Florida Undergraduate Research Journal

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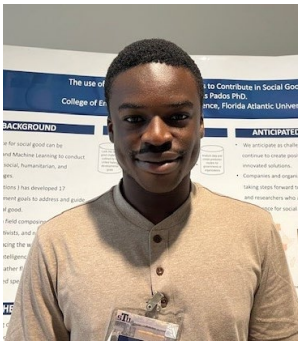
Meet the Editorial Board

Danny Alice



Hi everyone! I'm Danny Alice, a senior at Florida Atlantic University, Go Owls!!!, studying Sociology. My research encompasses how Artificial Intelligence in urban landscapes will significantly contribute to developing innovative, data-driven solutions such as downtown cities. This will create a positive impact on the intricate balance required to meet the needs of growing urban populations while preserving our planet's finite resources. Although I am kept busy, I organize my due dates on a planner and cross them off as I go.

Karam Abilmouna

Karam Abilmouna is a second-year undergraduate student at Florida International University majoring in Behavioral Neuroscience. As an intern in Dr. Tomas Guilarte's Brain, Behavior, and the Environment Lab and a MARC U*STAR Fellow, his project is on quantifying the degree of neurodegeneration in the cerebellum of SLC39A14-KO mice. His research interests revolve around neuroscience and neurodegeneration.

Tanner Bomstad

Tanner Bomstad is a Senior at the University of Tampa majoring in Biology with a pre-med focus. He is a military veteran who served as a Corpsman in the Navy. He is currently working on a research project examining the relationship between biodiversity and zoonotic spillover with a strong focus on the Everglade region and the potential zoonotic pathogens that reside there. His research pursuits reflect a keen interest in zoonotic epidemiology, disease ecology, and all things related to electron microscopy.

Kelly Canaday

Kelly Canaday serves as one of the Editorial Assistants for FURJ. She is a second-year graduate student at Florida Gulf Coast University majoring in English and teaching Introduction to Creative Writing. Her research interests are 18th-century British Literature and Victorian-Era London, while her current research project is focused on material culture Eliza Haywood's "The Female Spectator.

Dr. Melodie Eichbauer

My name is Dr. Melodie Eichbauer, and I am the Executive Editor of FURJ as well as the Interim Director of Scholarly Innovation and Student Research and a Professor of Medieval History at Florida Gulf Coast University. I am passionate about student research and the wide-ranging benefits it can bring. My own research specializes in legal and ecclesiastical history from c.1000 to c.1500. My research interests focus on legal pluralism and the evolution of legal principles. I am particularly interested in the dissemination of legal knowledge; the interpretation of law; and the ways in which social, political, and intellectual developments and trends shaped both during the height of the medieval period. By examining the larger processes linking law to the world in which it functions, my hope is to show new ways of thinking about current issues.

Maria Gonzalez

Maria Gonzalez is a fourth-year undergraduate student at the University of Central Florida. She is pursuing a major in psychology and a minor in biological anthropology. Her research focuses on bilingualism and language learning, particularly in how we operationally define these concepts and the interdisciplinary look at the different variables that play a role in the process of becoming a proficient speaker of a new language. Her honors undergraduate thesis explored the potential applications of vocal biomarkers as a novel method for assessing the acquisition of a second language. Previously, she contributed to the development of the "Survey of Diversity in Language Dominance," a new bilingualism questionnaire. Currently, Maria works remotely as a research associate at the Center for Healthy Aging at Pennsylvania State University. Beyond language, her research interests also include human cognition, aging and early human development.

Sydney Gross

Sydney Gross is a junior at Florida State University studying Accounting and Business Analytics. She currently works as a research assistant in the College of Business helping with data analysis and collection of insurance demand and supplier data to observe the stability of the Affordable Care Act, and she also assists with other insurance related projects. Undergraduate research has taught her many skills including how to use and code with various data visualization tools and research software.

Julia Hammond

Julia Hammond received her associate in arts degree in 2022 as a dual-enrollment student at Florida Southwestern State College. She is currently a senior in the Honors College at Florida Gulf Coast University (FGCU) majoring in English. She is also the Editorial Assistant for FURJ and FGCU's Aquila. In 2023, she presented her research on the importance of Mexican American representation at Eagle X, a research project showcase at FGCU, and won the award for "Standing for Social Justice." Her research motivated her into founding the first Mexican American student organization at FGCU: the Mexican American Student Alliance (MASA). After graduation, she aims to continue uplifting and advocating for the Mexican American community through research in graduate school.

Nancy Strever

Nancy Strever is a fourth-year undergraduate student at Eckerd College double majoring in animal studies and biology with a minor in marine science. She is currently conducting a senior thesis project on how dog personality affects success at solving a multi access puzzle box apparatus. She has conducted cognitive and behavioral research on many species including dogs, siamangs, lemurs, elephants, wild cats, red river hogs, and humans! Her research interests include animal personality and cognition, companion animal welfare, and behavioral research for wild conservation. She hopes to continue a career in research and academia through graduate school.

Welcome from the Editorial Board

Hello and welcome to the third volume of the *Florida Undergraduate Research Journal*! We are excited to share the original research that our student researchers have produced through their fascination and drive. Student researchers are one of the most valuable assets any higher education institution can have. For this reason, the *Florida Undergraduate Research Journal* is devoted to the publication of undergraduate research and believes that student researchers should have the opportunity to publish their research to a wider audience.

All submissions have cleared a rigorous, tiered review process consisting of an initial review by the Executive Editor, Editorial Assistant, and Editorial Manager, followed by a thorough review from the Editorial Board and a disciplinary faculty reviewer. The Editorial Board consists of undergraduate student volunteers from across the state schools—public and private, two-year and four-year—who meet monthly to review submissions, provide feedback to the author, and help advance the scholarship of fellow undergraduates. The diversity within the board offers student authors an interdisciplinary perspective and provides valuable experience for the Board to work together as colleagues in reviewing academic research.

This volume of the *Florida Undergraduate Research Journal* is a testimony to the hard work and dedication of the student researchers, Editorial Board, and faculty mentors.

Happy reading!

—Julia Hammond, Editorial Assistant

—Kelly Canaday, Editorial Manager

—Dr. Melodie H. Eichbauer, Executive Editor

Welcome from the Florida Undergraduate Research Association (FURA)

The Florida Undergraduate Research Association (FURA) is thrilled to partner with the Florida Gulf Coast University to launch the third volume of the *Florida Undergraduate Research Journal* (FURJ)! Helmed by Dr. Melodie Eichbauer along with a talented and committed Editorial Board, FURJ continues to be the first peer-reviewed undergraduate research journal composed of submissions from students across the state. FURA would like to offer special recognition to the authors whose research you will read about in the following pages, scholarship spanning across the disciplinary spectrum.

Dissemination, or the sharing of research, is a crucial component of the overall research process. It is not sufficient to conduct our research, if we are not sharing it in ways that benefit the wider public. FURA has long supported undergraduate research sharing through the Florida Undergraduate Research Conference (FURC), one of the nation's largest multi-disciplinary research conferences that is open to all undergraduate researchers from any Florida higher education institution. The addition of the *Florida Undergraduate Research Journal* provides another significant way for undergraduate researchers across Florida to share their research with this wider community, stretching beyond the boundaries of their individual institutions. We are especially delighted to have created a permanent DOI for the journal, so the incredible work of these undergraduate researchers will remain easily accessible moving into the future.

Again, congratulations to the student authors represented in our inaugural journal and a very special thank you to all those who volunteered their time to review submissions and craft this impressive feat. For those interested in joining the editorial board or submitting your own work in the coming year, please be sure to check out the FURJ page (https://journals.flvc.org/furj) on our FURA website or follow FURA on any of our social media accounts. We also encourage you to review the great work published in 2022 in the inaugural edition of FURJ.

Happy reading!

Florida Undergraduate Research Association

Abstracts

"No Statistical Difference in Measurements Between Caliper and Apps: A Comparison of Artifact Measurement Methods"

Taryn Lagor, with Dr. Alanna L. Lecher and Dr. April Watson, Lynn University

Measuring artifacts is one of the fundamental methods of archeological research. Though calipers are the traditional tool for such work, it is uncommon for scientists to carry a set of them around in their bag or pocket while in the field. There is a tool; however, that almost every person carries around with them constantly: the smartphone. In this experiment, we endeavored to discover if two measuring apps, the "Ruler" app and the "ARuler" app, would make good replacements for the caliper when measuring archeological artifacts. Measurements of five Common Atlantic oyster (Crassostrea virginica) artifacts and five faunal artifacts of varying species were taken with each tool. There was no statistical difference in measurements taken via any of the methods, indicating that the apps are suitable to replace the caliper for archeological measurement. Despite some limitations, this could prove useful for archaeologists in both lab and field settings for many reasons, chiefly convenience. Replications of this study and further exploration of the uses of these apps are worth considering.

"Collegiate Aviation Student Perceptions of Racial Influences in Aviation Education"

Trevor Simoneau, Rachel Siegel, and Ms. Samantha Bowyer, Embry-Riddle Aeronautical University

While the U.S. aviation industry has grown significantly in the last several decades, existing literature identifies a gap between progress for the industry and representation of minorities (Ison et al, 2016; Stevenson et al, 2020). According to the Bureau of Labor Statistics in 2019, out of the 141,000 persons employed as either "aircraft pilots" or "flight engineers," 2.6% were Black, 3.4% were Asian, and 2.2% were Hispanic or Latino, while 93.7% were White (BLS, 2019). What has yet to be investigated, however, is how that gap is perceived by students preparing to enter the aviation industry. This exploratory study examines the perceptions of collegiate aviation students, who represent the next generation of the aviation industry, and the impact race may have had on their choice to pursue an aeronautics or aeronautical science degree. Interviews were conducted with students currently enrolled in an aviation career degree program. Results indicated that while a slim majority of participants did not perceive race to be a barrier in aviation education, many participants identified examples of where racial barriers have played a role, in some form, during their aviation education career. In addition, several participants described the U.S. aviation industry's lack of diversity as an obstacle after beginning their collegiate aviation program. This case study provides an opportunity for institutions to consider how current diversity, equity, and inclusion efforts are impacting students, and what else may need to be done to increase minority representation within the aviation industry.

"Not my Child: Perceptions of Bullied Students with Behavioral Differences and Teacher Responses"

Olivia Schalk and Hope Geraghty, with Deah S. Quinlivan, Ph.D. and Leilani B. Goodmon, Ph.D., Florida Southern College

The current study aims to examine participants' attitudes toward children with behavioral differences and whether they support or condone bullying toward these children under various conditions. Participants were randomly assigned to read one of four vignettes; a situation was

described in which a fourth-grade student (with or without an outburst) was bullied and went to the teacher for assistance and either responded to the child positively or negatively. Participants then completed a questionnaire designed to assess their attitudes. The four vignettes were created to form a 2 x 2 factorial design where the valence of the teacher's response to the child (positive, negative) was crossed with whether or not the child exhibited an outburst. Participants in the positive teacher response condition reported that the student with an outburst "deserved" to be bullied significantly more than the student without an outburst. Participants reported that the teacher would have responded differently if the student with an outburst had a different behavioral history. Participants felt that the student that had an outburst was more likely to be acting out for attention than the student that had no behavioral outburst. Large-scale impacts of this study include a better understanding of peoples' perspectives of the classroom climate when children with behavioral differences are involved. This topic has not been researched in depth, and future research should expand upon this study to fully understand the biases toward children with behavioral differences.

"Comparing the effect of various cations on bacteriophage activity against *Xanthomonas euvesicatoria*"

Ian Fernandez, Peter Foerster, and Gage Collamore, Florida Atlantic University

Bacterial Spot is a common plant disease that affects tomatoes and peppers. This is caused by four bacterial strains belonging to the *Xanthomonas* genus, which have developed increased resistance to current copper-based treatments. Since copper is known to have phytotoxic properties, we sought to develop a bacteriophage-based biocontrol formulation as a treatment alternative for Bacterial Spot. Our previous plaque assay experiments showed that low-concentration Ca^{2+} supplementation of our isolated phages resulted in prominent lytic plaque formation when grown on a confluent lawn of *X. euvesicatoria* cells. Based on these findings, we aimed to test the effect of four other phytochemically significant cations (K^{+}, Na^{+}, Zn^{2+}, Mg^{2}) in a phage-host infectivity system. We hypothesized that phage supplementation with these cations at concentrations ≤0.1mM will induce increased virulence activity against *X. euvesicatoria*. Plaque assay results showed that larger and clearer plaques were mostly observed in bacteriophages supplemented with the divalent cations ($Zn^{2+}$and Mg^{2}) at concentrations ≤0.1mM. This study aims to contribute to the development of an optimized virus-based biocontrol agent that could serve as an environmentally safer Bacterial Spot treatment alternative to copper-based bactericides.

"Dietary Restrictions as a Source of Food Insecurity among FGCU Students, Faculty, and Staff"

Musarrat Shaira, Florida Gulf Coast University

Food insecurity is an issue that creates several challenges for individuals, including health complications, eating disorders, loss of productivity, and reduced ability. While food insecurity tends to be associated with poverty, unemployment, or lack of available food, dietary restrictions may also lead to food insecurity in places where food is otherwise plentiful. Dietary restrictions from allergies, cultural/ religious belief systems, and lifestyle choices could prevent access to food resulting in food insecurity. For example, halal requires believers to follow religious guidelines when eating. People who eat halal food avoid pork, alcohol, and dead animals, and only eat meals that are prepared according to Islamic law. As a result, a person practicing halal could experience food insecurity in places where their dietary considerations are not met. This study consists of a self-perception survey to better understand individuals' dietary requirements, access to food, and the perceived effects of skipping meals on academic performance,

professional work, and mental health. Results show that 70.8% of the participants have some form of dietary restrictions with the common forms coming from allergies (62.1%), personal preferences (31.8%), and cultural/religious beliefs (6.1%). The vast majority of participants with dietary restrictions described some difficulties finding food on campus with some saying that they could not find any appropriate food options. This study seems to indicate that dietary restrictions could be a factor leading to food insecurity, which also affects academic performance and physical and mental health. As a result, we need to invest in more food options, better labeling, and improved education to alleviate the detrimental effects of dietary restrictions on food insecurity.

"A Longitudinal Examination of Obsessive-Compulsive Symptom Severity as a Predictor of Posttraumatic Stress Disorder Development"

Mia Mantei, Florida State University

It is well established in literature that Obsessive Compulsive Disorder (OCD) and Posttraumatic Stress Disorder (PTSD) have high rates of comorbidity. Many studies consider trauma exposure as an etiological factor in the development of Obsessive Compulsive (OC) symptoms, however no research to date has considered the contributions of OC symptoms in the development and maintenance of posttraumatic stress symptoms (PTSS) following a traumatic event. Previous literature reports that trauma type and distress tolerance both influence presence and severity of PTSS and OC symptoms. The present study utilizes archival data from 97 trauma-exposed participants selected from a larger randomized controlled trial of four web-based interventions for anxiety and mood symptoms (N = 303). A hierarchical linear regression indicated that baseline OC symptoms predicted long-term follow-up PTSS over and above the variance explained by baseline PTSS, treatment condition, and trauma load. Further, a significant trauma type by OC symptom severity interaction indicated that baseline OC symptom severity had a greater effect on the development or maintenance of PTSS for individuals who experienced interpersonal trauma, as compared to those who experienced non-interpersonal trauma. Additionally, a mediation model demonstrated that month 3 distress tolerance fully mediated the relationship between baseline OC symptoms and long-term follow-up PTSS. The present study was limited by possible treatment effects, outdated methodologies utilized in the original study, and attrition. Despite its limitations the current study provides novel findings and advances our understanding of the relationship between OCD and PTSD symptoms.

No Statistical Difference in Measurements Between Caliper and Apps: A Comparison of Artifact Measurement Methods

Taryn Lagor
with
Alanna L. Lecher Ph.D
April Watson, Ph.D
Lynn University

Introduction

Studying cultural material is well known for uncovering vaults of knowledge that help scientists understand both the past and the present. For example, an archeological study completed in the Altai Mountains revealed "a near-continuous record of more than 3,500 years of human activity" (Taylor, et al. 2021:1). The zooarchaeological data from a study in Egypt revealed an enormous and distinctive picture of the use of marine resources in ancient culture (Szabó, et al., 2014). In many cases, studying paleoenvironments and human cultures can even provide guidance for what to expect in the future, chiefly as the world faces a continually and rapidly changing climate. The recognition of environmental changes through the examination of historic artifacts dates back to as early as 1848 with the interdisciplinary study of shell matrix sites in Denmark (Claassen, 1998). Often the most common remains in an archeological study are faunal and shell artifacts, from which much information can be gleaned. One example is the interaction of humans and animals and the impact of these relationships on the broader ecosystem around them (Reitz and Wing, 2008). A basic method of gathering this information is measuring the size of artifacts recovered from an archeological context. Comparing the measurements of wild live modern shells to archeological shells aids in monitoring and understanding past and present environmental changes (Dong et al. 2018:1-11). Measurements of faunal material provide insight into the influence of ecological resources on the survival and health of area inhabitants (Grosjean et al. 1997: 239-241). Domestically, measuring live shell is useful in determining the most efficient and effective farming methods, helping to preserve wild populations and ecosystems (Capelle et al. 2020:249-264).

