due to the variety of PTS symptoms covered in Criteria B-E of the DSM-5, there are many potential avenues for detrimental misdiagnosis. Risky or destructive behavior coupled with self-medication could mistakenly point to a substance abuse disorder or treatment may encourage Narcotics/Alcoholics Anonymous programs where individuals must re-experience their trauma. ADHD and PTSD share impulsivity symptoms, such as difficulty concentrating, risky behavior, and an inability to remember key features of a trauma that, in cases of non-qualifying events would not register on a PTSD diagnostic read. The stimulants often used to treat ADHD would compound arousal and reactivity symptoms of Criterion E [18]. While comorbidity is not uncommon in mentally-ill populations, disregarding non-qualifying traumas forces physicians to build an incomplete treatment plan that accounts only for symptoms exhibited, not how perception may have been altered by the subthreshold event. Those in the DSM-5 Anxiety and Dissociative Disorders Work Group favoring a narrow PTSD definition "proposed that symptoms overlapping with other disorders [such as the aforementioned] be eliminated from PTSD" [7]. Friedman indicates the inefficacy of such an elimination, noting that doing so in the medicinal diagnoses "would eliminate symptoms such as fever, pain, and edema [...] because they are found in so many other diseases" [7].

Nomothetic Effects on Generalizability of Research

The lack of information surrounding subclinical traumas in PTSD holds far-reaching implications in literature and research. The absence of these non-qualifying cases of trauma is frequently cited. Articles [4] and [12] explicitly exclude sub-Criterion A traumatic events, the latter listing unacceptable events such as "bereavement, chronic illness, business loss, marital or family conflict." Without the awareness or ability to study the whole picture of PTSD, possible interaction effects and correlations will be neglected. If research is conducted on individuals with PTSD with suicidal ideation, those with non-qualifying traumatic events will be excluded from the sample despite literature associating sub-symptomal Partial PTSD (and by extension, symptomal, sub-traumatic PTSD) with suicidal ideation [10, 17].

Present Study

This study will determine whether the rate of PTS symptomology expressed by individuals with traumas not covered by Criterion A of the DSM-5's

diagnostic criteria for PTSD is significantly different from individuals whose traumas qualify them for a PTSD diagnosis. The outcome of this research will determine whether individuals experience significant distress in the face of non-qualifying traumas and potentially illuminate an existing need for a specialized treatment program.

Materials and Methods

Participants

Participants (n=279) were drawn from Lochman's larger Coping Power Program study, which studied children with behavioral aggression and their adult guardians [9]. The present study utilized data from the guardians surveyed between 2007 and 2008. Participants ranged from 27-94 years of age, and were 97.85% female, 1.79% male, and 0.36% unknown. The annual household income ranged from less than $10,000 to over $100,000, with 53.4% reporting an annual household income of $25,000 or less. Based on their answers to the PTSD Index, participants were divided into three groups: non-traumatized, qualifying traumatized (QT), and non-qualifying traumatized (NQT). These titles refer only to the standing of their traumas as dictated by the DSM-5, not necessarily the extent or severity of symptoms as required by the DSM-5.

Due to the limitations of secondary data analysis, participants with missing information could not be reached for clarification. As the original study focused on neither adults nor PTSD diagnoses/ symptoms, the IV groups showed drastic variation in population assignment; of the 279 participants, 4 expressed a distinctly NQT event and 88 expressed a QT event. Of the 187 remaining participants, 8 individuals were missing data and 179 individuals expressed no traumatic experiences within a 12-month period, neither of which were included in the analyses resulting in a sample of 92 participants. Within symptom tests of the QT populations, missing data ranged from 0-2 participants and was noted accordingly.

Measures

The UCLA PTSD Reaction Index for DSM-IV, Life Experiences Survey, and Personal Demographic First form and Personal Demographic form gauged PTSD symptomology and correlations in a cross-sectional study of adults surveyed in 2007 and 2008 [14, 15, 9]. The PTSD Index is a 48-item measure assessing the nature of the experienced traumas [14]. Though the PTSD Index was designed using the DSM-IV guidelines for the questions, this study applies DSM-5 criteria to the answers given to find possible correlations for updated symptom criteria and subclinical trauma criteria. The Life Experiences Survey is a 57-item measure in which participants rate the impact of major life events as experienced in either Demographic Form includes 27 questions regarding the child's life, including potential correlations in lifestyle, environment, or family history [9].

Design

This study utilized between-subjects ANOVA and Independent Samples T-test designs. The two levels of independent variables of the ANOVA corresponded to the trauma specifications: the qualifying traumatized (QT) population and non-qualifying traumatized (NQT) population. These populations were analyzed according to prevalence of symptom Criteria B-E as well as overall rates of symptom expression. The QT population included any participant who answered "yes" to at least one of questions 4-11 of the PTSD Index and/or "yes" to questions 15-17 of the PTSD Index (hereafter referred to as "qualifying questions") as the endorsed trauma fulfills the "Exposure to actual or threatened death [or] serious injury" clause as necessitated by the DSM-5. This population qualifies as traumatized regardless of their answers to questions 1, 2, 3, 12, or 13 of the PTSD Index (hereafter referred to as "non-qualifying questions"). The NQT population consisted of participants who answered "no" to all qualifying questions and "yes" to at least one of the non-qualifying questions. If the participant answered "yes" to any of the non-qualifying questions, "no" to the qualifying questions, and "yes" to questions 18-21 of the PTSD Index, the Life Experiences Survey was consulted for details on the participant's trauma in order to determine if the event fulfilled "Witnessing, in person, the event(s)" or "learning [of accidental or violent] actual or threatened death of a family member or friend" clauses as expressed in the DSM-5. Traumas that fulfilled these criteria resulted in the participant's categorization as part of the qualifying traumatized (QT) population. Individuals who answered "no" to questions 1-13 were considered non-traumatized and were not utilized.

Procedure

Participants were interviewed as part of a larger research study on youth behavioral issues. Data was collected via questionnaires administered in person, over the phone, and online. ANOVA analysis compared the rate of PTS symptoms between the two groups to determine if symptoms were more prevalent for QT vs. NQT individuals. Independent Samples T-tests compared endorsement rates of individual items across the two test variables. This study aims to determine that the rate of PTS symptomology expressed by individuals with traumas not covered by Criterion A of the DSM-5's diagnostic criteria for PTSD is not significantly different from individuals whose traumas qualify them for a PTSD diagnosis. This hypothesis would indicate significant levels of distress resulting from non-qualifying traumas.

Results

In the cross-tabulations analysis in Table 1, zero of four individuals in the NQT group endorsed all four of the symptom criteria necessary to qualify for a PTSD diagnosis under the DSM-5 (SymptomQual), while 47 of the 86 QT participants expressed the required number of symptoms per criterion, thus rejecting the hypothesis. The 20 symptom questions of the UCLA-PTSD Index were divided into Criteria B-E based on which symptom class they most closely resembled. Criterion B (CritB) included questions 2, 3, 5, 6, and 18; Criterion C (CritC) included 9 and 17; Criterion D (CritD) included 7, 8, 10, 11, 14, 15, 19, and 20; and Criterion E (CritE) included 1, 4, 12, 13, and 16. These questions ask the participant to rate their symptoms on a 5-point nominal scale, though the current study judged symptom responses on a binary "yes/no" scale so as to follow the diagnostic criteria of the DSM-5 more closely. Of the NQT group, 75% endorsed CritD and E, a rate higher than the QT rate of CritD endorsement at 62.07% and near the QT rate of Criterion E endorsement at 82.95%. The largest discrepancy in criteria endorsement was seen under CritB, of which 25% of the NQT population expressed impairment and 87.21% of the QT population expressed impairment as seen in Table 1 (Mean Difference of T-test=-.622). 1-way ANOVAs of Trauma Status and questions pertaining to specific Criterion Clusters (CritB, CritC, CritD, and CritE) indicate similar results in Table 2, as does the 1-way ANOVA of Trauma Status and Symptom Qualifications (SymptomQual) (F=4.713, Sig.=.033).

		CritB		CritC		CritD	
Endorsement		no	yes	no	yes	no	yes
Trauma Status	NQT	3	1	2	2	1	3
	QT	11	75	20	67	33	54

		CritE		Symptom Qual	
Endorsement		no	yes	no	yes
Trauma Status	NQT	1	3	4	0
	QT	15	73	39	47

Table 1: Cross-tabulations analysis of QT/NQT Population and endorsement percentages

	F	Sig.
CritB	12.585	0.001
CritC	1.514	0.222
CritD	0.268	0.606
CritE	0.165	0.685

Table 2: 1-way ANOVA of Trauma Status and Criterion Clusters

Item-level Independent Samples T-tests were also conducted in Table 3. Though the majority of the data points to rejection of the null, CritD items 11, 14, and 20 and CritE item 13 point to a mean difference of –0.182 or less. The items are as follows in numerical order: "I have trouble feeling sadness or anger," "I have trouble going to sleep or I wake up often during the night," "I think that some part of what happened is my fault," "I am afraid that the bad things will happen again." Furthermore, CritD item 19 ("I think that I will not live a long life,") and CritE item 16 ("I have trouble concentrating or paying attention,") are more commonly endorsed among NQT populations by a mean difference of 0.600.

		Levene's Test for Equality of Variances		T-test for equality of means	
		F	Sig.	Mean Difference	Std. Error Difference
GPTSD11T	Equal variances assumed	0.002	0.961	-0.159	0.484
	Equal variances not assumed			-0.159	0.51
GPTSD13T	Equal variances assumed	2.52	0.116	-0.182	0.755
	Equal variances not assumed			-0.182	0.525
GPTSD14T	Equal variances assumed	0.316	0.575	-0.091	0.471
	Equal variances not assumed			-0.091	0.269

Table 3: Continued on next page

		Levene's Test for Equality of Variances		T-test for equality of means	
		F	Sig.	Mean Difference	Std. Error Difference
GPTSD16T	Equal variances assumed	0	0.997	0.602	0.434
	Equal variances not assumed			0.602	0.487
GPTSD19T	Equal variances assumed	13.427	0	0.598	0.423
	Equal variances not assumed			0.598	1.003
GPTSD20T	Equal variances assumed	0.385	0.537	-0.055	0.6
	Equal variances not assumed			-0.055	0.495

Table 3: Independent Samples T-test of Symptom Questions and Trauma Status

Discussion

This study sought to examine whether individuals with non-qualifying traumatic events experience the same rates of impairment as individuals with qualifying events as mandated by the DSM-5. A 1-way ANOVA of Trauma Status moderated by DSM-5 symptom guidelines indicated that individuals with non-qualifying traumas do not reach diagnosable levels of symptom impairment. However, 1-way ANOVAs of Trauma Status as moderated by Criterion Cluster questions indicate that QT individuals experience significantly higher rates of re-experiencing (CritB) and avoidance (CritC) behaviors, but insignificantly higher rates of hyperarousal (CritE). Rates of CritD symptoms were insignificantly higher in NQT populations, though this may be due to the number of items housed under each Criterion Cluster. Of the criteria, only Criteria D and E require two presentations each of symptoms.