In the majority of archaeological studies where measurements are collected for scientific data, sliding or spreading calipers are the traditional tool used for accurate readings. These precision measuring devices are typically made of metal or carbon fiber, are approximately a foot in total length, and have two hinged jaws, which are physically placed on either side of the object of interest and adjusted using a thumb roller. The resulting measurement is read on either a digital screen, a ruled scale, or a dial. Due to the size, shape, and fragility of calipers, it is uncommon for scientists to walk around with a set of them in their bag or back pocket; they are often reserved for the laboratory. However, generally cell phones are accessible and ubiquitous. While bone or shell measurements would mostly occur in the laboratory, there are scenarios where field measurements of these artifacts are desired or necessary. Additionally, it is possible that the laboratory might lack basic supplies such as calipers for analysis or the scientist themself is physically restricted in their ability to use calipers due to arthritis, missing digits, or missing limbs.

Smart phones are easily accessible, always on hand, and can save data without requiring extra tools. To date, the accuracy of smart device measuring apps juxtaposed against calipers in an archeological context has not been explored. For this reason, and due to the claims of accuracy by smart device measuring app developers, we hypothesized that there would be no statistically significant difference in the measurements of artifacts between the calipers and the apps, meaning the apps would make a suitable substitution for the caliper.

Literature Review

Measurements in zooarchaeology are critical as they represent the primary data collected by the archeologist. Some examples include the size of artifacts represented and the percentage of that artifact that remains, taxonomic identification, anatomical

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features that vary due to environmental change, pathologies, and human modification of bone, among other valuable insights (Reitz and Wing, 2008). These same data are available to archeomalacologists who study shell. A recent study revealed a reduction in the size of modern common Atlantic oysters compared to prehistoric common Atlantic oysters in the Gulf of Mexico (Hesterberg et. al., 2020). Since oyster size is an indicator of habitat function and population resilience, the findings of this study suggest current management practices overestimate species resilience and may be responsible for its continual decline, which could become irreversible (Hesterberg et. al., 2020). Similarly, another study used shell measurements to demonstrate the difference between the sustainable harvesting of common Atlantic oysters by Native Americans in the Chesapeake Bay area prior to the settlement of Europeans (Rick et. al, 2016). This study demonstrated that after European settlement oyster shell sizes declined due to overharvesting and artificial selection by humans, causing dwarfing in the oyster shells (Rick et. al, 2016). Measurements of oyster shell size can also provide clues about shell midden and mound construction. One study of shell middens in Crystal River, Florida, was able to demonstrate that certain middens were built suddenly because of feasting events as the common Atlantic oyster shell size did not vary significantly with depth in the midden (Sampson 2015:84-94). Ratios of shell valve height to length ratio also indicates where the shell was collected, for example, from an intertidal or subtidal area (Jenkins 2017:74-82). For both zooarchaeologists and archeomalacologists, measurements provide the framework to answer basic questions about the biology and health of the animals involved, the function of those animals in human society, and the environment in which the human-animal relationship is situated.

At a basic level, all analysts use size to eliminate certain taxa from consideration. For example, if a shell is quite large, the shell species might be a quahog (larger, round, edible clam) versus a smaller species such as coquina (small, wedge-shaped clam). Size is often used as an indicator of age, among other biological markers. Even more complex systems of measurements allow researchers to differentiate between closely related species, which often occurs with closely related fish species (Driver et al. 2011:19-39). Biometric measurements also allow archeologists to evaluate fragmentary specimens, which is frequently the case in archaeological contexts. For example, a study conducted on two species of turkey found in a Mayan archeological context spent years gathering careful biometric measurements of the turkeys. The turkeys represented two species that resembled each other osteologically (through their bone structure) yet culturally symbolized something different. This study, among many, revealed the importance of careful and accurate measurements of bone material (Emery et al. 2016:607-631).

Methods

This experiment compared 3 methods of measurement: the sliding caliper, the Ruler app on an iPhone 14 Pro, and the ARuler app on an iPhone 14 Pro using the iOS 16.1.1 operating system. The traditional tool of scientific measurement, the sliding caliper, was used to measure the shell and bone artifacts first. Specifically, a Husky digital caliper was used (Figure 1A). This stainless-steel caliper has a battery-operated digital display and is adjusted by the rolling of a thumb screw. Measurements can be taken in inches, millimeters, or fractions, and it has a guaranteed accuracy of +/ - 0.02 mm. Measurements for this experiment were taken in millimeters.

The Ruler app on an iPhone 14 Pro was the second measuring tool compared (Figure 1B). This tool is an app that, once opened on a smart device, provides a ruler on the device's screen. An item, provided it is small enough to fit on the device, is then placed directly on the screen. Once the item is placed, two sliding buttons are moved via touch to each end of the item. This then provides a digital measurement on a screen within the app with the size of the item either in centimeters or inches. Alternatively, the item can be placed to the far left of the smart device, and the ruler within the app can be used in a more traditional manner to read the measurement of the item. In this experiment, the first of the two methods was used, and the measurements were then converted from centimeters to millimeters. This app is completely free to download and use to measure in centimeters. However, there is a $1.99 charge to unlock the "Pro Features," which allow users to measure in inches and use other advanced features. This app is

downloadable for iOS devices and Android devices.

The ARuler app on the same iPhone 14 Pro was the last measurement tool compared (Figure 1C). This tool is also an app that is used on a smart device; however, it uses the device's camera for its measurements. To begin, the item to be measured is placed on a flat surface. In this experiment, we placed the shell and bone artifacts on a flat lab tabletop. Once this is completed, the measuring takes place by identifying the start point of the object of interest through the camera and then touching the device's screen. The camera is then moved to the end point of the item of interest and the screen is tapped again to complete the measurement. During this movement, an orange line with orange text appears showing the measurement as the camera is moved. After the screen is tapped a second time, concluding the measurement, the digital measurement is saved on the screen until a new measurement screen is started or the app is closed. This app can be used to measure items of all sizes (from centimeters to meters) in metric or imperial. For this experiment, the items were measured in centimeters and the measurements were then converted to millimeters. This app is free to download and use as described. There is a "Premium" purchase that allows the user to archive measurements, operate the app ad free, and use the new 3D lidar tool. This premium can be purchased at a monthly cost of $19.99 per month, a quarterly cost of $49.99 every 3 months, or an annual cost of $89.99 per year. This app is downloadable for iOS devices and Android devices.

The items measured for this experiment were 50 different shell artifacts (all common Atlantic oyster) and 50 different bone artifacts (various species). These shell and bone artifacts were chosen for this study as they are part of a larger archeological study at our institution and were easily accessible. Additionally, they are accurate representations of the types of artifacts found in professional archeological digs and therefore excellent models for this study. These artifacts were retrieved from one of three middens (large collections of domestic disposals from historic peoples) in South Inlet Park located in Boca Raton, Florida. Specifically, the park is located just north of the boundary between Palm Beach County and Broward County. The site number that the artifacts were retrieved from is 8PB05376 located at Township 47 South, Range 43 East, and Section 32 (Lecher and Watson 2021:5).

The length of each shell artifact was measured from the umbos, along the mantles, to the posterior ends (Figure 2). The lengths of each bone artifact were measured at their longest points (e.g. Figure 1), which varied from artifact to artifact. All artifacts were measured under the same conditions, over four days, by the same person. To determine if the measurement difference between each app and the caliper was significantly less than 1 mm, we applied a single sample t-test to the absolute difference measurements between the caliper and Ruler app and the caliper and ARuler app. To determine if the different measurement tools would create significantly different data sets of the same artifacts, we applied a one-way ANOVA to the raw measurement data of each tool. An ANOVA was executed for both the bone and shell artifacts, with the different measurement methods representing the different groups. ANOVA is an acronym which stands for Analysis of Variance, and it compares the variance within groups to the variance across groups to determine the probability (p-value) that no group is significantly different from the others (Lecher, 2018). The ANOVA and t-tests were executed using the Microsoft Excel Data Analysis Toolpak.

Results

The results of this experiment show no statistically significant differences (for shell $p = 0.960$, for bone $p = 0.999$) between the measurements taken using a caliper compared to the measurements taken using the Ruler and ARuler iPhone apps. Box and whisker plots of both shell measurements (Figure 3A) and bone measurements (Figure 3C) show the 3rd and 4th quartiles of the data largely overlap, and the medians and means are similar. Additionally, the t-test for the shell measurements revealed the difference in measurements between the caliper and the two apps were significantly less than 1mm ($p< 0.001$ Ruler app and 0.048 ARuler app). The t-test for the faunal artifact measurements revealed the same ($p < 0.001$ for Ruler app and $p <0.001$ for ARuler app). While the Ruler app measurements were closer to the caliper measurements than the ARuler app, both apps were significantly less than 1mm in measurement deviation with no statistically significant difference within the groups. All original measurement data,

ANOVA results, and t-test results can be viewed here.

Discussion

The data showed the Ruler app was the closer of the two apps to the caliper measurements, indicating the Ruler app should be preferred of the two apps. However, it does have one major shortcoming: The Ruler app is only able to measure something that is small enough or linear enough to fit on the screen of the smart device being used. If the artifact of interest is too large to fit on the screen, or if the artifact has an irregular shape which prevents it from being measured by a linear measuring tool, the Ruler app cannot be used. A good example of this is the common Atlantic oyster shells that were measured in this experiment wherein the shells of interest were small enough (50 mm to 100 mm) to fit on the screen of the iPhone 14 Pro that was used, yet these oysters have been recorded to grow as large as 259 mm, too large to fit on a phone screen (Rick et. al. 2016:65-69). Additionally, the farther away from the screen the point of measurement on the artifact becomes, the more difficult the reading becomes to take and the margin for measurement error enlarges.

The ARuler app was originally designed for interior decorating and small-scale construction; therefore, it has use in measuring much larger and nonuniform artifacts, potentially even mounds or midden sizes. While the ARuler app does not have the limitations of artifact size and linear shape as the Ruler app does, it is not without its caveats: This app has a large margin for error in use. Users must be very careful to keep the smart device leveled during measurement as the app may mistake camera tilt for extra size. Moreover, the measurement is dependent on the artifact resting on a flat surface; therefore, field measurements could become inaccurate if artifacts are not on level enough ground whilst being measured. There is also room for user bias as the app tells you what the measurement is as it is being taken. This could lead to users adjusting the camera to get different measurement sizes if this app is being used for repeat measurements. Updates to this app since this experiment was conducted present interesting potential: There is an "AR Plan 3D" option available now, which enables the measurement and creation of 3D floor plans. This could prove even more useful in measuring extremely large artifacts, mounds, and middens.

Despite both apps having their limitations, they were supported in this experiment as accurate enough for good archeological measurements. Though no significant differences in measurements were seen here, and differences in measurements were significantly less than one millimeter, the experiment is worth repeating with different artifacts, such as ceramics or modified shell and bone, to ensure similar results are replicated before the use of measuring apps becomes the default for archaeological research. If repeat experiments yield supporting results to this experiment, time, space, and effort could be saved by enabling archologists to do more (if not all) measuring in the field—avoiding the need to bring artifacts back to the lab if no further analysis is required, such as when excavating large amount of shell for example. It is worth noting that these apps were only used on an iOS device and were not tested on any Android devices. This is yet another avenue that should be explored before defaulting to these apps for scientific measurement. Additionally, the new 3D measurement component of the ARuler App could prove useful for archeological measurements, especially for the field, and may be worth future exploration and experimentation. These types of studies are important as quality assurance and control are central to zooarchaeological studies. Intra-observer errors in the measurement of artifacts may lead to differing opinions on classification. As Wolverton (2013) stated, every identification of an animal is a hypothesis, which must be supported or disproven using known techniques. Studies which evaluate the accuracy of the tools used by archeologists can only strengthen identification and subsequently add to the data that is known about past populations' way of life.

Conclusion

The results from this experiment supported the hypothesis that the measuring apps would produce a significantly similar length compared to the caliper, substantiating that the apps could be used in place of a caliper for the measurement of artifacts. Though these apps' measurements did not exactly match those of the calipers, the differences were less than one millimeter and not significant enough to designate them inaccurate, particularly

for the Ruler app. Thus, either of these apps could be used as a substitution for calipers for archeological measurements, most distinctly for field work.

The Ruler app is a sliding scale measurement method that is straight forward and simple to use and gives a digital measurement in centimeters to the hundredth's place. The ARuler app takes measurements through the smart device's camera lens, is a little more difficult to accurately use, and provides a digital measurement in centimeters to the tenth's place. The differences in which the measuring app functions and the differences in measurement numbers reported (hundredth's vs tenth's) account for the slightly differing results. Future experiments comparing measurement accuracy of the apps in the field versus a laboratory setting would be worth investigating, specifically for the ARuler, app which depends on the object of interest resting on a flat surface. Furthermore, the exploration of measuring very large artifacts, mounds, or middens in the field using the ARuler app should be conducted to investigate accuracy and usefulness.

The convenience of access to the measuring apps would be the primary benefit of their use. Calipers are sensitive tools that can easily become uncalibrated and/or are broken as well as typically of an unusual shape and size, restricting them primarily in the laboratory. Smart devices, on the other hand, are more durable instruments and an additional purchase of protective casing can reinforce them further. In addition to always having their phones on hand as habit, like most people do, some archaeologists already use their phones to take requisite photos during an excavation. Using smartphones to take measurements of artifacts while in the field seems to be a natural progression of integrating digital smart devices into archeological fieldwork. Similarly, when measuring a great number of samples such as hundreds or thousands of oyster shells, archaeologists may be limited by the number of measuring devices they have (Sampson 2015:84-94). If five volunteers are available to assist with measurement, but the archaeologist only has access to two calipers, the remaining volunteers could still contribute measurements by using one of the apps described in this study. Additionally, efficiency is another benefit to using apps as a measuring technique as we found the use of the apps, especially the Ruler app, to be much faster than a caliper. Many archaeological studies focused on shells measure hundreds or thousands of shells (e.g. Sampson et al, 2015). Thus, having a faster but equally accurate method for measurement can be valid even in a laboratory setting**.** These apps appear a suitable alternative or addition to the typical archeologist's tool kit.

Author Contributions

TL conducted the measurements, statistical analysis, and writing. AL conceived of the study and mentored TL through the analysis. AW ensured compliance with regulations regarding the artifacts. AL and AW conducted the original excavation and provided edits and comments on the paper.

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Figure 1: Measuring a bone artifact A) Caliper, B) Ruler app, C) ARuler app

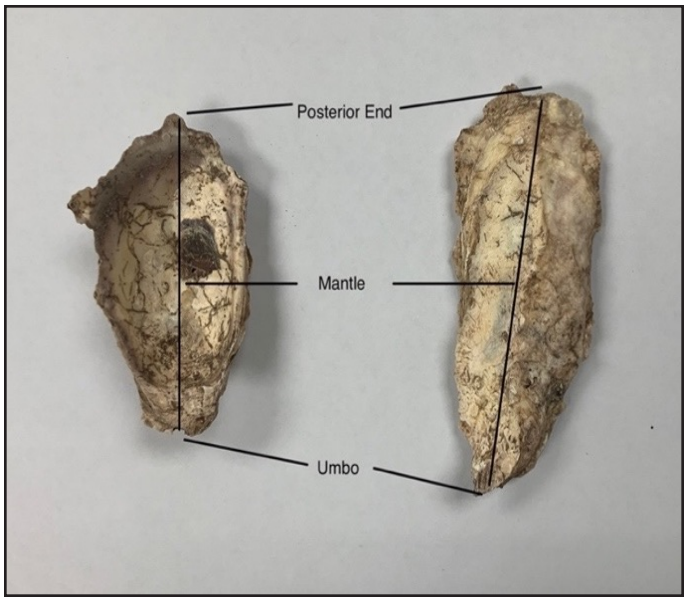

Figure 2: Shell artifact anatomy.

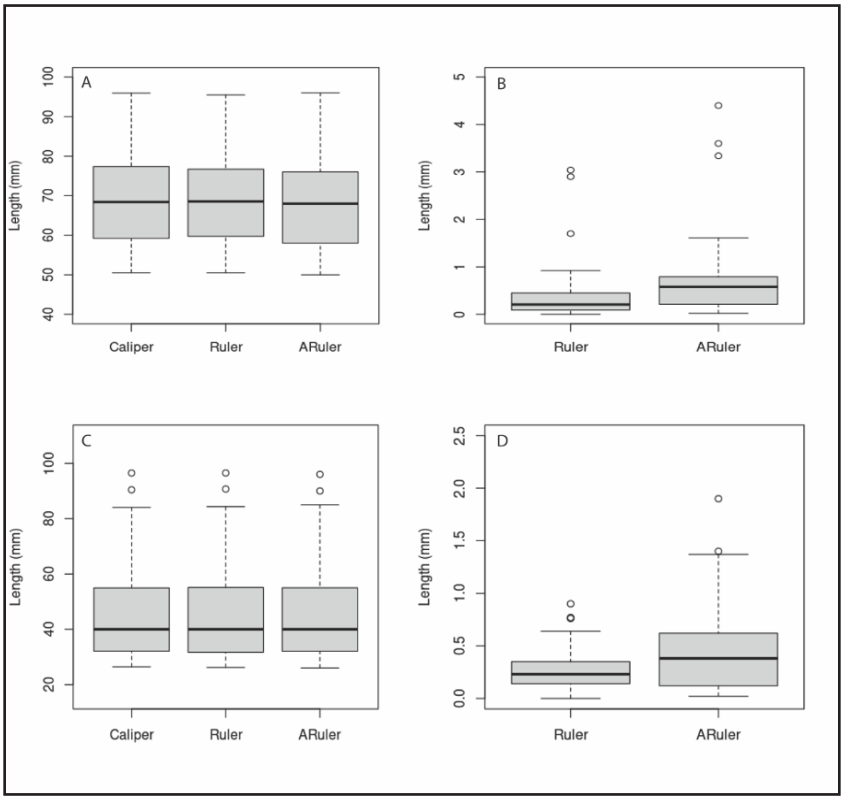

Figure 3: A) Box and whisker plot of shell measurement data from calipers, Ruler app, and ARuler app (ANOVA, $p = 0.960$). B) Box and whisker plot of absolute difference data between shell measurements from caliper and Ruler app and calipers and ARuler app (t-test, $p < 0.05$). C) Box and whisker plot of bone measurement data from calipers, Ruler app, and ARuler app (ANOVA, $p = 0.999$). D) Box and whisker plot of absolute difference data between bone measurements from calipers and Ruler app and calipers and ARuler app (t-test, $p < 0.001$).