In the itemized Independent Samples T-test, nearly equal rates of endorsement between the two Trauma Status groups were seen in the following items, listed numerically within the UCLA PTSD Index and with corresponding criteria in parentheses:

- 11. "I have trouble feeling sadness or anger." (CritD)
- 13. "I have trouble going to sleep or I wake up often during the night." (CritE)
- 14. "I think that some part of what happened is my fault." (CritD)
- 20. "I am afraid that the bad things will happen again." (CritD)

Equal or near-equal endorsement rates of these items may point to similar experiences of numbing, worry/hyperarousal, self-blame, and hopelessness. CritE item 16 ("I have trouble concentrating or paying attention,") and CritD item 19 ("I think that I will not live a long life,") were more commonly endorsed among NQT populations. Item 16, much like item 13 above, may indicate a heightened sense of worry or hyperarousal in response to a traumatic event regardless of DSM-5 qualification. Item 19 points to an increased sense of hopelessness similar to item 20. Further research is needed to determine if these outcomes were due to unreliability between items or a pattern of higher CritD and E expression in NQT populations.

When comparing the symptom-focused results of this study with current criteria for Subthreshold/Partial PTSD, it is curious whether the expression rates of CritD and E in NQT populations stand as an extension of Schützwohl and Maercker's research [17]. Given the similarities between the Subthreshold PTSD diagnostic criteria and the symptom expression shown in the current study as a possible result of non-qualifying traumas, sub-traumatic PTSD might fit under the Subthreshold PTSD umbrella. The implication is particularly important as the number of individuals experiencing impairment after trauma is substantially greater than full PTSD rates suggest [17].

Limitations

When considering the implications of this study moving forward, it is important to remember that symptom responses were judged on a dichotomous (yes, no) scale and did not account for severity in the two populations according to the items. The participants selected were also predominantly female and from low-income households, limiting the generalizability of the outcome. The discrepancy in sample size between the NQT and QT populations surveyed affects the validity of the current study, which encourages further research with equal participant endorsement of qualifying and non-qualifying traumas. Per requirements of Criterion H that the symptoms not otherwise be explained by other illness, the endorsement could point to the participants' experience of other disorders (though this relates to concerns regarding Trauma-Informed care/treatment plans [3]). The

data was also not cross-referenced to account for such symptoms being explained by medication or substance use per Criterion H.

Conclusion

Future Research and Clinical Implications

Future research directions should correct for the dearth of NQT participants, focusing on symptom outcomes with broader trauma criteria. The Life Events Survey, coupled with the symptom-focused items from the latter half of the UCLA-PTSD Index, may be a more productive means of moderating Trauma Status in future studies. Individuals with (1) any item rating -2 or lower or (2) multiple negative events on the Life Events Survey could be further subdivided into "qualifying" and "non-qualifying" populations. Additional research may choose to focus on efficacy of treatment plans for individuals with sub-threshold trauma events. For example, whether typical PTSD treatment plans such as Anxiety Management or Stress Inoculation Training improve symptoms or if specialized programs may need to be developed for their unique needs.

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Testbed for Real-Time Control & Parameter Estimation

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The electromagnetic constants of permanent magnet synchronous motors (PMSM) used in vector control equations are typically determined during manufacturing for each individual motor. AC electric motor control is widely needed and used in industrial applications, including process industry and robotic automation. In practical applications, motor parameters can be changed broadly depending on environment and conditions. However, these motor parameters are not actually constant, but have some small variance depending on the context of use. Therefore, it is beneficial for motor control & power efficiency to have a way to accurately estimate and update these parameters in real-time, thus further optimizing motor performance. The goal of this project is to design a real-time control and parameter estimation technology for a Permanent Magnet Synchronous Motors (PMSM) and drive.

Introduction

The electromagnetic parameters of an electric motor used in feedback control are typically determined during manufacturing. However, these parameters tend to vary with environmental conditions and motor workload. This project aimed to increase the efficiency of electric motor control by developing models to estimate motor parameters in real-time. Due to their increased use in industrial robotics and electric vehicles, the Permanent Magnet Synchronous Motors (PMSM) was specifically chosen as the application of model design.

The parameters of interest for this motor are the stator d-q domain inductance and stator resistance. The feedback signals used to estimate these parameters are the three phase currents and control voltages of the motor, as well as the speed in revolutions per minute and angle of the rotor. Simulations were implemented for testing of our physical motor controller and dynamometer testbed system. All controller models were designed in MATLAB/Simulink, which is the same software environment on which the estimation algorithms were developed.

This document outlines the implementation of the hardware motor testbed for physical motor control, and the software control system that is able to estimate and update motor parameters in real-time in order to optimize motor performance and energy efficiency.

Components and Function

Permanent Magnet Synchronous Motors

PMSM are AC motors that have embedded magnets in the rotor. The presence of these permanent magnets allow the motor to rotate at a frequency that is synchronized with the line frequency. The electromagnetic constants of PMSM used in vector control equations are typically determined during manufacturing for each individual motor. However, these motor parameters are not actually constant, but have some small variance depending on the context of use. Therefore, it is beneficial for motor control & power efficiency to have some way to accurately estimate and update these parameters in real-time, thus further optimizing motor performance [6]. dSPACE and Dynamometer were connected with PMSM to verify speed and position measurements with digital feedback from motor encoder speed and position data. dSPACE was used on the data acquisition system to determine parameter values by measuring time constant, τ, of rotor current transient from a step response as well as stator resistance R_s using ohm meter. They were put into the equation $L_{d/q} = (2/3)\ \tau_{d/q} R_s$ to get the numerical value of L_d and L_q in mH. This was repeated multiple times to get an average value for both parameters [5].

AMPLIFIER PCB

The purpose of this amplifier circuit is to increase the Pulse Width Modulation (PWM) signal from 5 V to 15 V that is required by the inverter in the control system [8]. This document outlines the function, design, manufacturing, integrating, and testing that went into developing this printed circuit board (PCB). The function of the PCB is to simply boost the incoming 5 V to 15 V. In order to do this, the non-inverting op-amp was designed (Figure 1) and the test result was captured on PSpice simulation (Figure 2).

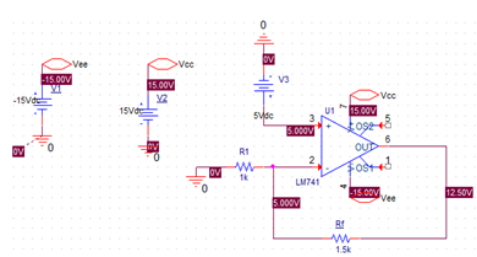

Figure 1: PSpice design for non-inverting op-amp to increase the PWM signal from 5 V to 15 V to fit the requirement voltage of inverter in the control system.

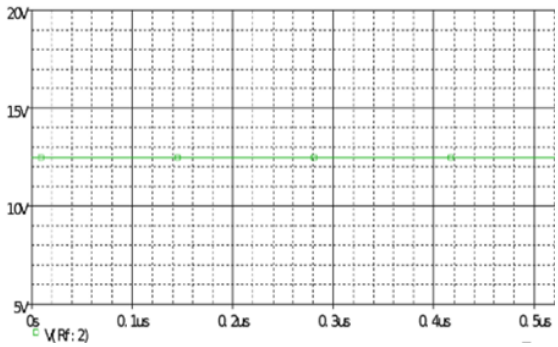

Figure 2: PSpice simulation results showing that PWM signal is boosted from 5 V to 13 V which is very close to the desired voltage value of 15 V.

LEVEL SHIFTER PCB

The level shifter is a component that is able to translate a signal from one voltage logic level to another. In this project, the level shifter translated a 5 V signal into a 15 V signal. This component is very efficient at handling higher frequencies, which is exactly what is needed for this project. This document outlines the function, design, manufacturing, integrating, and testing that went into developing this PCB. The component has a total of sixteen pins which can support six inputs (Ain ... Fin) and six outputs (Aout … Fout) (Figure 3). In this project, the 5 V signals A, B, C, ~A, ~B, ~C were mapped to their own input. Vcc was connected to a 5 V power supply and Vdd was connected to a 15 V power supply to serve as reference for the output voltage.

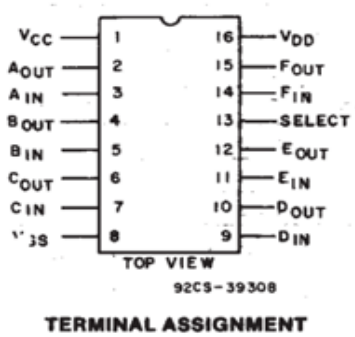

Figure 3: Level Shifter Pin Assignment.

A picture of the schematic used within the DesignSpark PCB software can be seen in Figure 4. This schematic shows how all the components of the Level Shifter board fit together. This includes the actual level shifter component, 5 V connection, 15 V connection, and the six signals to be amplified. The signal outputs are mapped to six Bayonet Neill–Concelman (BNC) connections at the right of the schematic.

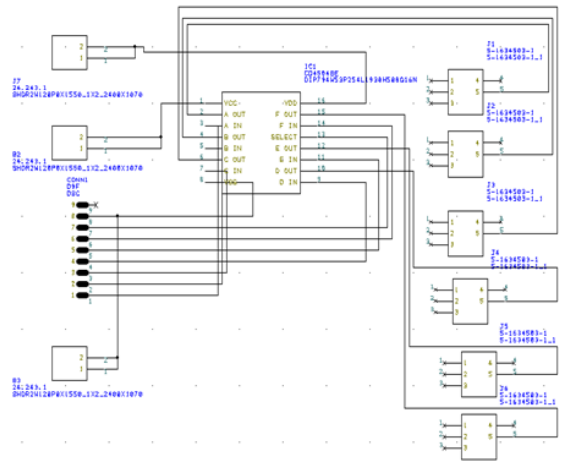

Figure 4: Level Shifter Schematic shows how the components are arranged on the circuit board. The signal outputs come from sex BNC connections at the right of the schematic.

The schematic was used to create a translator in order to generate the PCB. The appropriate elements were placed and routed within the board. Then JLCPCB was used to manufacture the PCBs. Once the PCBs were manufactured, each component was hand soldered into their appropriate place. In order to test the design, power supply and oscilloscope were used to verify that the six signals running into the PCB were properly being amplified (Figure 5) [3]. The turquoise signal represents one of the 5 V input signals, and the yellow signal represents the 15 V output signal.

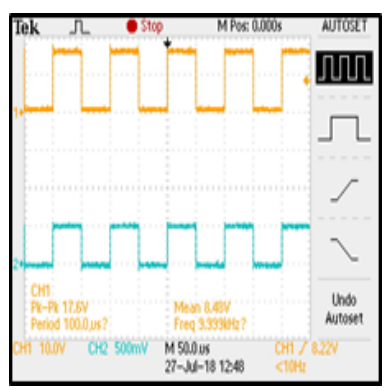

Figure 5: Level Shifter Testing shows a picture of the oscilloscope after running this test. The yellow signal is 15 V output signal and turquoise signal is 5 V input signal which shows that six signals running into the PCB were properly being amplified.

DATA ACQUISITION SYSTEM

The data acquisition system which was used for this project is the OPAL-RT 8660. Its primary function is to sense and measure the three-phase current that is being sent to the PMSM motor. This is accomplished by sending the AC power from the IGBT inverter through the data acquisition system [8]. From there, unaltered three-phase current is sent to the motor, and measurements from the data acquisition system are taken at the same time. These measurements are in the form of voltage signals between ± 10 V. The voltage signals are then sent to the dSPACE MicroLabBox for processing.

DSPACE MICROLABBOX

The dSPACE MicroLabBox is a microcontroller with dedicated motor control features. It has a dual-core real-time 2 GHz processor and an on-board FPGA. There are over 100 channels that can be configured to inputs or outputs. The dSPACE also has a real-time interface for Simulink. This means Simulink models can be compiled directly into the firmware for the dSPACE. This makes it much easier to run our system rather than using a high level programming language such as C.