Collegiate Aviation Student Perceptions of Racial Influences in Aviation Education

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Introduction

The United States (U.S.) is rapidly becoming a more diverse nation (Frey, 2020; Jones et al., 2021). However, this reality is not reflected in the U.S. aviation industry as historically this industry has never had a racially diverse workforce (Ison et al., 2016; Stevenson et al., 2020). Even recently, the industry remains staggeringly single sided as illustrated by the fact that in 2019, according to the Bureau of Labor Statistics (BLS), more than 93% of aircraft pilots or flight engineers were White (BLS, 2020). Moreover, the extent to which aviation students are aware of, or impacted by, the lack of racial diversity in the aviation industry is a relatively unexplored area of study. Accordingly, it is vital to understand the perceptions aviation students hold of this issue at two levels: 1) the broader perceptions students hold of racial influences within the aviation industry in general; 2) the specific perceptions aviation students hold of racial influences regarding their individual experiences in pursuing an aviation career. This study primarily investigates the latter, focusing on collegiate aviation students. Collegiate aviation students are those whose degree program is focused on their goal of becoming a professional pilot. A collegiate aviation student's degree program also has a flight program embedded within the academic curriculum.

This exploratory case study seeks to investigate the perceptions of collegiate aviation students regarding the influence of their race and the racial diversity of the industry on their decision to pursue an aviation career, specifically as a pilot, and by seeking a corresponding bachelor's degree. These perspectives are obtained by speaking firsthand with students and flight instructors at Embry-Riddle Aeronautical University's (ERAU) Daytona Beach campus about their experiences in the collegiate aviation education environment.

Interviews with students included questions about what initially inspired their interest in pursuing an aviation career, the role family members or mentors played in their choice to pursue an aviation career, why they chose to attend a collegiate aviation program, and how they feel their race, if at all, has influenced their aviation education careers. The interview questions This provide an opportunity to gain insight about collegiate aviation students' individual perceptions with respect to racial influences in aviation education, while simultaneously considering how other factors, such as family or mentors, impact the issue. Furthermore, understanding student perceptions of this topic plays a crucial role in developing higher education programs aimed at improving racial diversity both in aviation education and in the industry.

Literature Review

While the aviation industry has grown substantially in the last several decades, aviation lags significantly behind when compared to the racial diversity of the overall U.S. workforce. Existing literature identifies this gap, in one example, by illustrating that when you walk through an airport, most pilots in uniform are white males (Stevenson et al., 2020). Accordingly, improving diversity within the aviation industry has recently been a key focus of both government and industry initiatives (Bridging the Gap, 2021). However, at the time of this study, there is limited research with respect to students' individual perceptions of how the industry's lack of racial diversity impacted their decision to attend a collegiate aviation program, obtain an aviation degree, and ultimately pursue a career in the aviation industry.

Historical Perspective and Diversity Statistics

To properly examine collegiate aviation student perceptions of racial influences in aviation education, it is critical to understand the historical perspective of the race discussion in the context of aviation and education within the United States as a whole. On July 26, 1948, President Harry S. Truman signed Executive Order (EO) 9981 ending segregation in the U.S. military by prohibiting discrimination based on race, color, religion, or national origin. The executive order came soon after the end of World War II. During that time, the Tuskegee Air-

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men became the first black pilots in the U.S. Army Air Forces, achieving resounding success after overcoming numerous flight training barriers (Haulman, 2011). The triumphs of the Tuskegee Airmen and the significance of EO 9981 were two of the many occurrences aiding in the commencement of the Civil Rights Movement during the 1950s and early 1960s (NPS, 2020). President Lyndon B. Johnson signed the Civil Rights Act on June 2, 1964, which was considered the most comprehensive civil rights legislation since Reconstruction (Bowen, 2015). Six years later in 1954, following the controversial U.S. Supreme Court decision in Plessy v. Ferguson (which held that if facilities for Blacks and Whites were equal, racial segregation of public facilities was legal), the Court held in Brown v. Board of Education of Topeka, Kansas the doctrine of "separate but equal" violated the 14th Amendment of the U.S. Constitution and was, thus, unconstitutional. This significant ruling by the court ultimately led to the desegregation of U.S. schools. Indeed, the 1954 ruling in Brown served as a major turning point in the history of education in the United States. However, more than 60 years later, there are still indications within the aviation context, of an industry with significant racial disparities.

Diversity at all levels—students, faculty, and staff—within institutions is of the utmost importance as it "enriches the educational experience…promotes personal growth-and a healthy society…strengthens communities and the workplace…[and] enhances America's economic competitiveness" (American Council on Education, 2012, p. 1). Higher education researchers argue that access and equality have been the goals of American higher education institutions for decades (Hurtado et al., 1997). Statistical evidence concurs with this argument as recent data shows higher education institutions have been growing rapidly, with total enrollment of recent high school graduates ages 16 to 24 rising to 69.5% in 2016 (Espinosa et al., 2019). From 2000 to 2016, total college enrollment rates increased for White students from 39% to 42%, for Black students from 31% to 36%, and for Hispanic students from 22% to 39% (de Brey et al., 2019).

Despite the awareness for a more diverse workforce within the aviation industry, barriers for minorities remain in place. Davidson et al. (2020) found that factors such as ACT standardized testing, home and school support systems, and financial aid are perceived as barriers to enrollment in higher education institutions by African American students. And once enrolled, if a negative racial campus climate exists, "academic persistence and retention rates fall" (Lee et al., 2020, p. 2).

Recent decades have brought about a particular emphasis on science, technology, engineering, and mathematics (STEM) fields in higher education (Baber, 2015). Correspondingly, since the 1957 launch of Sputnik by the Soviet Union, there has been "unprecedented U.S. investment in STEM education," but importantly, such investment came at a time when leading research institutions "remained unequal due to de facto segregation" (Baber, 2015, p. 253, as cited in Anderson, 2006). The past two decades have seen recent calls for improved diversity, yet issues of "recruitment and retention in STEM" fields persist (Lee et al., 2020, p. 2). Students likewise recognize the importance of diversity in STEM fields. For example, Martin and Fisher-Ari (2021) interviewed high school students to learn about their perceptions of race and gender representation in STEM fields, finding that many of the participants identified family members and mentors "as sources of support for STEM vocations" (p. 1094). Martin and Fisher-Ari's study supports the significance of representation in these fields.

Aviation education and the aviation industry are directly connected to STEM education. For example, Raupp (2021) reported "some savvy STEM educators are using aviation and aerospace concepts to inspire the next generation of young scientists and inventors" (para. 1). Innovative aviation and aerospace educational programs can play a significant role in inspiring interest in STEM careers, and "inspire them [students] to explore careers in flight" (Raupp, 2021, para. 6). According to the Federal Aviation Administration ([FAA], 2022), STEM plays a critical role in an aviation student's success and is "a driving force behind our country's [the United States] strategic positioning and economic wellbeing" (para. 4).

As in other STEM fields, aviation is not immune from recruitment and retention issues, especially with respect to minority representation. Historically the U.S. aviation industry is known for having few minority participants and poorly reflects the diversity of the overall U.S. workforce as "U.S. airlines have

been peopled mostly by white males, and it is still the case that white males dominate the management and piloting ranks of the industry" (Hansen & Oster, 1997, p. 115). In the U.S. in 2019, out of the 141,000 persons employed as either aircraft pilots or flight engineers within the U.S. aviation industry, 2.6% were Black, 3.4% were Asian, and 2.2% were Hispanic or Latino, while 93.7% were White (BLS, 2020).

With respect to collegiate aviation programs, Hedge (2007) recommended that, among other things, collegiate aviation programs focus recruitment efforts toward minorities and support minority students with scholarships. Hedge (2007) also called for further research to investigate the perceptions of minority pilots with the specific purpose of developing "new and innovative programs to motivate minorities to pursue aviation careers" (p. 77). Ison et al. (2016) concluded that "within collegiate flight programs, minorities, including women, now make up 27.3% of the student population" (p. 8). Clark (2006) found the most influential factor affecting American students' choice to attend collegiate aviation programs was that "they always wanted to be a pilot" (p. 53). This remains true for female and minority students, according to Clark (2006), though additional factors, such as "institutional education quality, availability of scholarships," and "tuition and fees," (p. 53) were also influential in female and minority students' choice to attend a collegiate aviation program. In addition, Clark (2006) found "the most frequently selected factors that attract students to four-year post-secondary aviation programs were similar across all gender and racial lines" (p. 54).

As of October 2021—the time at which this study was conducted—out of the 6,926 undergraduate students enrolled at Embry-Riddle Aeronautical University's Daytona Beach campus, 5% are Black/African American, 5% are Asian, 14% are Hispanic or Latino, 11% are Nonresident Alien, 5% are two or more races, 58% are White, and 2% are unknown (ERAU, 2021). According to these institutional statistics, 40% of enrolled undergraduate students at Embry-Riddle Daytona Beach are minorities. This is an important difference compared to the 8.2% total of minorities employed in the U.S. aviation industry and further illustrates the racial minority gap between higher education institutions and the U.S. aviation industry.

Webb (2014) found that, at one institution, most students surveyed did not perceive "racial bias and barriers exist in the Aerospace Department" (p. 34). Even still, some survey responses indicated that "in the opinion of minority students, there was a racial/ethnic barrier present" in this institution's Aerospace Department (p. 34). Correspondingly, Webb (2014) found most minority participants believed the Aerospace Department at this institution "did not consist of faculty members of different racial/ethnic backgrounds" and that "students would benefit from having a more diverse faculty" (p. 34). Webb (2014) also concluded that a majority of students surveyed believed "the Aerospace Department does not effectively recruit minority students" (p. 35).

Murillo (2020) conducted open-ended virtual interviews with underrepresented minority graduates of U.S. collegiate aviation flight programs, which are defined in this study as "students whose ethnic/racial background includes Black, Hispanic, Asian, Pacific Islander, American Indian/Alaska Native, and two or more races" (p. 6). Notably, this definition does not differentiate between ethnicity and race amongst participants. Murillo (2020) stated that "participants were selected based on gender and race/ethnicity identification to represent minorities in STEM/aviation" (p. 72). The key findings of this study were that administrative resources, financial aid, and personal support were all "Contributors to Success" (p. 89) for underrepresented minorities. Conversely, a lack of social capital, a lack of belonging, a limit on financial resources, and an institution's ability to bridge the gap between industry and academia were all identified as "Barriers to Persistence" (p. 89). However, Murillo (2020) did not define the term barrier.

Extending beyond racial influences in the collegiate aviation environment, Harl & Roberts (2011) investigated the experiences of Black pilots in the business aviation industry. Their study concluded, among other things, that most Black participants "had to work harder than Whites to prove their skills to industry" (p. 16) and "skin color cannot be an issue when safety is the first mission of the team, yet minorities often have to accommodate Whites who are uncomfortable working with a minority on their team" (p. 16). In addition, Harl & Roberts (2011) called for further research to investigate, among

other things, the role of mentors and networking in achieving success in the aviation industry, specifically in the context of what more can be done to provide mentoring and networking opportunities for young minorities. What is more, Ragbir et al. (2021) investigated consumer perceptions and bias towards female and racial minority commercial pilots and flight students, finding that females and racial minorities were generally favored less by consumers than males and White pilots. These results, Ragbir et al. (2021) suggest, indicate "females and individual ethnic minorities face bias that can influence their achievement in professional domains such as aviation" (p. 9).

Stevenson et al. (2020) found a "consistent lack of racial diversity" when examining the representation of Black aviation professionals, also identifying a "markedly erratic" percent change of Black pilots across a 10-year period; this was in contrast to a "relatively stable" percent change for White pilots across the same 10-year period (p. 15). Accordingly, Stevenson et al. (2020) called for further research to investigate the causes of this trend, specifically qualitative studies "involving focus groups and in-depth interviews" (p. 15).

Additionally, in recent years, there have been a considerable number of initiatives aimed at improving these participation rates. Ison et al. (2016) noted that groups such as the Organization of Black Aerospace Professionals, Women in Aviation, Latino Pilots Association, and the Hispanic Professional Pilots Association have developed programs, in conjunction with the FAA, to promote STEM and aviation careers to minority students through scholarships, internships, and other opportunities. For example, the FAA has committed to supporting various projects organized by the Organization of Black Aerospace Professionals, launched a program designed to support Native American/Alaska Native students with educational expenses through scholarship, and supported a minority serving internship (Ison et al., 2016). What is more, many airlines have launched similar initiatives focused on diversity, equity, and inclusion. For instance, Delta Airlines (2021) is rolling out enhanced inclusion training to all Delta employees, and in September 2020 Southwest Airlines (2021) announced new company goals aimed at strengthening and improving diversity, equality, and inclusion efforts within the company.

Understanding "Racial Influences" in the Context of Aviation

When discussing racial influences, this study considers two elements: opportunities and barriers. In the context of race, both an opportunity and/or a barrier may influence the experiences of a collegiate aviation student. The final interview question posed to participants includes the terms opportunity and barrier (see Table 1). Accordingly, it is important to conceptualize both terms. The United States Census Bureau defines "race" as "a person's self-identification with one or more social groups" (U.S. Census Bureau, 2020). Furthermore, according to the Bureau, the U.S. Office of Management and Budget (OMB) outlines five race categories (White, Black or African American, American Indian or Alaska Native, Asian, and Native Hawaiian or Other Pacific Islander) used to collect information for Federal programs and making civil rights policy decisions (U.S. Census Bureau, 2020). These categories are used for analysis in this study. The term "racial barrier," with respect to this study, may be understood as a form of racial discrimination, meaning unfavorable treatment towards someone because he/she is of a certain race (U.S. Equal Employment Opportunity Commission, 2021). In other words, because a person was of a certain race, that fact created a barrier that influenced their aviation education career. Throughout history, there have been numerous examples of racial barriers within aviation education: specifically, the Tuskegee Airmen encountered myriad barriers throughout their flight training in Tuskegee, Alabama, a city located in the heart of a Jim Crow community during the early 1940s, prior to the enactment of Executive Order 9981. Separately, the meaning of opportunity is seemingly more obvious. The term, with respect to this study, may be understood as an instance where because a person was of a certain race, that person was afforded an opportunity that influenced their aviation education career as in, for example, the opportunity to apply for a scholarship.

Talking About Race: Methods and Analysis

Sue (2015) identifies that "race talk" has the potential to push "powerful emotional hot buttons in people" and may invoke a variety of different avoidance strategies, depending on the person (p. 11). Forming a dialogue about race is a sensitive

task. The researchers utilized prescribed methods outlined in Researching Racism: A Guidebook for Academics and Professional Investigators by Quraishi & Philburn, 2015. The authors of this book argue the qualitative interview is a prime method for exploring the relationship between race, subjectivity, and "lived experience" (Quraishi & Philburn, 2015); thus, qualitative interviews were selected as the primary research method for this study. The one-to-one, face-to-face environment aids in allowing participants to articulate as much information as possible about their experiences and promotes a safe environment for exploration of one's personal experiences, feelings, attitudes, prejudice, beliefs, and behaviors (Quraishi & Philburn, 2015).

Additional aspects include respecting the words of participants, considering participant comments will be subjectively charged, and the setting of the interview. In this study, the authors used a non-naturalistic setting, which is unfamiliar to the interviewee but is more controllable (Quraishi & Philburn, 2015). Another significance of the qualitative interview is it provides participants "the possibility to articulate these issues in their own words, and on their own terms" (Quraishi & Philburn, 2015, p. 61). With respect to qualitative interview analysis, it is important to use thematic analysis of the generated data through interview transcripts (Quraishi & Philburn, 2015). A complete outline of how data was analyzed in this study is described by the authors in the next section of the paper.

Methodology

The aim of this study was to obtain collegiate aviation student perceptions of how race plays a role in aviation education by seeking to answer the following research question: What perceptions do collegiate aviation students have of racial influences and/or biases within aviation education?

To answer this research question, the researchrs selected ERAU's Daytona Beach campus as the location for the case study. Participation in the study was open to ERAU Daytona Beach undergraduate students enrolled in either aeronautical science or aeronautics degree programs, or instructor pilots (IPs) currently employed by the university and have been enrolled in a collegiate aviation program within the previous three years. At ERAU Daytona Beach, the aeronautical science degree program is available to students who fly on campus as part of Embry-Riddle's flight program (ERAU, 2023a). In the aeronautics degree program, the academic curriculum is nearly identical to the aeronautical science degree program. However, the aeronautics degree is reserved for students who fly off campus (ERAU, 2023b). "Instructor pilot" is the term Embry-Riddle uses to describe certificated flight instructors—individuals properly certified by the FAA to teach students how to fly.

Participants were recruited via flyers and posters, including a mass email sent to all aeronautical science and aeronautics undergraduate students currently enrolled at Embry-Riddle's Daytona Beach campus. At the time, the student population in those two degree programs was approximately 1,500 students, and approximately 50 eligible flight instructors. Qualified candidates volunteered to participate in the study. Prior to beginning the interview, participants were asked to complete a demographics survey and confirm that they met the eligibility requirements. While one of the interviewing researchers knew two participants and the other interviewing researcher knew one participant, no participant was directly asked to participate in the study. Participation in the study was voluntary.

The study was conducted through a qualitative research methodology using individual interviews with participants. Participant interview responses were recorded using an audio recording device. Both authors collaboratively conducted the interview session in order to comply with Yin's (2018, p. 85-6) best practices for collecting case study data, which includes observing body language and tone as well as the raw answer. One researcher was responsible for leading the interview by setting up the audio recording device, asking the prescribed questions, and noting key times for reference during analysis. The other researcher observed and notated participant body language for reference during analysis. The research team asked each of the following questions and allowed time for the participants to respond freely. While many of the questions could have been answered with a simple "yes" or "no" response, the research team asked participants to elaborate if such an answer was provided. However, follow up questions were limited specifically to, "can you explain

that more?" or "are you able to elaborate?" Thirty participants were interviewed. Interviews took place in conference rooms housed within the College of Aviation at Embry-Riddle's Daytona Beach campus.

As this is an exploratory case study, the research team did not necessarily expect for results to be highly generalizable. The research team obtained permission to conduct this research from Embry-Riddle Aeronautical University's Institutional Review Board (approval #22-019).

Analysis Process

Key words, phrases, and themes were codified with numbers for manual conceptualization in order for the authors to "connect the qualitative data collection phase with the data analysis phase of a study" (Rogers, 2018). Interviews were manually transcribed and annotated to identify key words, phrases, and themes, or the interviews were individually coded in accordance with process set forth by Creswell and Poth (2018) with the results brought together and evaluated for objectivity. This phase is important because, as noted by Rogers (2018), coding is "not an exact science with right and wrong answers," so multiple perspectives allow for greater objectivity. Moreover, the coded data was presented to the faculty advisor, who did not participate in the interview process, for validation. Participant body language observations during the interview process focused on, but were not limited to, general friendliness with the interviewers, eagerness and/or hesitancy to answer interview questions, eye contact, eye movement, tone of responses, hand movements, posture, and restlessness. Participants were given pseudonyms for anonymity. The resulting data was segmented to develop the study's conclusions and is outlined in the next section of the paper. Additionally, demographic survey data was analyzed quantitatively and utilized in order to make more objective conclusions.

Results

Out of the 30 students/instructors who participated in the study, 27% were Asian, 6.5% were Black or African American, 27% were Hispanic or Latino, 33% were White, and 6.5% were two or more ethnicities. Four of the 30 participants identified as female, which is about 13% of the participants in total. The significance of reporting this table as shown is that it provides a comprehensive view of the participants' gender and race despite gender not being a focus of this study. Complete participant demographics are shown in Table 2.

Table 3 shows participant responses to interview question 7, including each reason or explanation articulated by participants in their response. Table 4 illustrates each reason participants referenced when asked what sparked their interest in pursuing an aviation career. Table 5 highlights common themes in participant responses for the most frequently occurring reasons why participants chose to pursue an aviation career. Table 6 identifies specific reasons mentioned by participants when asked whether they had experienced any hesitancy towards pursuing an aviation career.

Discussion

The overall findings of this case study suggest that out of the 30 collegiate aviation students/instructors who participated, a slim majority do not perceive race to be a barrier within aviation education (see table 3). This result corresponds with the findings of Webb (2014). In total, 53% of participants responded their race did not create either a barrier or opportunity. Out of those 53% (n = 16), according to the results, 18.8% were Asian, none were Black or African American, 25% were Hispanic or Latino, 50% were White, and 6.2% were two or more races/ethnicities. In total, 37% of participants responded their race did create a barrier or opportunity. Out of those 37% (n = 11), only 1.8% (n = 2) responded their race created an opportunity. One of these participants was Black or African American while the other identified as two or more races/ethnicities. Of the remaining nine participants who responded their race created a barrier, their specific responses were justified using a variety of examples.

One participant indicated he had experienced a microaggression during his flight training. According to Pierce et al. (1977), microaggressions "are subtle, stunning, often automatic, and non-verbal exchanges which are 'put downs' of individuals" (p. 65) usually from, as observed by Lui & Quezada (2018), minority and marginalized groups. Participant Toby, a student who self-reported as Hispanic or Latino, shared a scenario he was a part of explaining that race is:

> Definitely a barrier. When I was doing my private pilot checkride, the DPE [Desig-

> nated Pilot Examiner], he… I guess he tried to word a question a certain way, but I guess it didn't come through as right, so he brought in another instructor that was also Hispanic to try to, I guess, make more sense.

Toby went on to express that he felt the examiner appeared to think the communication barrier was strictly because they spoke English differently, and that someone who looks like him may be able to explain it more effectively instead of taking the time to work on communicating with him directly. Another participant expressed that, while they did not feel their race had influenced the situation, they knew at least one other person who had an experience where they felt it had. Some participants discussed their experiences as international students studying in the United States, and described how company-wide and collective industry interest in boosting diversity positively affected their hiring chances.

One participant referenced race as a barrier in the context of the September 11, 2001, terrorist attacks. Participant Charles, a student who self-reported as Asian, explained that race is a barrier because "Being Indian, having brown skin in the aviation world ever since 9/11, has kind of been… you get jokes and stuff made about it." He went on to describe these assumptions are "usually [made by] strangers, not friends… which is kind of odd." Additionally, in referencing race as a barrier, two participants noted lack of representation within the industry as an issue. One of these participants self-reported as Black or African American and the other self-reported as Hispanic or Latino.

Participants who responded that they felt their race created an opportunity mostly referenced scholarship opportunities and U.S. aviation industry diversification. Participant Wyatt, who self-reported as White, said his perception of the aviation industry is that minority representation has improved since he has been with ERAU, and that he has noticed the industry has recently made efforts to increase diversity, which appear to be working. Participant Emma expressed that being a first generation Mexican-American woman on campus had its challenges, but this has also benefited her in the sense that:

> …you don't see many Hispanics, especially Hispanic women, in aviation. It's definitely a bit weird coming here and not seeing any people like me. But I would also say that it has created opportunities; like a lot of companies are interested in boosting their diversity, so I say that that has helped me with scholarships and stuff like that.

When asked, "What sparked their interest in pursuing an aviation career?" 57% of participants responded that it was parental/familial influence. Out of those 57% (n = 17), 29.3% were Asian, 23.5% were Hispanic or Latino, 41.2% were White, and only 6% were Black or African American. Notably, out of the 57% of participants who referenced parental/familial influence, the vast majority cited a male figure, such as their father, grandfather, or uncle, who worked in the aviation industry. Only two referenced both parents and none explicitly referenced a female figure, such as a mother, grandmother, or aunt, who specifically worked in the aviation industry. For example, one participant, Dylan, who self-reported as White, noted his dad would take him to airshows and "him [his dad] being in the aviation industry sort of set that ball rolling, an early start." Some participants also stated that their interest in aviation originated with having to travel on airplanes to visit family members or for their family members' jobs. For example, one participant, Kent, who self-reported as Asian, shared that his parents both worked in government, "so they traveled around a lot, and I always tagged along with them."

When asked, "Is there an external person you know or do not know that inspired you to pursue an aviation career?" 40% of participants referenced either a friend or mentor. Within the Asian population of the study, 38% credited their interest in aviation to a friend or mentor, 38% of the Hispanic or Latino population credited their interest in aviation to a friend or mentor, and 60% of the White population credited their interest in aviation to a friend or mentor. All Black or African American participants responded "no" to that question same for the participants who identified as two or more races.

When asked, "Did you ever express any hesitancy towards pursuing an aviation career?" only 13.3% of participants said no. Half of these participants were Hispanic or Latino and the other half were White. The remaining 86.7% of participants referenced one, or multiple, reasons why they had

experienced hesitancy towards pursuing an aviation career. Notably, four out of the five participants who referenced workload were White (See Table 5).

When responding to this question, many participants identified a common theme highlighting a separate underlying barrier: financial concerns and insecurities. This is consistent with the findings of Murillo (2020). A significant number of participants, 43% in total, mentioned financial concerns as their primary reason for apprehension. Out of those 43% (13 participants), 23.1% were Asian, 7.7% were Black or African American, 30.8% were Hispanic or Latino, 23.1% were White, and 15.3% were two or more races/ethnicities.

One participant, Neil, who self-reported as two or more races/ethnicities, explained his perspective when it came to financial concerns: "Knowing how much money it was going to cost was a huge hesitation, but once you start, it's kind of hard to justify stopping." A second participant, Zachary, who self-reported as White, remarked, "… It's expensive! I mean, it's one of those things where it's hard work and it's expensive, so a lot of times I think about it."

A third participant, Oliver, who self-reported as Hispanic or Latino, also referenced this theme:

> …to be honest, I am drowning in debt. About $200k…I'm at a point where I say, 'well, if I take another twenty-grand; well, what difference will that make?'… But that was a massive barrier for me was money.

Oliver touched upon how these barriers presented to him, referencing a lack of defined assistance for minorities specifically regarding tuition and flight training, a lack of scholarships freely given to minorities as they are to women in aviation and the reliance on grades to earn financial assistance. He also described witnessing the impact of financial barriers on others, emphasizing, "I know that this is a barrier for a lot of colleagues I have who are minorities: their biggest story is that they love aviation enough to drown themselves in debt." Another participant, James, who self-reported as Asian, said "I knew the cost of the school is a little outrageous, so I had to hide that from my parents. When it came to college decision day, I finally told them 'Hey, I know I've always talked about going and having a business major, something I don't really care for, but I actually like aviation. I know the school costs a lot and I will do my best not to leave the school,' and I'm a senior, so I believe I've succeeded in that aspect."

Overall, the responses of students and instructors who participated in this case study recognized the lack of diversity within the U.S. aviation industry. Most participants offered thoughtful, detailed responses about their experiences within aviation education. Notably, many of these responses identified key issues ranging from specific examples of racial barriers to financial concerns and insecurities.

Conclusion

The aim of this study was to answer the research question: What perceptions do collegiate aviation students have of racial influences and/or biases within aviation education? Based on the results, the major finding of this case study is that while a slim majority of participants did not perceive race to be influential in aviation education, some participants were able to identify examples where racial influences have played a role during their aviation education career. Additionally, none of the participants directly described lack of industry diversity as a hesitation towards pursuing an aviation career. However, several participants did describe the U.S. aviation industry's lack of diversity as an obstacle after beginning their collegiate aviation program. Many perspectives of the students who did perceive race as influential in some form centered around either specific examples or big picture concepts associated with the topic. This is generally in line with the results of Webb (2014); however, both studies seem to be in isolation from aviation industry perspectives. This may be a result of the fact that these two studies focused on collegiate flight programs with pilots newer to the industry. The exact reasoning cannot be determined, but this research team speculated that the participants have a lack of experience within the aviation industry, or simply represent a new generation with a different perspective. As a result, this should be studied on a larger scale over a longer period of time to make any conclusion regarding the "why" of these results.

Another significant finding is that approximately half of Black or African American, Hispanic or Latino, and two or more ethnicities, identified financial concerns as a barrier toward initially pursuing

and continuing with a collegiate aviation program, whereas a third of White participants identified financial concerns as a barrier that has influenced their aviation education career. The overall results of this case study, arguably, offer a hopeful perspective with respect to the progression of diversity, equality, and inclusion within aviation education. The perspectives of the participants who perceived race to be an influence within aviation education are inarguably significant, and more must be done to tackle the remaining remnants of this problem. Furthermore, the results of this case study provide an opportunity for aviation-focused institutions to consider how current diversity, equity, and inclusion efforts are impacting students.

Study Limitations

The primary limitation of this study is that as it was an exploratory case study focused solely on students and flight instructors at Embry-Riddle Aeronautical University's Daytona Beach campus. Thus, it lacks generalizability. An additional limitation is the study's voluntary nature—providing the perceptions of 30 students who were willing and available to participate in the study. Further, the data analyzed from participants, particularly the direct quotes contained here within, may be subject to personal participant bias. It should be considered that the racial diversity of Embry-Riddle's Daytona Beach campus may be different than other collegiate aviation programs. Additionally, participants chose to attend a collegiate aviation program and clearly were not deterred from pursuing this career because of race.

Future Research

Unpacking this topic in its entirety is a complex task. This exploratory case study indicates, at one university, there have been specific instances experienced by collegiate aviation students where racial influences have impacted their aviation education careers. As these results support similar conclusions of research at another university, further research must be conducted to gain a better understanding of the perceptions of students in other collegiate aviation programs in the United States. Such research will aid in bringing the topic of this case study to a more comprehensive evaluation of students and instructors across the country. To truly begin to understand the precise problems associated with race in aviation education, it is crucial to examine the direct perceptions of individual students using qualitative methods as done in this study, but it is equally crucial to look at the bigger picture by examining student perceptions at institutions offering collegiate aviation programs throughout the United States, perhaps also through quantitative methods to gauge where the entire aviation education community stands. Moreover, to improve racial diversity in the aviation industry, this research team suggests that efforts—both academic and industry based—should be focused on students, specifically on what may be done to inspire minority students to pursue aviation careers. Finally, the relationship between race and gender in the collegiate aviation environment was not explicitly explored in this paper. This is another topic that should be examined in future studies because the intersection between gender, race, and the choice to pursue a collegiate aviation degree program is an imperative issue that has broader implications for supporting the improvement of both gender and racial diversity in the aviation industry.[1] The authors hope this study encourages future research and inspires others to pursue their own research in this area as we work toward a more diverse aviation industry.

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1. While not germane to this study's literature review, there is ample literature that has examined female underrepresentation in the aviation industry and the perceptions collegiate aviation students have of gender diversity within the industry. See, for example, Luedtke (1993), Mitchell et al. (2006), Depperschmidt (2008), Ferla & Graham (2019), Casebolt & Khojasteh (2020), Marintseva et al. (2022), and Lutte & Morrison (2022). None of this literature, however, is focused directly on relating gender to race, or discusses the intersection of the two.

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Table 1

Interview Questions

Number	Question
1	What sparked your interest in pursuing an aviation career?
2	Why did you choose to attend a collegiate aviation program?
3	Do you have any family members within the aviation industry? Please elaborate: who? What field?
4	Is there an external person you know or do not know that inspired you to pursue an aviation career?
5	Has mentoring had an impact on your career thus far, either as a mentor and/or a mentee?
6	Did you ever express any hesitancy towards pursuing an aviation career? If participant responds yes, we will ask them to explain.
7	Have you been in a situation where you felt your race created an opportunity or a barrier that influenced the scenario?

Table 2

Participant Demographics

Participant Race/Ethnicity	Asian		Black or African-American		Hispanic or Latino		White		2 or more Ethnicities	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Participant Gender*										
Female	0		0		2	6.7%	2	6.7%	0	
Male	8	26.7%	2	6.7%	6	20%	8	26.7%	2	6.7%
Totals	8	26.7%	2	6.7%	8	26.7%	10	33.4%	2	6.7%

*When asked about gender identity, participants were provided with an "other" option. None of the participants in this study selected that option.

Table 3

Participant Responses to Interview Question 7: Have you been in a situation where you felt your race created an opportunity or a barrier that influenced the scenario?

Participant Race/Ethnicity	Opportunity	Barrier[a]	Barrier, Societal Attitude Towards 9/11	Barrier, Lack of Representation	Barrier, Microaggression in Training	Both	No Influence	Other[b]	Financial Concerns Only[c]
Asian	0%	50%	100%	0%	0%	33.3%	18.8%	30%	0%
Black or African American	50%	16.7%	0%	50%	0%	0%	0%	0%	0%
Hispanic or Latino	0%	33.3%	0%	50%	100%	33.3%	25%	30%	50%
White	0%	0%	0%	0%	0%	33.4%	50%	40%	50%
2 or more ethnicities	50%	0%	0%	0%	0%	0%	6.2%	0%	0%
Totals	100% n = 2	100% n = 6	100% n = 2	100% n = 2	100% n = 1	100% n = 3	100% n = 16	100% n = 10	100% n = 2

[a] Reflects the answers of 6 participants total that did not specify the exact reason for their perception of a "barrier" in aviation education.

[b] Reflects the answers of 10 participants total that related to other broad categories, in particular the challenges of being an international student.