For this project, the dSPACE will generate six synchronous PWM signals for control of current to the motor. The dSPACE also has various ADCs on board which will be used for the analog current measurements being sent from the data acquisition system. Speed and position data from the motor is also sent to the dSPACE via an encoder cable. The Simulink model shows the inputs which are the ADC channels and encoder data being sent to the dSPACE (Figure 6). The outputs are the PWM signals that are generated from a control voltage that is determined within the controller block.

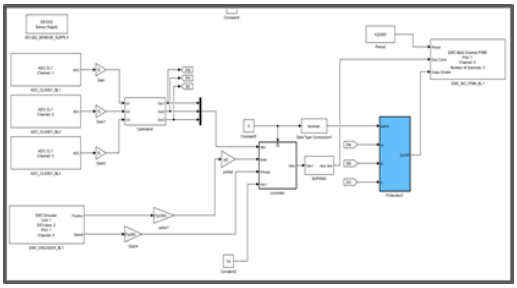

Figure 6: Simulink PMSM Testbed Control System Model for control the PMSM motor. The inputs and encoder data were sent to the dSPACE.

As previously stated, the Simulink model is compiled directly into machine code for the dSPACE to run. ControlDesk software is used as a real-time interface for the dSPACE. The window shows all data being collected by the dSPACE. This includes the three -phase current being sent to the motor as well as the speed and positioning data coming from the encoder (Figure- 7).

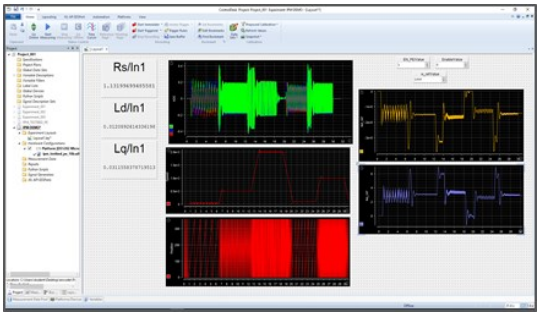

Figure 7: ControlDesk Real-Time Interface can monitor all the data that being collected by the dSPACE. The top right of the figure shows the interface where the motor speed can be manually set.

Testing

The PMSM Testbed System can be tested by a simulation model within Simulink (Figure 8). This model contains all the components from the physical testbed setup. The model shows the PWM signals being sent an inverter, the data acquisition system, and even a PMSM motor. The values and constants of this simulation model have been changed to match that of the physical system.

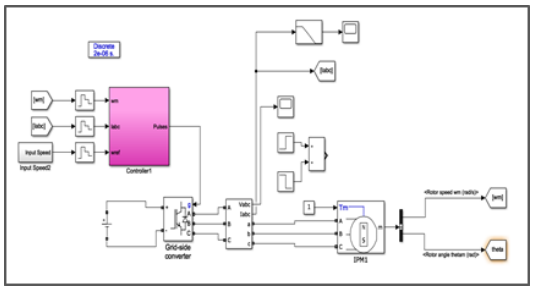

Figure 8: Simulink Simulation Model used to test the PMSM Testbed system. It illustrates that PWM signals can be sent to the Inverter, data acquisition system and PMSM motor.

During the testing phase of this project, a simple test was run on this physical testbed system and its results were compared to a similar test within the simulation model. This was a thirty second test set at five different speeds. There was a constant torque of five N·m applied to the motor during this test. The figures clearly show that when the speed was changed in the testbed, the transient spike appeared on the monitor (Figure 9). This spike levels out as the test progress-

es. Other than these spikes, the results are very similar to the simulation. Similarly, for the simulation speed, there is also a transient spike in response to the changing of speed within the testbed. Other than this spike, the results are similar to the simulate-on (Figure 10)

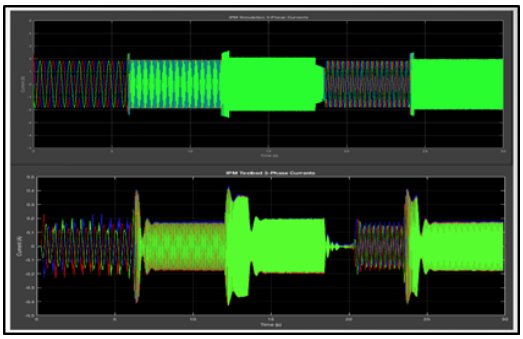

Figure 9: The test was run on this physical testbed system and the results were compared with simulation model. There was a constant torque of five N·m applied to the motor during this test. The top picture shows the simulation three-phase currents of the motor, and bottom picture shows the testbed three-phase currents. The figure shows the transient spike with the changing of speed in the testbed. This PMSM signal levels out as the test progresses. Other than these spikes, the physical testbed system results are very similar to the simulation result.

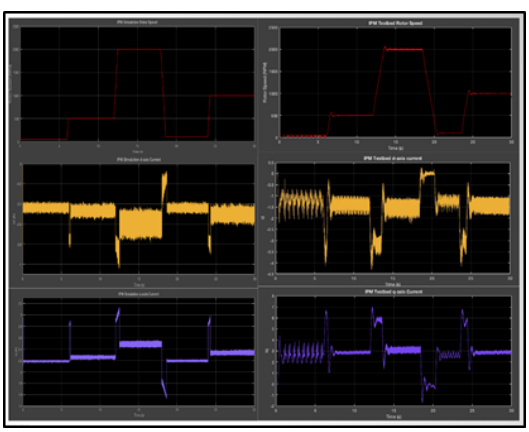

Figure 10: The left three pictures show the simulation speed, d-axis current, and q-axis current of the motor. Additionally, the right three pictures show the testbed speed, d-axis current and q-axis current of the motor. The physical testbed system results are similar to the simulation results. For the three-phase current within simulation and testbed testing systems, the transient spike happened in response to changing the speed.