[c] Reflects the answers of 2 participants that definitively explained race was not any part of the picture in terms of a barrier, financial concerns were the only barrier they encountered.

Table 4

Participant Responses to Interview Question 1: What sparked your interest in pursuing an aviation career?

Participant Race/Ethnicity	Parental/Familial Influence	Mentor Influence	Childhood Interest	Gliders	Flight Simulators	Last-Minute Decision	Public Service Aspect	Military Benefits	Introductory Flight	Diversify the Industry
Asian	29.3%	0%	27.8%	0%	25%	0%	0%	100%	0%	0%
Black or African American	6%	0%	11%	0%	0%	0%	0%	0%	0%	0%
Hispanic or Latino	23.5%	100%	27.8%	0%	50%	50%	100%	0%	100%	0%
White	41.2%	0%	27.8%	100%	25%	0%	0%	0%	0%	100%
2 or more ethnicities	0%	0%	5.6%	0%	0%	50%	0%	0%	0%	0%
Totals	100% n = 17	100% n = 1	100% n = 18	100% n = 3	100% n = 4	100% n = 2	100% n = 1	100% n = 1	100% n = 1	100% n = 1

Table 5
Top Reasons Why Participants Chose to Pursue an Aviation Career

Reason for Interest	Example Quote	Frequency, n (%)
Childhood Interest	"I thought it would be something fun to do. I lived my entire life doing extreme sports and the whole nine yards, so when I was six years old, I went to an airshow, and from then on, I was like, 'I'm gonna do that.' So come this spring, I'm going to commission, and hopefully go fly somethin' real fun. So I thought, just the attraction of how fun it would be, coupled with the nice professional career at the end after I'm done with the military, thought it would be very good for me."	18 (60)
	"So, I actually wanted to get involved in aviation ever since I was in third grade, ever since I took my first international flight, and I fell in love with the scenery I saw outside, and the environment of the airplane itself. That's how I got involved in aviation."	
Parental/Familial Influence	"It's kind of personal. My dad was a pilot, so I was influenced from that and really liked it. I wanted to be a pilot all the time. I wanted to fly because it was cool, and I really never thought of doing anything else."	17 (56.7)
	"That honestly started with my dad. I was born in India. My dad is from India as well, and he always wanted to be a pilot when he was a kid, and his parents did not let him due to cultural beliefs. Over there, you're either a doctor or an engineer, not a pilot. So he was kind of not allowed to be a pilot, and then when my parents moved to this part of the world with me and my brother, my parents told me I could pursue whatever I wanted to. My dad used to take me plane-watching a lot in Toronto and New Orleans, where we used to live, and ever since then I've always liked the aesthetic of aviation. And I love traveling. When I was a kid at airports, whenever I saw pilots, I would always ask to go to the cockpit and say 'I want to be like you someday!' and I'm looking forward to hearing that from someone else."	
	"Really, it started when I was a kid. My dad would take me to airshows, and him being in the aviation industry sort of set the ball rolling, an early start. My first steps to becoming a pilot were joining a gliding school in my home state of Georgia, and that's really where it all started."	

Table 6
Participant Responses to Interview Question 6: Did you ever experience any hesitancy towards pursuing an aviation career? If participant responds yes, we will ask them to explain.

Participant Race/Ethnicity	Yes, Financial Concerns	Yes, Workload	Yes, Commitment	Yes, Present/Future Impact on Lifestyle	Yes, Personal Struggles	Yes, Instructor Conflict	Yes, Parental Interference	Yes, Societal Influence	No
Asian	23.1%	20%	0%	100%	50%	0%	100%	0%	0%
Black or African American	7.7%	0%	0%	0%	0%	50%	0%	0%	0%
Hispanic or Latino	30.8%	0%	33%	0%	0%	0%	0%	67%	50%
White	23.1%	80%	67%	0%	50%	50%	0%	33%	50%
2 or more ethnicities	15.3%	0%	0%	0%	0%	0%	0%	0%	0%
Totals	100% n = 13	100% n = 5	100% n = 3	100% n = 2	100% n = 2	100% n = 2	100% n = 3	100% n = 3	100% n = 4

Not My Child: Perceptions of Bullied Students with Behavioral Differences and Teacher Responses

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Introduction

Reactions to Teachers' Responses of Bullied Students with Behavioral Differences

Children with behavioral disabilities and special educational needs are often victims of bullying in schools. This increased risk might lead to other effects, such as refusing to attend school, low self-concept, and fewer feelings of acceptance (Hartley et al., 2015). In the general education classroom, students with special educational needs experience a different social and emotional state than neurotypical students. Specifically, students with classroom learning disabilities (CLD), classroom behavior problems (CBP), or both were more likely to face a disadvantaged social and emotional situation than those without CLD, CBP, or both (Krull et al., 2010). Disadvantages include lower sociometric integration or greater social rejection, a negative academic self-concept, fewer feelings of acceptance from teachers and peers, and a poor interpretation of the classroom climate (Park et al., 2020).

Further, autistic children (those with autism spectrum disorder) are at greater risk of becoming victims of bullying than neurotypical students. Jones and Fredrickson (2020) found that peers of autism spectrum disorder (ASD) students viewed ASD students as "uncooperative" and "help-seeking." ASD students were also rated to be the most undesirable students. Additionally, autistic students are more likely to refuse to attend school earlier than non-autistic students (Ochi et al., 2020).

Because autistic children are at a greater risk for bullying, the teacher's response to the bullying is critical because these children may benefit from feeling supported. Teachers' responses to bullying directly impact the classroom climate (Sokol et al., 2016). For example, researchers of Sokol et al. (2016) prompted teachers to complete questionnaires regarding four videotaped scenarios, each depicting various victim responses to bullying (angry, sad, ignoring, and confident). The researchers found that teachers viewed "ignoring victim responses" and "confident victim responses" as the most effective and, thus, were least at risk for further victimization. The results of this study illustrate teachers' views on their potential willingness to assist student victims of bullying. Byers et al. (2011) discovered that teachers view overt bullying as more severe than covert bullying; therefore, teachers showed more empathy toward the victims, making intervention likely in those cases. Research addressing classroom climate is essential to students' de-stigmatization of behavioral differences.

It is essential to note teachers' attitudes toward bullying prevention methods taught in schools. Dake et al. (2003) investigated teachers' perceptions and practices regarding school bullying prevention methods. Researchers randomly selected 700 schools across the country. Experimenters mailed a four-page questionnaire to teachers at randomly selected schools. The questionnaire assessed elementary school teachers' perceptions of three bullying prevention techniques, and 685 teachers responded. Results indicated that 29% of participants had not considered involving students in creating rules against bullying. Two-thirds of participants were not allotting classroom time to discuss bullying and prevention techniques, and there is a lack of evidence to establish whether this is because those teachers feel that bullying is not an issue at their school, whether those teachers understand bullying prevention techniques, or whether they perceive these techniques as ineffective. The researchers did identify at least one bullying prevention technique that a majority of teachers were not actively utilizing. One-third of the participants used all three methods of bullying prevention described in the study. Thus, most classrooms are not maintaining the safest possible environment regarding bullying prevention.

Some critical characteristics influencing teacher responses to bullying include empa-

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thy, self-efficacy, and perceived seriousness (Yoon, 2004). Teachers who perceived bullying as more serious reported a higher self-efficacy and greater empathy and were likelier to report intentions of intervening. As such, these characteristics appear essential in whether or not a teacher intervenes in an instance of bullying. Furthermore, the perceived seriousness of the situation was more important than the other two characteristics. These findings suggest that increasing teachers' awareness about the severe implications of bullying behaviors may change their appraisal of it, thus increasing the likelihood of intervention.

Some of the studies previously outlined (Jones & Fredrickson, 2020; Ochi et al., 2020; Park et al., 2020) have focused on whether autistic children are included or excluded in a social setting based on the non-disruptive individuals' perceptions of the disabled peer. Other studies previously outlined (Dake et al., 2003; Sokol et al., 2016; Yoon, 2004) discussed teachers' responses and perceptions of bullying and bullying prevention methods. However, the research failed to compare social inclusion and acceptance through teachers' responses in the classroom. Previous research did not focus on how attitudes toward ASD children change depending on the teacher's reaction. A study by Ashburner et al. (2008) explored associations between sensory processing and classroom outcomes of ASD children. The participants of this study included randomly selected children with ASD in classrooms taught by regular education teachers. Researchers assessed participants using various evaluations to determine classroom emotional, behavioral, and educational outcomes. Results indicated that the responses of ASD children to sensory input differ from that of neurotypical children. It was also determined that auditory filtering difficulties were associated with deficits in learning and attention; thus, they are functionally disabling to the academic achievement of ASD children. This study reinforces previous assumptions regarding the challenges ASD children face in the classroom due to potential ASD symptoms (auditory filtering difficulties, sensory processing).

In some cases, these difficulties in sensory processing may influence the presence of behavioral outbursts. For instance, many ASD children with severe speech impairments use challenging behaviors (self-injury, tantrums, and aggression) as a form of expressive communication in classrooms (Chiang, 2008). In mainstream schools, acknowledging disruptive students, like those with autism spectrum disorders (ASDs), is one of the most complex and poorly understood areas of education (Humphrey et al., 2008).

Purpose

The current study aimed to survey participants' attributions (i.e., bias) toward a student (with or without behavioral outbursts) and the teacher's response to the bullying (negative or positive response). The purpose of the current study addresses how an immediate teacher response affects the way the child is perceived while also aiming to examine further biases toward students with behavioral differences under various classroom conditions. This study fills a research gap by forcing participants to consider both the behavior of the student and the teacher. There was no mention of a diagnosis, developmental disorder, or ASD in this study, ensuring participants would not feel socially obligated to answer the attitude questionnaire in a specific way, thus increasing the likeliness of answering the questionnaire honestly. This research assesses whether participants are more likely to support or condone the poor treatment of a student with a disruptive outburst under various conditions and circumstances.

Based on previous research showing teachers' responses to bullying prevention methods (Dake et al., 2003; Sokol et al., 2016; Yoon, 2004), the researchers hypothesized that participants would be more likely to agree with the teacher when they react positively to a student who does not have outbursts. The researchers also hypothesized that participants would disagree with the teacher when they responded negatively to a student who does not have outbursts. Additionally, the researchers expected that the participants' reactions would differ when the teacher responded negatively to a student without outbursts compared to when the teacher responded positively to a student without outbursts. Lastly, researchers hypothesized that participants' reactions would also differ when the teacher responded negatively to a student with outbursts compared to when the teacher responded positively to a student without an outburst, based on the research stating that autistic children are pushed out of social groups (Jones & Fredrickson, 2020; Ochi et al., 2020; Park et al., 2020).

Methods

Participants

Participants (N = 139) were recruited from a southeastern university in the United States. Participants signed up using a Research Participation System (SONA) for selection and included students in introductory psychology and sociology classes. The participants' ages ranged from 18-22, with an average age of 19.06. There were (66%) cisgender females, (24%) cisgender males, (1%) transgender males, (1%) transgender females, (2%) non-binary individuals, and (6%) individuals who identified as other. Of the (139) participants, there were (68%) non-Hispanic White individuals, (6%) African American, (9%) Hispanic, (5%) Asian, (0.05%) Pacific Islander, (0.05%) Middle Eastern, and (11%) biracial, including White/Hispanic, Asian/White, Afro Caribbean, Asian/Indian, Black/Hispanic, and Hispanic/Asian. Participants were randomly assigned to one of the four conditions in this experiment. The study lasted about 30 minutes, and students received course credit as determined by their instructor for participating.

Design

This experiment formed a 2 x 2 between-subjects factorial design with teacher response (positive, negative) and child behavior (disruptive outburst, non-disruptive behavior) as the between-subjects factor and participants' responses to each of the 11 questions as the dependent measure. Survey Monkey randomly assigned participants to one or four conditions. The dependent variables were attributions and attitudes toward the bullied student and the teacher. The post-reading questionnaire assessed how participants felt about the vignette, whether they believed the child seeking teacher assistance was considered tattling, and whether they deserved the treatment they received.

Materials

Vignette (see Appendix A). After participants completed and agreed to the informed consent, each participant was randomly assigned to read one of four vignette scenarios. The vignettes depict different situations of one peer bullying another peer and the teacher's response to the bullying situation. There were no specific diagnostics attributed to the target student. Each vignette illustrates one of the following four scenarios: 1) a positive reaction from the teacher to a student who has had disruptive outbursts was bullied by a peer, 2) a negative reaction from the teacher to a student who has had disruptive outbursts that a peer bullied, 3) a positive reaction from the teacher to a student who showed no disruptive behaviors that a peer bullied, and 4) a negative reaction from the teacher to a student who showed no disruptive behaviors that a peer bullied.

Attitude Questionnaire. Participants continued to the next page, where they completed a questionnaire. The questionnaire consisted of 11 questions; each response was based on a scale of 1-10 (1 being not at all or no and ten being very or yes). The questionnaire measured the participants' opinions on the outcomes of those events. Some questions include: "Do you believe the teacher's response was appropriate for the situation?" "Does the student deserve to be bullied for their actions in class?" and "Do you believe the student was mistreated by their peers?"

Demographic Information. Participants continued to the next page of Survey Monkey, where they filled out their demographic information on the demographics form.

Manipulation check. Participants also completed a manipulation check designed to assess how they perceived the manipulation of the independent variables in this study. This two-question form assessed participants' attention to the outburst or no outburst and positive or negative teacher response condition.

Procedure

Participants signed on to a Zoom link the researcher provided. During the Zoom session, students used a Survey Monkey link that took them through the study. Participants read and signed an informed consent or provided a parental assent form. After completing the required form, Survey Monkey randomly assigned participants to one of four vignette conditions. The vignettes varied by whether the bully victim had a disruptive outburst or no outburst, and whether the teacher responded positively or negatively. In the vignette, the bullied student informed the teacher of the bullying, and the teacher's response would be positive or negative. In a positive teacher response, the teacher acknowledges the student's concerns and reacts sympathetically. In a negative teacher response, the teacher brushes off the student's concerns and instructs

them not to be disruptive by telling their peers. Next, the participants answered a questionnaire regarding their attitudes and feelings toward the child and the teacher. Upon completing the post-reading questionnaire, participants completed a demographics questionnaire and manipulation check on Survey Monkey. Lastly, participants read over a debriefing statement, submitted the Survey Monkey, and signed off Zoom.

Results

A 2 x 2 between subjects factorial ANOVA and post-hoc tests (t-tests) were conducted to explore for interactive (see Table 1) and main effects (see Table 2 & 3) of child behavior (disruptive outburst, non-disruptive behavior) and teacher response (positive, negative) on attributions and attitudes toward the bullied student and teacher. All results were based on a 10-point Likert scale. Each of the following headings are derived from the post-reading questionnaire.

Appropriate Teacher Response

There was a main effect for whether the teacher's response was appropriate in the teacher response condition, F (1,139) = 433.11, p = 0.00, η_p^2 = 0.76, observed power = 0.05. The average for the negative teacher response condition (M = 1.64, SE = 0.199) was lower compared to the positive teacher response condition (M = 7.62, SE = 0.21). There was no main effect for whether the teacher's response was appropriate in the child behavior condition, F (1,139) = 0.12, p = 0.73, η_p^2 = 0.00084, observed power = 0.05. The average for the no outburst condition (M = 4.58, SE = 0.20) was not different compared to the average of the outburst condition (M = 6.68, SE = 0.21). There was no significant interaction between teacher response and child behavior F (1,139) = 0.66, p = 417, η_p^2 = 0.0047, observed power = 0.05.

Tattling

There was no main effect for whether the child was perceived to be tattling in the teacher response condition, F (1,139) = 0.21, p = 0.65, η_p^2 = 0.0015, observed power = 0.05. The average for the negative teacher response condition (M = 1. 2.51, SE = 0.26) was no different than the positive teacher response condition (M = 2.68, SE = 0.27). There was no main effect for whether the child was seen as tattling in the child behavior condition, F (1,139) = 0.24, p = 0.63, η_p^2 = 0.0017, observed power = 0.05. The average for the no outburst condition (M = 2.5, SE = 0.25) was not different compared to the average of the outburst condition (M = 2.68, SE = 0.27). There was no significant interaction between teacher response and child behavior F(1,139) = 0.67, p = 413, η_p^2 = 0.0048, observed power = 0.05.

Deserving Bullying

There was a main effect for whether the student deserved to be bullied in the teacher response condition, F (1,139) = 4.07, p = 0.0455, η_p^2 = 0.0285, observed power = 0.05. The average for the negative teacher response condition (M = 1.18, SE = 0.10) was lower than the positive teacher response condition (M = 1.45, SE = 0.10). There was a main effect for whether the student deserved to be bullied in the child behavior condition, F (1,139) = 7.18, p = 01, η_p^2 = 0.05, observed power = 0.05. The average for the no outburst condition (M = 1.13, SE = 0.09) was no different than the average of the outburst condition (M = 1.50, SE = 0.1). The main effects were qualified by a significant interaction between teacher response and child behavior, F (1,139) = 4.07, p = 0.05, η_p^2 = 0.03, observed power = 0.05 (see Figure 1). Follow-up t-tests indicated differences in the negative, outburst and positive, outburst conditions, p = 0.006, $C.I.$ = (0.16, 0.95), as well as in the positive, no outburst condition and the positive, outburst condition, p = 0.001, $C.I.$ = (0.25, 1.03). Follow-up t-tests also indicated no differences in the negative, no outburst and positive, no outburst conditions, p = 1.0, $C.I.$ = (-0.37, 0.37), and negative, no outburst and negative, outburst conditions, p = 0.63, $C.I.$ = (-0.28, 0.47).