Parameter Identification of PMSM Motor Based on Least Squares Method

System identification is a theory and method to study how to use the input and output data with noise to establish the mathematical model of the subject. System identification and control theory are closely related. With the development of computer technology and the improvement of system control technology requirements, control theory has been widely used. In the application of control theory, in order to achieve the desired effect, it is inseparable from the accurate mathematical model of the controlled object [7]. However, in many cases, the mathematical model of the controlled object is unknown. Sometimes, the parameters of the mathematical model will change during the normal operation of the system, which greatly reduces the control effect of the system depending on this model [2].

Therefore, when applying control theory to the PMSM, the establishment of mathematical models for the control system is the key to the successful application of the theory.

The so-called mathematical model of object is based on system identification. Research shows that the external knowledge of the system is realized by its input and output data. The mathematical model is a way of describing the dynamic characteristics of the system and is bound to be contained in its changing input and output data. System identification is determined by recording the input and output data of the system in normal operation, or by measuring the output response of the system under the action of artificial input. Followed by processing, calculating and summarizing these data properly, and extracting the system information contained in the data, the mathematical description of the controlled object can be established [2]. That is to say, system identification is a method of extracting mathematical models of objects from input and output data by means of mathematical methods.

Least Squares Method

For the mathematical model of PMSM parameter estimation (PE), the Recursive Least Squares method was used in this system. When the Least Square method is used to identify the parameters of a system, it is necessary to know the model of the system, measure the state and output of the system at the same time, and then get an estimate of the parameters based on the measured data. The mathematical model for the PMSM parameter estimation system can be described by the following formula: The variable y is a parameter that needs to be estimated and consists of a set of n variables x1, x2,,,,xn in a linear relationship with θ as shown below [1,2]. The variable x and θ are the states and outputs of the system.

Linear Equations of X and Y [1]:

$$y = \theta_1 x_1 + \theta_2 x_2 + \cdots + \theta_n x_n$$

X, y and θ are observed and recorded m times at time t1, t2,,,,tn. In the linear equation, m stands for observation values, i for observation order. After that, observed values of x and y are placed into the linear equation, so the linear equation becomes as shown below.

Linear Equation of X and Y after observed m times [1]:

$$\begin{cases} y(1) = \theta_1 x_1(1) + \theta_2 x_2(1) + \cdots + \theta_n x_n(1), i = 1 \\ y(2) = \theta_1 x_1(2) + \theta_2 x_2(2) + \cdots + \theta_n x_n(2), i = 2 \\ \vdots \\ y(m) = \theta_1 x_1(m) + \theta_2 x_2(m) + \cdots + \theta_n x_n(m), i = m \end{cases}$$

Therefore, $y = x * \theta$. However, because of the possible measurement errors, model errors and calculation errors, y will never actually equal x times θ. Let the error vector be E, then y, x and θ equation can be rewritten as $y = x * \theta + E$. Now that the criterion of measuring data is fitted by the minimum sum of squares of errors, let J represent the criterion. [1]

Equation of J [1,2]

$$J = \sum_{i=1}^{m} \varepsilon_i^{\,2} = E^T E$$

The method of determining θ by using J as the minimum criterion is called the Least Squares method [1].

Conclusion

Compared with traditional motor, PMSM has many advantages such as higher power density and higher efficiency. Whether the parameters of the motor are accurate is of great significance in motor control. Therefore, the study of motor parameter identification is not only a theoretical subject, but also a practical one. Based on the vector double closed-loop system of PMSM, this paper proposes to improve the performance of PMSM control system and motor parameter identification scheme. Based on the theory of system identification, a method of motor parameter identification based on least squares is proposed, which improves the identification accuracy of motor inertia and the identification effect. However, considering the practical engineering application, the accuracy of parameter identification results need to be further improved. Nonlinearity, parameter variation, disturbance and noise in motor control system will affect the performance of the system [5]. In this respect, the intelligent control algorithm has more advantages than the traditional algorithm. Therefore, further research should be done to study the intelligent algorithm applied to motor control system to improve its performance.

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Behzad Mortazavi, PhD
Professor and Department Chair
University of Alabama Department of Biological Sciences

JOSHUA Staff: *Would you mind taking us through what eventually led you to UA and to later becoming the Biology Department Chair? Where are you from, where did you go to college, and what did you do prior to taking on this role?*

Dr. Mortazavi: I was born in Iran and moved to France during high school where I went to the American School of Paris. I did not speak any French at the time, so I took many intensive French classes. Once I graduated with my International Baccalaureate, I moved into the French university system and started a degree in marine sciences/marine ecology. I graduated with the equivalent of a master's degree in marine ecology. I moved to the United States in 1992 to attend Florida State University. I received my PhD in biological oceanography in 1998 from FSU. My work focused heavily on chemistry, as I investigated how nutrients derived from the Apalachicola River Watershed affected the health of Apalachicola Bay. The bay is the largest estuarine system in Florida and receives water from the third largest river in the Gulf of Mexico. My PhD project involved three years of sampling in Apalachicola Bay. Once a month I would be on a boat collecting samples and I quickly found that my research also had an applied aspect. There are no water allocation rules for the eastern coast of the United States. The city of Atlanta wanted to draw water from the Apalachicola River and use it for consumption and agriculture. This would potentially mean less water coming from the river into the Bay. Therefore, we were interested in understanding how reduction in freshwater flow, would impact the Apalachicola estuarine ecosystem. I remained at FSU for close to a decade as a Research Scientist after finishing my Ph.D. I continued to examine the exchange of elements like carbon and nitrogen at the land ocean interfaces. I also expanded my research to see how carbon was exchanged between the forest and the atmosphere. In January 2008 I was hired as an Assistant Professor at The University of Alabama. UA has historically had a facility at the Dauphin Island Sea Lab. I was based at the Sea Lab and promoted to Full Professor in 2017 and in August 2018 I moved up to the main campus to take on the role of Department Chair.

JS: *What are you most looking forward to as the new Biology Department Chair and what are your plans for the future of the department?*

M: In the forthcoming years, the Biology Department has three major areas of focus. The first is hiring new faculty. We have had a lot of retirements and we have not been able to keep up with the growth in the number of students. While a challenge, this also provides us with an opportunity to grow strategically by addressing core needs while at the same time thinking about new frontiers in biology. This year we have three new hires, and we hope in the future, we will be able to recruit and have additional hires that will help to grow the department in new and exciting areas.
The second area that I think a lot about is providing opportunities and support for our graduate students. I am interested in creating opportunities for them to travel to other labs in the country and internationally to collaborate with colleagues so that their perspective expands. Today, we find that science is more and more conducted in collaboration with others rather than individuals working alone. We want to give our graduate students the opportunity and experience to work with others while they are still students here. This will help them expand their network and will help them with future career options. Another key area of focus is the undergraduate program. The number of students in the department has blossomed and we are getting amazing cadre of young scholars. We want to make sure they get the best possible experience out of their education at UA. This means enhancing experiential learning opportunities and providing opportunities where they can work closely with faculty while they are undergraduates. I think that would be a great achievement of this department. We already do a lot of this, but we need to work more on making it easier for students and potentially more in line with their interests.

JS: *We understand your research involves projects that revolve around impactful environmental concerns, such as oil spills and engineering ways to mend ecosystems. What led you to this field?*

M: Marshes are incredibly valuable ecosystems. They buffer the impact of waves, they help remove nutrients that come from the watershed before they reach the ocean, they serve as refuge and nursery habitats, and they are aesthetically pleasing. Research in my lab has focused on determining the capacity of coastal ecosystems to remove nitrogen. Nitrogen is commonly used as a fertilizer on golf courses, lawns, and elsewhere. While nitrogen is a valuable nutrient, too much of it leads to harmful algal blooms, low oxygen waters on the coast, and fish kills. There is a natural process mediated by microbes that can remove this excess nitrogen from the coastal waters (or any ecosystem) and return it to the atmosphere as an inert gas. This process is called denitrification.

Microbes use nitrates, some of which is delivered from the watershed, and return nitrogen to the atmosphere, acting much like wastewater treatment plants. This process is highly significant in salt marshes. Salt marshes are known as the "kidneys of the land," as they remove this excess nutrient. Before it goes into the ocean, nitrogen is removed by microbes in the sediment. When the BP oil spill happened in April of 2010 a lot of these salt marshes were impacted along the coast of Louisiana, Mississippi, Alabama, and some in Florida. The marshes eroded at the edge and just washed away. How would this impact the potential for removing nitrogen? Students in my lab have been working over the last nine years to try to understand the capacity of natural marshes to remove nitrogen. And most recently we have started to examine the capacity of reconstructed marshes to remove nitrogen. The Clean Water Act mandates that if you destroy an acre of marsh, you must create an acre of marsh. The field of restoration ecology that I am engaged in focuses on re-establishing marshes in areas where marshes are damaged or where marshes have historically been but are no longer present. My research interest is focused on the comparison between the reconstructed and natural marshes in the removal of nutrients. Following the oil spill, our focus turned to looking at the capacity for marshes, natural and reconstructed, to remove nitrogen and what the implications are if we lose these marshes to oil spills.

JS: *What does a typical day in your lab look like?*

M: All the students in the lab and my post-doc have projects they are moving forward, however, I have found from years of conducting scientific research, that there are very few typical days. Over the course of a week my students will be involved in setting up experiments, collecting and analyzing samples. What I have found to be critical to the day to day operation of the lab is that the students are trained to solve problems. Most days students are faced with problems that they need to work through. I encourage and train my students to handle challenges that arise so that once they move on from my lab, they have enough experience to be able to independently handle the next challenge they meet.

JS: *What has been the most exciting advancement in your research since you started at UA?*

M: At the time of the oil spill in 2010, I had never worked in salt marshes; however, that all changed, overnight. I saw the opportunity for my lab to be part of the effort to provide the necessary metrics to determine the damage that an oil spill does to the salt marsh ecosystem and to explore the question, if we are going to restore salt marshes, how well can we restore them? Developing new techniques and procedures for working in salt marshes and examining the role of these amazing ecosystems that are doing the work of waste-water treatment plants has been exciting for me. Out of a terrible disaster, an opportunity arose to contribute to science.

JS: *What opportunities has being affiliated with both The University of Alabama and the Dauphin Island Sea Lab brought to your research?*

M: For over a decade, I was located at the Dauphin Island Sea Lab as a full faculty member at The University of Alabama and the Department of Biological Sciences. Being at the Sea Lab provided me with an incredible opportunity to explore the coast with my students and to do research in beautiful places. When the oil spill happened, I was also able to be in the field conducting research quickly. I was on the ground and immediately started to collect data. Another great part about being part of the Sea Lab and The University of Alabama, is that I have had the opportunity to collaborate with incredibly talented scientists. I feel as if I have had the best of both worlds. I have had great colleagues on both the main campus and the Sea Lab.

JS: *What advice would you give a student interested in going into this field of research?*

M: One thing that everyone says is "follow your passion," but I would say "follow your passion with tenacity." Being a scientist is an amazing opportunity to contribute to this world, but it's not an easy path. So I think being tenacious is sometimes even more important than being passionate. If a student is interested in this field, they have to work hard at it; sometimes, the passion develops along that road. You can't really be a scientist by being passionate alone. Being persistent and willing to go through the challenges that come along, is what really makes it possible for someone to be successful. When students think about being a scientist, they think about taking courses in organic chemistry, physics, biology, and the like. But I would also say, early on, become good communicators. Being able to communicate your science is an absolute necessity. So start early to develop writing skills, learn how to develop and deliver presentations to let others know what you are doing. These are abilities that students will benefit from tremendously. I also believe there will also be numerous opportunities for students to solve meaningful problems that society is facing. I would like to encourage students to develop an interest in helping the world by engaging in science that can help solve problems we face—whether it's dealing with sea level rise, urban development, or our impact on biodiversity. Those are real problems that need solutions, and I hope the students that come into this field will be passionate about and tenacious in wanting to solve these problems. I see plenty of opportunities for students in the future to do exactly those things. Our students are going to be the ones who develop solutions for many of the problems that exist or will develop in the future. I am hopeful and also certain that the next generation has the talent and skill needed to succeed.