Valid Feelings

There was no main effect for whether participants considered the students' feelings to be valid in the teacher response condition, F (1,139) = 0.92, p = 0.34, η_p^2 = 0.01, observed power = 0.05. The average for the negative teacher response condition (M = 8.26, SE = 0.27) was no different than the positive teacher response condition (M = 8.64, SE = 0.28). There was a main effect for whether the students' feelings were perceived as valid in the child behavior condition, F (1,139) = 5.1644, p = 0.02, η_p^2 = 0.04, observed power = 0.05. The average for the no outburst condition (M = 8.90, SE = 0.27) was greater than the average of the outburst condition (M = 8.00, SE = 0.29). There was no significant interaction be-

tween teacher response and child behavior F (1,139) = 0.43, p = 0.52, η_p^2 = 0.0031, observed power = 0.05.

Treated Fairly

There was a main effect in whether the student was perceived as being treated fairly by the teacher in the teacher response condition, F (1,139) = 347.49, p = 0.00, η_p^2 = 0.71, observed power = 0.05. The average for the negative teacher response condition (M = 1.80, SE = 0.22) was less than the positive teacher response condition (M = 7.68, SE = 0.22). There was no main effect for whether the student was perceived as being treated fairly by the teacher in the child behavior condition, F (1,139) = 0.14, p = 0.71, η_p^2 = 0.001, observed power = 0.05. The average for the no outburst condition (M = 4.68, SE = 0.22) was no different than the average of the outburst condition (M = 4.80, SE = 0.23). There was no significant interaction between teacher response and child behavior F (1,139) = 1.49, p = 0.22, η_p^2 = 0.0106, observed power = 0.05.

Mistreated by Peers

There was no main effect in whether the child was perceived as having been mistreated by their peers in the teacher response condition, F (1,139) = 1.70, p = 0.19, η_p^2 = 0.01, observed power = 0.05. The average for the negative teacher response condition (M = 8.69, SE = 0.23) was no different than the positive teacher response condition (M = 8.26, SE = 0.24). There was no main effect for whether the child was perceived as being mistreated by their peers in the child behavior condition, F (1,139) = 0.14, p = 0.70, η_p^2 = 0.001, observed power = 0.05. The average for the no outburst condition (M = 8.41, SE = 0.23) was no different than the average of the outburst condition (M = 8.53, SE = 0.24). There was no significant interaction between teacher response and child behavior F (1,139) = 1.01, p = 0.32, η_p^2 = 0.0072, observed power = 0.05.

More Likely to be Mistreated in the Future

There was a main effect for whether the student was likely to be mistreated within the classroom in the teacher response condition, F(1,139) = 16.76, p = 0.00007, η_p^2 = 0.1076, observed power = 0.05 (see Figure 2). The average for the negative teacher response condition (M =7.79, SE = 0.26) was greater than the positive teacher response condition (M =6.26, SE = 0.27). There was a main effect for whether the student was likely to be mistreated within the classroom in the child behavior condition, F(1,139) = 25.48, p = 0.00, η_p^2 = 0.15, observed power = 0.05. The average for the no outburst condition (M = 6.08, SE = 0.27) was less than the average of the outburst condition (M = 7.96, SE = 0.27). The main effects were qualified by a significant interaction between teacher response and child behavior, F (1,139) = 5.75, p = 0.018, η_p^2 = 0.0397, observed power = 0.05. Follow-up t-tests indicated there were differences in the negative, no outburst and positive, no outburst conditions, p = 0.00, $C.I.$ = (1.41, 3.43), as well as in the positive, no outburst condition and the positive, outburst condition, p = 0.000001, $C.I.$ = (-3.84, -1.71). Follow-up t-tests also indicated no differences in the negative, outburst and positive, outburst conditions, p = 0.25, $C.I.$ = (-1.71, 0.44) as well as in the negative, no outburst and negative, outburst conditions, p = 0.058, $C.I.$ = (-2.01, 0.03).

Different Behavioral History

There was no main effect for whether participants believed the teachers' response would have differed had the child had a different behavioral history in the teacher response condition, F(1,139) = 1.39, p = 0.241, η_p^2 = 0.0099, observed power = 0.05 (see Figure 3). The average for the negative teacher response condition (M =6.48, SE = 0.28) was no different than the positive teacher response condition (M =6.96, SE = 0.29). There was a main effect for whether participants believed that the teachers' response would have differed had the child had a different behavioral history in the child behavior condition, F(1,139) = 9.82, p = 0.002, η_p^2 = 0.06596, observed power = 0.05. The average for the no outburst condition (M = 6.08, SE = 0.28) was less than the average of the outburst condition (M = 7.36, SE = 0.30). The main effects were qualified by a significant interaction between teacher response and child behavior, F(1,139) = 26.45, p = 0.00, η_p^2 = 0.1598, observed power = 0.05. Follow-up t-tests indicated there were differences in the negative, outburst and positive, outburst conditions, p = 0.007, $C.I.$ = (0.44, 2.80), in the negative, no outburst condition and the positive, no outburst condition, p = 0.000009, $C.I.$ = (-3.68, -1.48), and in the negative, no outburst and the negative, outburst condition, p = 0.00, $C.I.$ = (-4.50, -2.26). Follow-up t-tests also indicated no differences in the outburst and positive, outburst conditions, p = 0.166, $C.I.$ = (-0.34, 1.98).

Acting out for Attention

There was no main effect for whether participants believed that the child acted out for attention in the teacher response condition, F (1,139) = 2.28, p = 0.13, η_p^2 = 0.0161, observed power = 0.05 (see Figure 4). The average for the negative teacher response condition (M =2.93, SE = 0.23) was no different than the positive teacher response condition (M =3.44, SE = 0.24). There was a main effect for whether participants believed that the child acted out for attention in the child behavior condition, F (1,139) = 23.34, p = 0.000004, η_p^2 = 0.14, observed power = 0.05. The average for the no outburst condition (M = 2.37, SE = 0.23) was less than the average of the outburst condition (M = 4.0, SE = 0.246). There was no significant interaction between teacher response and child behavior F (1,139) = 0.13, p = 0.7189, η_p^2 = 0.0009, observed power = 0.05. There was a main effect for the child's likelihood of returning to the teacher after the way they responded in the teacher response condition, F (1,139) = 150.52, p = 0.00, η_p^2 = 0.5199, observed power = 0.05. The average for the negative teacher response condition (M = 2.26, SE = 0.23) was lower compared to the positive teacher response condition (M = 6.34, SE = 0.24). There was no main effect for the likelihood of the child returning to the teacher after the way they responded in the child behavior condition, F (1,139) = 0.0528, p = 0.8186, η_p^2 = 0.00038, observed power = 0.05. The average for the no outburst condition (M = 4.26, SE = 0.23) was not different compared to the average of the outburst condition (M = 4.34, SE = 0.24). There was no significant interaction between teacher response and child behavior F(1,139) = 0.30, p = 0.59, η_p^2 = 0.0021, observed power = 0.05.

Continuing the Behavior

There was no main effect for the likelihood of the child continuing the behavior after the reaction they received from the teacher in the teacher response condition, F (1,139) = 0.115, p = 0.735, η_p^2 = 0.0008, observed power = 0.05. The average for the negative teacher response condition (M = 6.18, SE = 0.25) was no different than the positive teacher response condition (M =6.06, SE = 0.26). There was a main effect for the likelihood of the child continuing the behavior after the reaction they received from the teacher in the child behavior condition, F (1,139) = 11.99, p = 0.0007, η_p^2 = 0.0794, observed power = 0.05. The average for the no outburst condition (M = 5.49, SE = 0.25) was less than the average of the outburst condition (M = 6.75, SE = 0.27). The main effects were qualified by a significant interaction between teacher response and child behavior, F (1,139) = 11.765, p = 0.000795, η_p^2 = 0.078, observed power = 0.05. Follow-up t-tests indicated there were differences in the negative, outburst and positive, outburst conditions, p = 0.011, $C.I.$ = (0.32, 2.44), in the negative, no outburst condition and the positive, no outburst condition, p = 0.025, $C.I.$ = (-2.12, -0.14), and in the negative, no outburst and negative, outburst condition, $p < 0.001$, $C.I.$ = (-3.53, -1.52). Follow-up t-tests also indicated no differences in the positive, no outburst and positive, outburst conditions, p = 0.982, $C.I.$ = (-1.03, 1.06).

Conclusion

This study aimed to examine the biases children with behavioral outbursts face in the classroom and how participants reacted to a bullying situation. Another goal was to determine if individuals support or condone the poor treatment of a student with behavioral outbursts under various conditions. The researchers hypothesized that participants were inclined to align themselves with the teacher when they reacted positively to a student who did not have outbursts. Researchers also believed that the participants' reactions would differ when the teacher responded negatively to a student without outbursts compared to when the teacher responded positively to a student without outbursts. It was predicted that participants' reactions would also differ when the teacher responded negatively to a student with outbursts compared to when the teacher responded positively to a student without an outburst. The results supported all hypotheses.

Participants believed the child who displayed behavioral outbursts deserved to be bullied, especially when the teacher displayed a positive response to the outburst. In the teacher response condition, participants felt the student with an outburst deserved to be bullied significantly more than the student without an outburst. In the outburst condition, participants felt the student that received the positive teacher response deserved to be bullied more than the student that received the negative teacher response. The results of the current study revealed that participants viewed the poor treatment of a child with behavioral differences

as more acceptable than the poor treatment of a child without behavioral differences. Taken together with earlier studies of children with behavioral disabilities (Hartley et al., 2015; Krull et al., 2010), it can be concluded that children with behavioral differences face disadvantages in their social and emotional well-being as people are more accepting of those children being treated poorly. This may be in part due to human nature: It is more convenient to blame the child that disrupted the classroom than it is to blame the child that did not. It was also found that regardless of the behavioral outburst condition, a positive teacher response was significantly favored and deemed more appropriate.

Participants in the negative teacher response condition felt the child was less likely to return to the teacher than participants in the positive teacher condition. This is not corroborated or conflicted by previous studies as few studies focused on the teachers' responses to bullying. Participants identified that the teacher would have responded differently if the student with an outburst had a different behavioral history. When the child with an outburst sought help from the teacher, participants felt they were doing so to gain attention. Previous research identified that autistic children are at greater risk of being victims of bullying (Park et al., 2020). The current results revealed that when a child with outbursts seeks help (from the teacher), participants felt they were doing so to gain attention. Teachers are less likely to take action when they do not believe the student is serious (Yoon, 2004). The teachers in this study felt that seriousness was the most important factor when deciding whether or not to take action. Once educated about bullying prevention, teachers felt more empathetic toward the children. Taken together with the current study, the results indicate that bully prevention education is vital to reduce stigmas surrounding children with behavioral differences. In the current study, participants felt that the child in both conditions was more likely to be mistreated within the classroom. Previous research suggests children with ASD receive more inconsistent social support in schools than neurotypical children (Humphrey et al., 2008). When taken with the current results, children with or without outbursts are more likely to be bullied within the classroom. Thus, children with outbursts are at an even greater disadvantage as they receive inconsistent social support inside that classroom. Research by Dake et al. (2003) suggests that most teachers are not implementing ways to decrease bullying in the classroom. The lack of preemptive measures puts children with ASD at a greater risk of being bullied. Participants felt that the child in the outburst condition was more likely to continue disruptive behaviors regardless of the teacher's response. Previous research revealed that neurotypical students viewed their ASD peers as uncooperative and undesirable to work with (Jones & Fredrickson, 2020). Taken with the current results, it is apparent that there are negative beliefs about current and future behaviors of children with behavioral differences.

One possible limitation of the current study is the inability to generalize this data to neurodivergent children diagnosed with ASD or other attention related disorders (ASD, ADHD, etc). Researchers did not want participants to have a social bias toward the child based on a diagnosis, so no specific diagnostics were mentioned in the vignettes. Future research can be done to expand upon this study by having participants watch a video instead of reading a vignette. The study could be replicated using elementary-aged children as participants. The child in the vignette was a fourth grader, targeting similarly aged children as participants may produce different results. Other limitations include participants having viewed the vignettes virtually (due to COVID-19) and the sample of participants in the study, which included college students from a small liberal arts college, thus introducing bias. The post-reading questionnaire questions should be adjusted for future use to incorporate more variation in the wording and more consistency in rating individuals' opinions with the 10-point Likert scale.

The current study examined potential bias toward students with behavioral differences. Large-scale impacts of this study include a better understanding of peoples' perspectives of the classroom climate when children with behavioral differences are involved. Participants generally aligned themselves with the child that did not exhibit an outburst, thus equating the child with a behavioral outburst socially disadvantaged. This study also provided insight into how a child with behavioral outbursts is perceived based on how a teacher responds to the child (positively or negatively). Participants felt the child with an outburst deserved to be bullied more

than the child without an outburst regardless of the how the teacher responded to them. This research is unique in that the questionnaires were designed to measure how participants viewed the mistreatment of students with behavioral differences while accounting for how the teacher responded. Future studies can expand upon this research to further support our findings and investigate why participants justify the mistreatment of students with behavioral differences.

These findings support the use of strategies to promote an inclusive classroom climate and interventions to increase positive attitudes toward full inclusion for ASD students. Increasing positive attitudes through intervention strategies could likely lead to more openness toward interacting with and less desired social distance from atypical peers in classrooms (Underhill et al., 2019). This research is essential as results revealed clear social biases toward students with behavioral differences. In order to address this, researchers need to understand why these biases exist and how they continue to function. While people have become mindful to the label and biases associated with ASD, there are still unpleasant personal attributes and implicit biases of non-autistic adults exhibiting autism-related symptoms (Jones, 2021). Further research should explore the biases towards ASD children of color and/or genders. This topic has not been thoroughly researched, and there are many specifics to further investigate in order to fully understand classroom climates surrounding ASD children.

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Appendix A

Vignette 1

A fourth-grade student gets pushed into a bookcase and called names after recess on a Wednesday afternoon. This student tends not to be well-liked by their peers and sometimes has behavioral outbursts. During those outbursts, they scatter objects across desks, move and flip furniture, and scream/yell loudly. This student does well on assignments, homework, and tests. After being pushed, the student goes to their teacher and describes what has just occurred. The teacher acknowledges the student and sympathetically responds by saying they will handle the situation one on one with the students who acted as the bullies.

Vignette 2

A fourth-grade student gets pushed into a bookcase and called names after recess on a Wednesday afternoon. This student tends not to be well-liked by their peers and sometimes has behavioral outbursts. During those outbursts, they scatter objects across desks, move and flip furniture, and scream/yell loudly. This student does well on assignments, homework, and tests. After being pushed, the student goes to their teacher and describes what has just occurred. The teacher fails to acknowledge the concern of the student and asks that they not be disruptive by telling on their peers at that time. They then ask the student to have a seat back at their desk so they can get on with the lesson.

Vignette 3

A fourth-grade student gets pushed into a bookcase and called names after recess on a Wednesday afternoon. This student tends to be well-liked by their peers and never experiences any sort of disruptive behavior. This student does well on assignments, homework, and tests. After being pushed, the student goes to their teacher and describes what has just occurred. The teacher acknowledges the student and sympathetically responds by saying they will handle the situation one on one with the students who acted as the bullies.

Vignette 4

A fourth-grade student gets pushed into a bookcase and called names after recess on a Wednesday afternoon. This student tends to be well-liked by their peers and never experiences any sort of disruptive behavior. This student does well on assignments, homework, and tests. After being pushed, the student goes to their teacher and describes what has just occurred. The teacher fails to acknowledge the concern of the student and asks that they not be disruptive by telling on their peers at that time. They then ask the student to have a seat back at their desk so they can get on with the lesson.

Table 1

Averages (with standard error) per condition where higher numbers mean more agreement

Questions	Positive teacher response and outburst	Positive teacher response and no outburst	Negative teacher response and outburst	Negative teacher response and no outburst
Do you believe the teacher's response was appropriate for the situation?	7.55 (0.307)	7.68 (0.278)	1.81 (0.285)	1.47 (0.278)
On a scale of 1-10, how much of what the child did was considered tattling?*	2.61 (0.398)	2.74 (0.36)	2.75 (0.369)	2.26 (0.36)
Does the student deserve to be bullied for their actions in class?*	1.77 (0.146)	1.13 (0.132)	1.22 (0.136)	1.13 (0.132)
Were the students' feelings valid?	8.07 (0.419)	9.21 (0.379)	7.94 (0.389)	8.58 (0.379)
Do you believe the student was treated fairly by the teacher?	7.55 (0.337)	7.82 (0.305)	2.06 (0.313)	1.55 (0.305)
Do you believe the student was mistreated by their peers?	8.48 (0.354)	8.03 (0.32)	8.28 (0.328)	8.79 (0.32)
Do you believe this student is ore likely to be mistreated within the classroom?*	7.65 (0.399)	4.87 (0.361)	8.28 (0.37)	7.29 (0.361)
Do you believe the teacher's response would have been different if the student had a different behavioral history?*	6.55 (0.437)	7.37 (0.394)	8.17 (0.405)	4.79 (0.394)
Do you believe that the child acted out for attention?	4.19 (0.361)	2.68 (0.326)	3.81 (0.335)	2.05 (0.326)
How likely is it that the child would come back to the teacher after the way they responded?	6.29 (0.356)	6.40 (0.322)	2.39 (0.33)	2.13 (0.322)
How likely is it that the child will continue to act this way after the reaction they received from the teacher?*	6.07 (0.392)	6.05 (0.354)	7.44 (0.364)	4.92 (0.354)

Note: *indicates a significant interaction at the .05 level.

Table 2

Averages (with standard error) per condition where higher numbers mean more agreement

Questions	Positive teacher response	Negative teacher response
Do you believe the teacher's response was appropriate for the situation? *	7.62 (0.207)	1.64 (0.199)
On a scale of 1-10, how much of what the child did was considered tattling?	2.68 (0.268)	2.51 (0.258)
Does the student deserve to be bullied for their actions in class?*	1.45 (0.099)	1.18 (0.095)
Were the students' feelings valid?	8.64 (0.282)	8.26 (0.271)
Do you believe the student was treated fairly by the teacher?*	7.68 (0.218)	1.80 (0.227)
Do you believe the student was mistreated by their peers?	8.26 (0.238)	8.69 (0.229)
Do you believe this student is ore likely to be mistreated within the classroom?*	6.26 (0.269)	7.78 (0.258)
Do you believe the teacher's response would have been different if the student had a different behavioral history?	6.96 (0.294)	6.48 (0.283)
Do you believe that the child acted out for attention?	3.49 (0.243)	2.93 (0.234)
How likely is it that the child would come back to the teacher after the way they responded?*	6.34 (0.24)	2.26 (0.231)
How likely is it that the child will continue to act this way after the reaction they received from the teacher?	6.06 (0.264)	6.18 (0.254)

Note: *indicates a significant main effect at the .05 level.

Table 3

Averages (with standard error) per condition where higher numbers mean more agreement

Questions	Student outburst	No student outburst
Do you believe the teacher's response was appropriate for the situation?	4.68 (0.21)	4.58 (0.196)
On a scale of 1-10, how much of what the child did was considered tattling?	2.68 (0.272)	2.5 (0.254)
Does the student deserve to be bullied for their actions in class?*	1.50 (0.1)	1.13 (0.093)
Were the students' feelings valid?*	8.00 (0.286)	8.90 (0.268)
Do you believe the student was treated fairly by the teacher?	4.80 (0.23)	4.68 (0.216)
Do you believe the student was mistreated by their peers?	8.53 (0.241)	8.41 (0.226)
Do you believe this student is ore likely to be mistreated within the classroom?*	7.96 (0.272)	6.08 (0.255)
Do you believe the teacher's response would have been different if the student had a different behavioral history?*	7.36 (0.298)	6.08 (0.279)
Do you believe that the child acted out for attention?*	4.00 (0.246)	2.37 (0.231)
How likely is it that the child would come back to the teacher after the way they responded?	4.34 (0.243)	4.26 (0.227)
How likely is it that the child will continue to act this way after the reaction they received from the teacher?*	6.75 (0.267)	5.49 (0.25)

Figure 1

Interactions between Teacher Responses and Behavioral Outbursts on Deserved Bullying

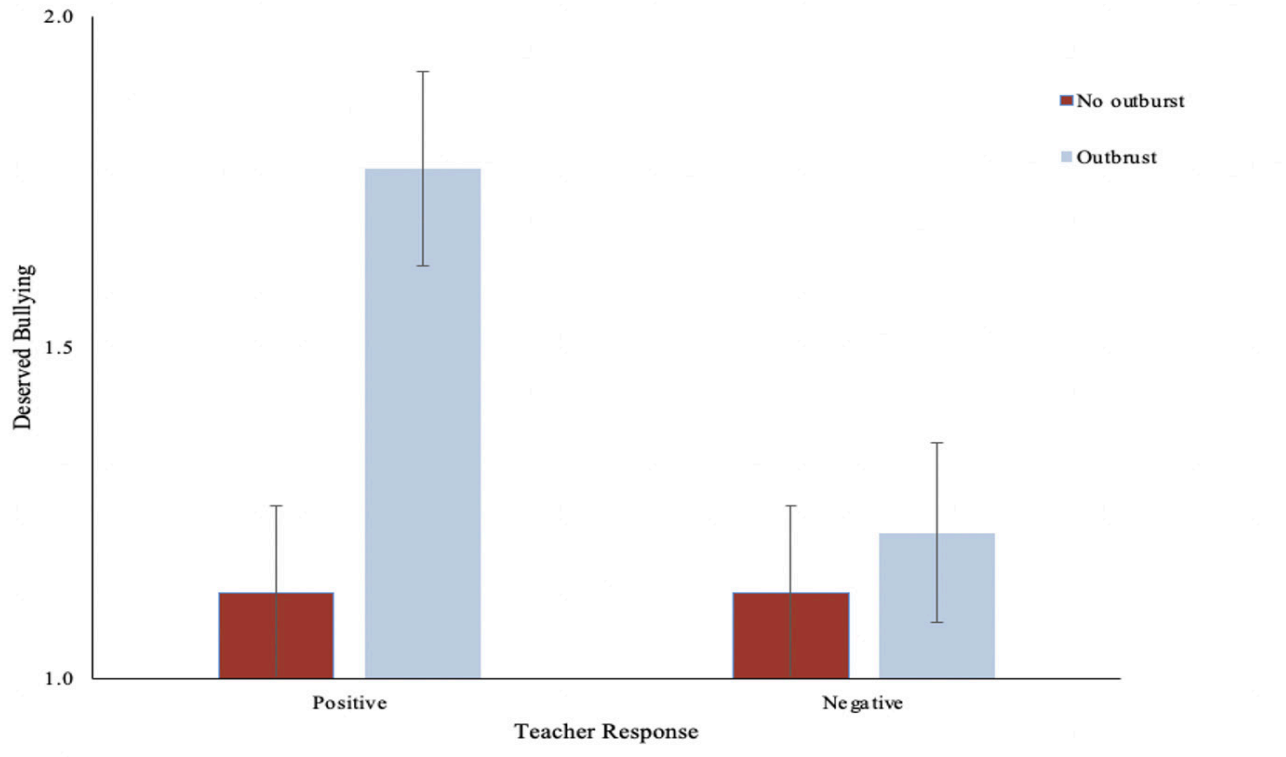


Figure 2

Changes in Mistreatment Perception as a Function of Teacher Response

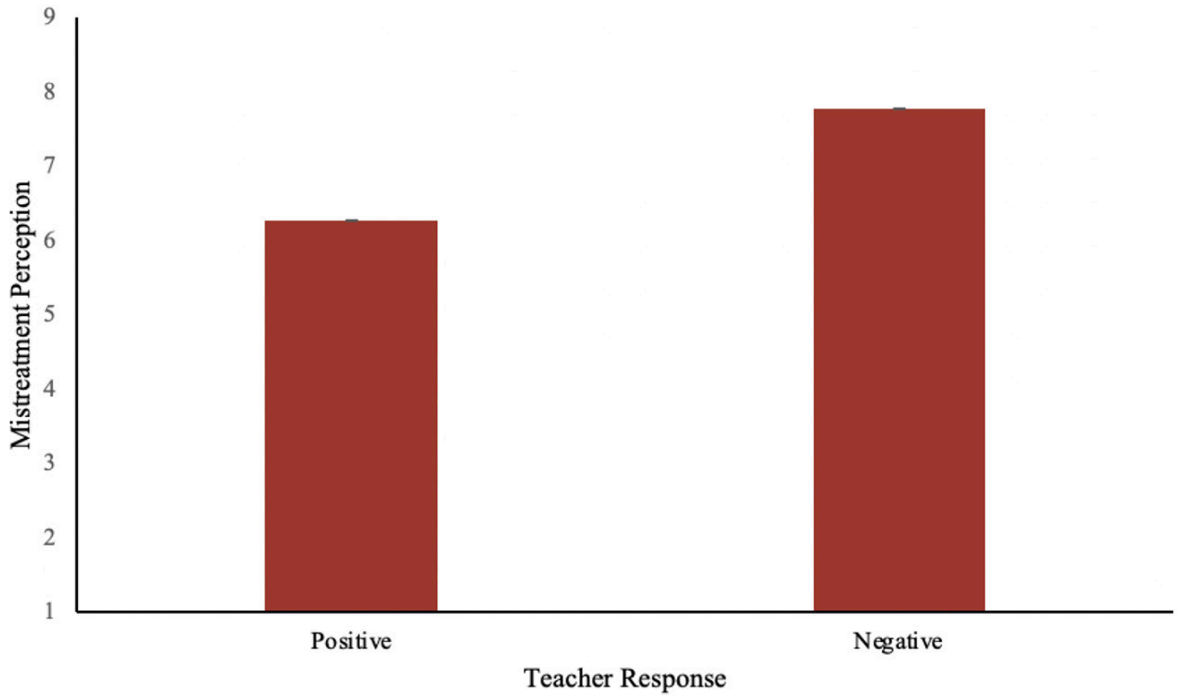


Figure 3

Interaction between Teacher Responses and Behavioral Outbursts on Student Different History

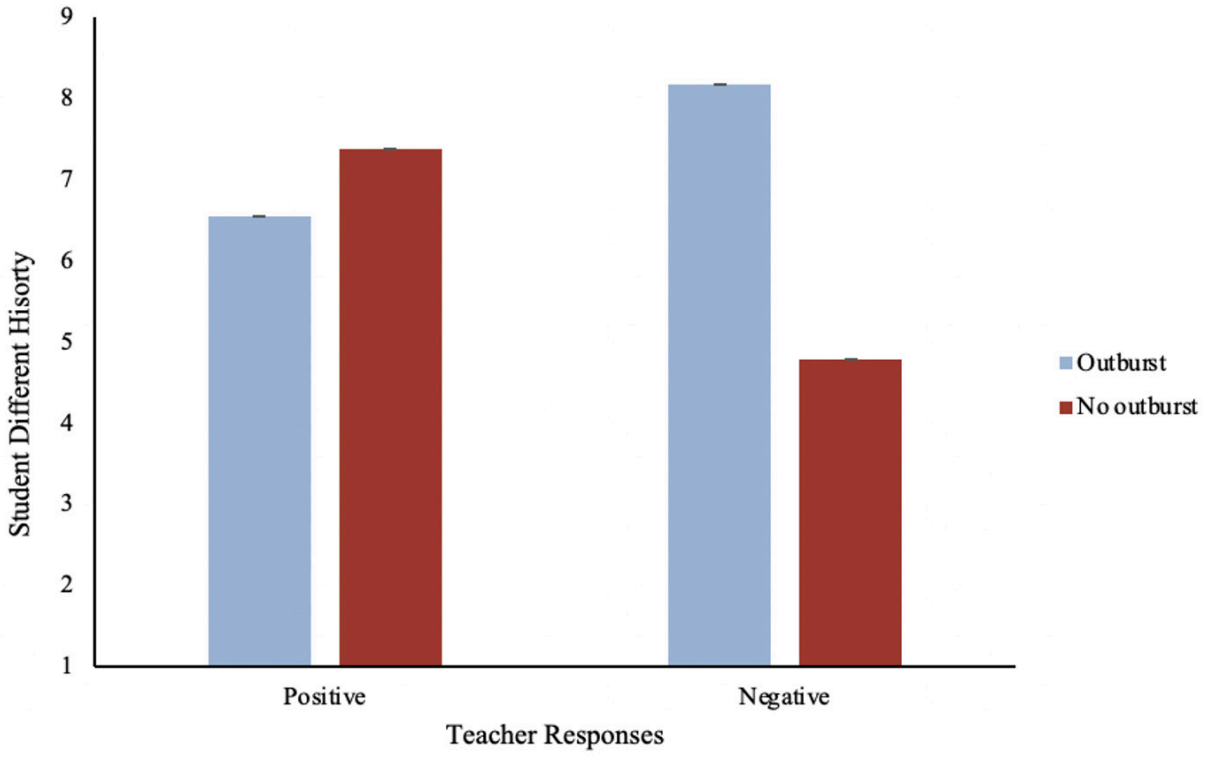
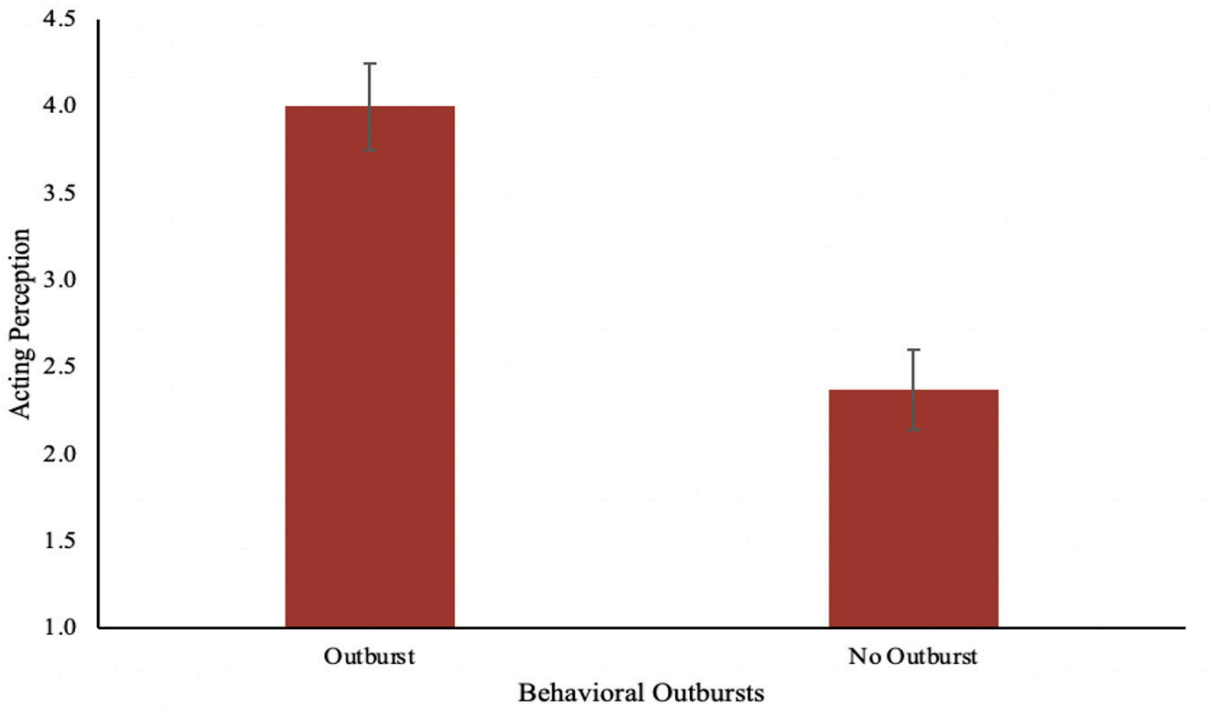


Figure 4

Changes in Acting Perception as a Function of Behavioral Outbursts



Comparing the Effect of Various Cations on Bacteriophage Activity Against *Xanthomonas euvesicatoria*

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Introduction & Background

The world is experiencing rising demand for crop production due to increases in biofuel consumption, meat and dairy consumption, and the global human population (Ray et al., 2013). To meet this demand, it is imperative for crop supply to increase by as much as 80-110% over current production rates by the year 2050 (Buttimer et al., 2017; Ray et al., 2013). However, to reach that level of production and sustainability, the impact of crop disease must be reduced. It has been previously estimated that at least 10% of global food production is lost to plant diseases (Buttimer et al., 2017; Strange & Scott, 2005). One such plant disease, Bacterial Spot, is common everywhere in the world where tomatoes and peppers are grown (Figure 1). Severe cases of Bacterial Spot infection result in about 23%–44% of direct tomato and pepper crop yield losses per year (Bashan et al., 1985; Osdaghi et al., 2021). Bacterial Spot is especially prevalent in the southeastern United States due to the high temperature, high humidity, and rainy climate of this region (Strayer-Scherer, 2019). Bacterial Spot disease is caused by the following four aerobic, Gram-negative species of phytopathogenic bacteria belonging to the genus *Xanthomonas*: *X. euvesicatoria*, *X. vesicatoria*, *X. perforans*, and *X. gardneri*. These strains were formerly grouped together and referred to as *Xanthomonas campestris* pv. *vesicatoria* (Jones et al., 2004; Strayer-Scherer et al., 2019).