This interview was conducted by Jenna Bennett and Gabriella Dwyer, Assistant Editors on the JOSHUA staff. The text has been condensed and edited.

JOSHUA was made possible by the following organizations:

University of Alabama
Office for Academic Affairs

University of Alabama
Department of Biological Sciences

Tri-Beta National Honor Society
Kappa Beta Chapter

Howard Hughes Medical Institute

Randall Research Scholars Program

And by the 2018-2019 JOSHUA Editing Staff

2020 Submission Guidelines

We accept articles from current undergraduate students at The University of Alabama (UA). If you are a graduate student or recent alumnus of UA, we will consider your article if the majority of your work was conducted while you were an undergraduate at UA. Undergraduate students from other institutions may submit; however, priority will be given to those who conducted their research at UA.

1. Your name, e-mail address, and phone number must be included.

2. Your submission must relate to science or health.

3. Your work must be sponsored by a faculty member.

4. The length of your submission must be between 2000 and 4500 words. We will accept longer submissions if the author can limit the submission to the required length for the publication, and any extra material is able to be published online.

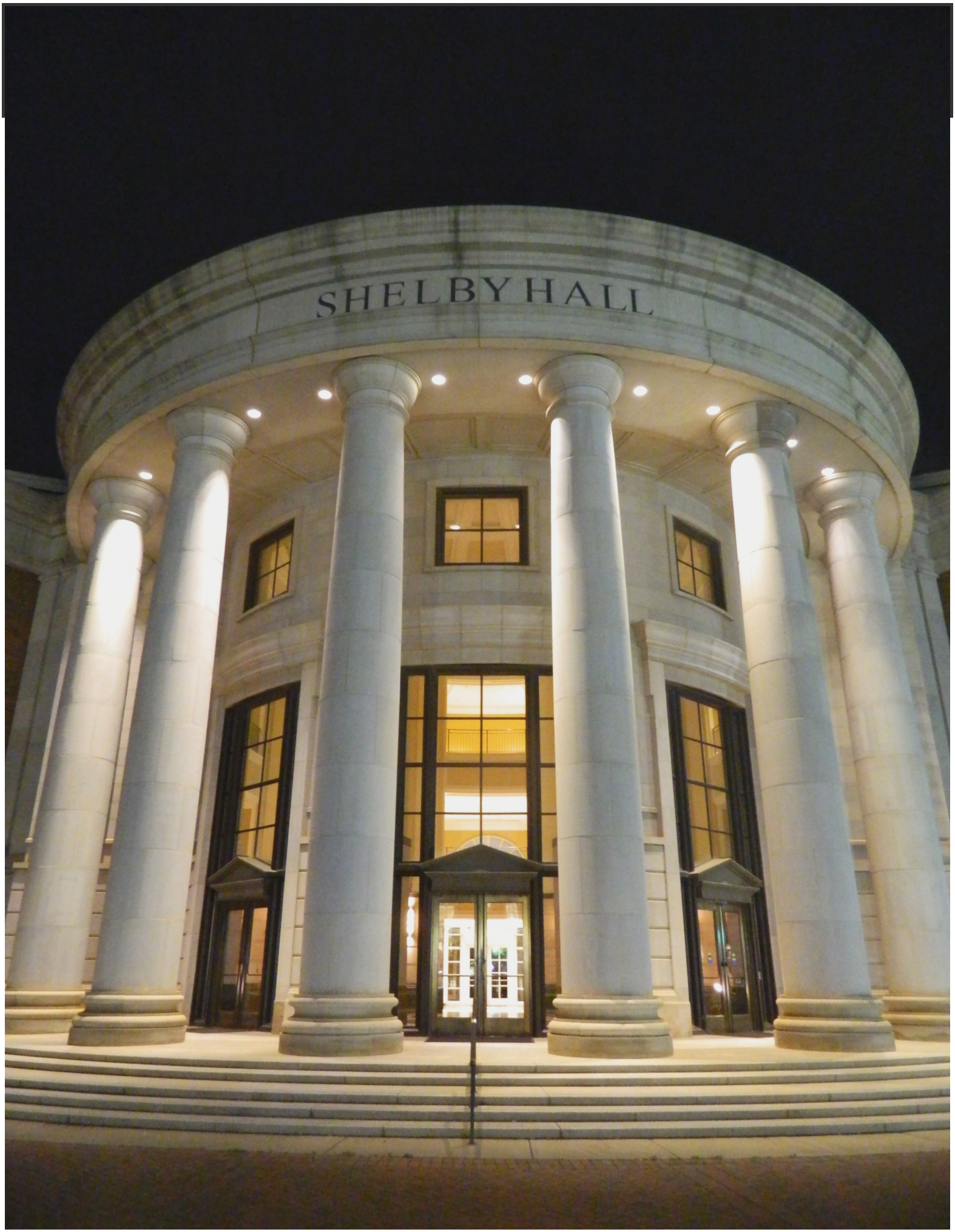
5. Figures, charts, and graphs are allowed but not required. (Note: The color will be mostly black and white.)

6. Your paper must contain an abstract.

7. Your citations must follow the guidelines listed on our website at: https://joshua.ua.edu/submissions-and-guidelines.html

8. The deadline for submission is February 12, 2020.

9. E-mail submissions to joshua.alabama@gmail.com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