Since the early 1800s, copper has been used as a treatment to manage many types of plant pathogens, including *Xanthomonas campestris* pv. *vesicatoria*. By the 1980s, however, copper-resistant strains of this phytopathogen began to emerge, which limited the effectiveness of copper-based bactericides (Marco & Stall, 1983; Strayer-Scherer et al., 2019; Thayer & Stall, 1961). Therefore, control of Bacterial Spot disease was only achievable with the addition of an ethylene-bis-dithiocarbamate compound known as mancozeb to existing copper bactericide formulations. Copper-mancozeb treatment mixtures have since been the standard practice for controlling Bacterial Spot (Conover & Gerhold, 1981; Marco & Stall, 1983; Strayer-Scherer et al., 2019). However, there are many disadvantages that result from the excessive use of this method to combat the increasingly resistant phytopathogens. For instance, copper-mancozeb can cause negative, non-target environmental impacts such as copper-induced phytotoxicity, soil aridity, and overaccumulation of copper ions due to their inability to degrade in soil (Koller, 1998; Strayer-Scherer et al., 2019). Strayer-Scherer et al. (2019) further found that copper-mancozeb reduced the effectiveness of controlling resistant plant pathogens. Since copper-mancozeb fails to adequately control Bacterial Spot when copper-tolerant strains are present under optimal disease conditions (Jones & Jones, 1985; Obradovic et al., 2005; Strayer-Scherer et al., 2019), we sought to investigate the development of a plant biocontrol method implementing bacteriophages, which can also be interchangeably referred to as phages or viruses that exclusively infect bacteria, as an alternative preventative treatment approach.

Rather than engineering a bacteriophage cocktail (mixture of various types of phages) or utilizing antibiotic compounds to prevent Bacterial Spot more effectively, our study aims to supplement *Xanthomonas*-specific bacteriophages with various monovalent and divalent cations (Drulis-Kawa et al., 2012; Strayer-Scherer et al., 2019). A cation is an atom with a net positive charge resulting from the loss of one or more electrons. This approach was chosen based on the functions of Ca^{2+} in phage-host infection systems. A previous study that tested the effect of calcium ions on *Bacillus subtitlis* Phage 41c adsorption, suggested that Ca^{2+} concentrations ranging from 0.1mM to 10mM, fulfill the requirement for phage-cation attachment, with the most efficient absorption occurring at reduced Ca^{2+} levels (Landry, 1975; Landry & Zsigray, 1980). Findings from this study showed that the lytic cycle of Phage 41C requires the presence of at least 10mM Ca^{2+}, as the plaquing efficiency of

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the virus is reduced to less than 0.1 in the absence of this cation (Landry, 1975; Landry & Zsigray, 1980). Although more than 90% of the phage adsorbs onto the surface of *Bacillus subtilis* cells at 0.1mM Ca^{2+}, successful infection can only be achieved at higher Ca^{2+} concentration levels (0.1mM–10mM calcium-dependent phage adsorption). It is important to note that the concentration of Ca^{2+} is known to affect the efficiency of phage infection, and sub-optimal concentrations can result in the loss of infected centers, indicating an early post-adsorption requirement of this cation. Furthermore, Ca^{2+} is involved in phage-bacterium complex formation, and other divalent ions cannot replace its role in this process (Landry, 1975; Landry & Zsigray, 1980). Generally, cations such as Ca^{2+}, may enhance the virulence of bacteriophages by stabilizing phages, facilitating phage adsorption and penetration into bacterial cells, promoting phage-mediated gene transfer, and reducing the production of virulence factors in bacteria (Wagner & Waldor, 2002; Clifton et al., 2015; Christi et al., 2016; Ma et al., 2018; Hsu et al., 2020; Secor et al., 2020). However, further research is needed to fully understand the molecular mechanisms underlying the relationship between cations and phage virulence – particularly, that of phytopathogen-specific bacteriophages. Due to their proximity to Ca^{2+} on the periodic table, $Mg^{2+,}$ Zn^{2+}, K^{+}, and Na^{+} were selected for phage supplementation testing in this study.

Although there are currently no existing bacteriophage biocontrol formulations that solely implement environmentally safe cations, there are studies found in the current literature that test the effect of cations in phage-host infection systems. In a previous study, a growth curve experiment was performed on the human pathogen, *Bacillus cereus,* in the presence of its isolated bacteriophages under various conditions of cation supplementation (Bandara et al., 2012). The findings highlighted that cation-supplemented bacteriophages decreased the growth of the bacteria in the liquid culture in a shorter amount of time when compared to *B. cereus* growth without phage or cations and *B. cereus* growth with only phage present (Bandara et al., 2012). However, despite these findings, little is still known about how bacteriophages interact with other cations in a phytopathogen host infection system.

Objectives

The objective of this study was to test the effect that supplementation with the following cations: K^{+}, Na^{+}, Zn^{2+}, and Mg^{2+} had on the virulence activity of our isolated and purified phage samples against *X. euvesicatoria*, at six different concentration levels (0mM, 0.001mM, 0.01mM, 0.1mM, 1.0mM, 10mM). It was hypothesized that cation supplementation of our three purified bacteriophage samples would have an effect on virulence activity against the *Xanthomonas* phytopathogen. Furthermore, we hypothesized that this supplementation would yield a greater virulence effect against *X. euvesicatoria* at concentrations ≤0.1mM than at concentrations >0.1mM. It is important to consider the implications drawn from our preliminary results, which demonstrated that more of the purified phage samples were able to form plaques on plates containing 0.01mM Ca^{2+} than on plates containing 0.1mM Ca^{2+}. Thus, we proposed a continuation of the plaque assay approach implemented in our previous calcium supplementation experiment to test our hypotheses. This research will serve to investigate methods for improving the effectiveness of bacteriophages in plant therapeutic agents, as well as to minimize the negative non-target environmental impacts associated with existing bacteriophage biocontrol formulations and current copper-mancozeb Bacterial Spot treatment standards.

Materials & Methods

Environmental sample collection

To initiate this study, we purchased a healthy and fully-grown tomato plant from a Walmart in Parkland, FL. We then sowed the tomato plant on a patch of fertile soil in a partially shaded area located in the same city. The growth of the tomato plant was monitored under uncontrolled environmental conditions and in the presence of sunlight. After three weeks, small dark brown lesions were observed on the dorsal and ventral surfaces of the plant leaves (Figure 2A). Leaf samples were collected in a 50mL conical tube and taken to the laboratory for further experimentation.

Isolation and characterization of the target bacterium

To isolate the bacteria from the infected plant, DI water was first added to the conical tube containing the leaves and vortexed for about 30 seconds. Differ-

ent concentrations of the supernatant were then plated on nutrient broth agar, which is a rich medium (Hernandez et al., 2018). After the plates were incubated at 28°C for 96 hours, a mixture of morphologically distinct colonies formed and were then ready to be characterized (Figure 2B). Isolated bacterial colonies were obtained from the plate with the lower supernatant concentration. *Xanthomonas* bacterial colonies are characterized by round, punctiform colonies with bright yellow pigmentation and a mucoid surface. Target colonies were then picked and streaked onto Tween agar (Figure 2C), which is a semi-selective medium that allows for the detection and isolation of *Xanthomonas* strains (McGuire et al., 1986). The suspect isolate was then streaked onto nutrient broth agar for storage and use (Figure 2D). Following its isolation, the suspect *Xanthomonas* isolate underwent a series of selective and differential biochemical characterization tests to further confirm its identity as the target bacterium. Based on the results from the tests performed, we were able to characterize our suspect isolate as one that cannot ferment lactose, exhibits motility, is Gram-negative, grows optimally at 25–30°C on nutrient broth-based medium, and induces Bacterial Spot symptoms on healthy tomato fruits and leaves. These characteristics match those of a *Xanthomonas* bacterium, per the literature (Büttner & Bonas, 2010; An et al., 2020; Osdaghi et al., 2021).

Identification of suspect isolate – Xanthomonas euvesicatoria

Once the characteristics of the target bacterium were confirmed, a glycerol tube containing an inoculated sample of its cells was sent to the genome sequencing company GENEWIZ, from Agenta Life Sciences (South Plainfield, New Jersey). We opted for GENEWIZ's Bacterial Identification service, which involves the isolation of the submitted sample's DNA followed by an amplification of the 16S rRNA gene sequence via PCR. GENEWIZ then sent back a file containing this sequence, which we then compared to known *Xanthomonas* 16S rRNA gene sequences in the GenBank database by conducting a BLAST search. Our comparative analysis confirmed that the 16S rRNA gene sequence of our suspect isolate was 99.4% similar to that of *Xanthomonas euvesicatoria* (Figure 2), thus confirming the identity of our isolate as the target bacterium.

Bacteriophage amplification and selection

To isolate the *Xanthomonas*-specific bacteriophage samples, the phages present in our environmental samples were first amplified by preparing an enriched culture using our previously acquired infected tomato plant leaf sample (Poxleitner et al., 2018). The solution in the enriched culture was then filtered to only isolate the various phages present in the environmental sample. A phage filtrate was produced. Following phage amplification, a spot test was performed to see if the phages in the filtrate were able to infect the isolated *Xanthomonas* bacterium and form plaques (Khan Mirzaei & Nilsson, 2015; Poxleitner et al., 2018). Spot plates were inoculated in triplicate and incubated in sets of 3. Each 3-plate set was to be incubated at a different temperature (25°C, 28°C, and 30°C) to evaluate the optimal plaque-forming temperature for the phages. Spot plates in each 3-plate set (9 total spot plates) contained 6 spaced-out small drops ('spots') of phage filtrate. After 24 hours of incubation, the plates were examined for prominent plaque formation within the six boxed sections of each spot plate. Five different phage spots from the leaf sample enriched culture were selected from the spot plates that were incubated at 28°C. Our rationale for phage sample selection was to choose the spot boxes containing the clearest and largest plaques. The five selected phage samples were then isolated and stored in SM Buffer at 4°C until the subsequent phage purification experiment.

Streak Plate Purification of bacteriophage samples

Purification of our selected bacteriophage samples ensures the isolation of a single species from the mixed-species phage filtrates spotted in the previous test – known as a pure phage lysate. To obtain a pure lysate for each phage sample, a streak plate method of phage purification was performed 2-3 times, or until defined, isolated single lytic plaques could be observed for each of the five phage samples (Figure 3). In contrast to the subsequent plaque assay protocol, it is important to note that the addition of 1.0mM $CaCl_2$ to the top agar used for plate overlay in the streak plate phage purification method significantly facilitated the formation of plaques. Once each of the five phage samples was purified, they were stored in SM buffer at 4°C and assigned

a unique identifier based on the last name of each researcher who contributed to their isolation (FFC-#). This served as a temporary nomenclature for our bacteriophages, as they have not yet been identified or morphologically characterized using Transmission Electron Microscopy (TEM). After about a year of storage, only three of the five previously purified phage samples could still form lytic plaques. As a result, only Phages FFC-3, FFC-8, and FFC-11 were selected for subsequent plaque assay experimentation.

Preparation of X.euvesicatoria log phase culture

To achieve qualitative plaque formation, *X. euvesicatoria* cells in their logarithmic phase of growth must be utilized for the plaque assay protocol, rather than an overnight culture. Therefore, before the start of each plaque assay, *X. euvesicatoria* cells were first cultured in the rich medium, Nutrient Broth (containing peptone, glucose, yeast extract, beef extract, and sodium chloride), and subsequently placed in a 180-rpm shaking incubator at 28°C. Cells were then harvested once they reached the logarithmic phase.

Cation supplementation of purified bacteriophage samples – Plaque Assay

To test the effect of our selected cations on the lytic activity of the three re-purified phage samples against *X.euvesicatoria*, a plaque assay was performed for each cation (Baer & Kehn-Hall, 2014; Lee, 2020). Since each plaque assay tested the supplementation of each phage sample with a cationic salt at five different concentration levels (as well as a negative control condition of 0mM), a total of 54 plates were utilized per plaque assay experiment (3 phage samples × 3 dilution factors × 6 cationic concentration levels = 54 total plates). Each plaque assay began with the preparation of 0.5% nutrient broth top agar and five 1:10 serial dilutions of each phage sample. 100mL aliquots of log phase *X. euvesicatoria* liquid culture were dispensed into each of the 54 test tubes.

60mL aliquots of top agar were then dispensed into each of the six 250mL flasks. 6.67mL of the appropriate cationic salt solution was added to each of the five flasks that denoted the experimental concentration conditions. Prior to adding the 5mL aliquots of respective 0.5% top agar solutions into the respective test tubes, 10µL aliquots of the respective phage dilutions were added to each test tube containing the 100µL of *X. euvesicatoria* log phase culture and lightly vortexed. Once the phages were added to the bacteria, they were allowed to sit in suspension for 15-20 minutes to allow the phages time to attach to their host cells. Following this stage of phage attachment, 5mL of the respective top agar solutions were added to the respective test tubes containing 110µL of bacteriophage/bacteria suspension in an organized manner to allow time for plate overlay.

Once the 5.11mL mixtures were prepared in each of the respective test tubes, they were lightly vortexed and subsequently poured/overlayed onto the respective nutrient broth agar plates. After the 54 plates were overlayed with the top agar solution and allowed to solidify, they were placed in a 28°C incubator for 48 hours. After incubation, plates were examined for analysis and observable plaque formation. If quantifiable plaques formed, a viral titer was then calculated for that plate. Viral titer is the concentration of virulent phages in the stock solution, which is a value expressed in Plaque-forming Units per milliliter of solution (PFU/mL). The following formula was used to calculate viral titer: [# of plaques / (amount plated in mL x dilution factor)] = viral titer (PFU/mL). The above steps were repeated for each of the four plaque assay experiments performed in this study (Landry, 1975; Lee, 2020).

Results

For each incubated plate, the number of observable/quantifiable lytic plaques, the diameter of the largest observable plaque in mm, and the degree of turbidity (cloudiness) for the plaques that formed were recorded. The virulence activity of the three phage samples was tested against *X. euvesicatoria* in the absence of cation supplementation for the negative control in each of the four plaque assays. This was done to gauge the plaque-forming ability of each phage sample without additional supplementation and to also establish a baseline for drawing comparisons between the induced effects of each cation on each phage. viral titers were calculated for plates that demonstrated quantifiable plaque formation (Table 1).

Based on result evaluations for each plaque assay performed, it should be noted that a considerable degree of variance in plaque formation was observed among the four cations tested. Figure 4

shows a visualization of the plate results for Phage FFC-11, as it was the only phage sample that yielded observable plaques under the same supplementation condition for each of the four plaque assays performed. When supplemented with each cation at 0.01mM, Phage FFC-11 was able to form at least one observable plaque on the *X. euvesicatoria* confluent lawn. A visualization of these plates is necessary to compare the differences in the plaque(s) formed after supplementing one of our phage samples with each cation at concentrations ≤0.1mM.

An ordinal and subjective increasing turbidity scale ranging from 1–5 was created to represent the different levels of observable plaque cloudiness. Only plaques with a turbidity level of 5 are clear enough to be considered lytic. According to the literature, a plaque can only be considered lytic when it is completely clear or lacks cloudiness entirely (Landry, 1975). For the purposes of this study, the ideal result would be the formation of these clear lytic plaques because they serve as a strong indication of lytic activity against the host bacterium and the presence of infectious phage cells. Due to the lack of a larger sample size of plaque-forming plates for each combination of plaque assay experimental conditions, a statistical analysis of the data presented in this study was unable to be conducted.

Discussion & Conclusions

Every plaque assay performed in this study tested the effect of cation supplementation on Phages FFC-3, FFC-8, and FFC-11 against *Xanthomonas euvesicatoria* – a previously isolated Bacterial Spot causal agent. Each cation implemented in this study was tested at six different concentration levels. Each plaque assay consisted of 18 different conditions, with three plates per condition. All plaque assays yielded the formation of plaques for at least one condition, which supported our first hypothesis that monovalent and divalent cation supplementation of our purified phage samples will have an observable effect on virulence activity. The plaque assay that tested Zn^{2+} phage supplementation yielded plaque formation for 15 conditions. The plaque assay that tested Mg^{2+} phage supplementation yielded plaque formation for 16 conditions, which is the greatest amount of virulence activity observed from the four plaque assays performed. Based on the results of the initial trial, Phage FFC-8 yielded the highest average viral titer compared to the other two purified phage samples.

Out of the four cations tested, our three purified phages exhibited more plaque formation when supplemented with Zn^{2+} and Mg^{2+} than with K^{+} and Na^{+}. A feasible interpretation of this finding could be that divalent cations may be more effective than monovalent cations in inducing virulence activity when used to supplement our phages against *X. euvesicatoria*. However, further replication and validation of our current data remains necessary. A comparative analysis of the viral titer values calculated from the four plaque assays performed in this study demonstrated that more virulence activity was exhibited by our purified phage samples when supplemented with cations at concentrations ≤0.1mM. This result supported our second hypothesis that cation supplementation of our phage samples would yield a greater virulence effect against *X. euvesicatoria* at concentrations ≤0.1mM than >0.1mM. Further investigation is necessary to determine whether other divalent and/or monovalent cations are also able to increase virulence activity against a *Xanthomonas* phytopathogen when used to supplement phytopathogen-specific bacteriophages at concentration levels ≤0.1mM.

Another key finding of the current study is that out of the four cations tested, the plaque assay that tested Mg^{2+} supplementation resulted in the formation of plaques under the most conditions (16 of 18 possible conditions). This was also the only plaque assay that yielded plaque formation in the control condition (0mM). However, it is important to note that plaque assay data for the 0mM concentration condition requires further critical validation before a baseline viral titer can be established for our three purified phage samples. Furthermore, the incidence of plaque formation in the Mg^{2+} plaque assay control condition may also be attributed to extraneous factors such as top agar contamination or the presence of unwanted catalytic cofactors during phage-host attachment. Due to time constraints, only one trial of plaque assay experimentation for each selected cation was conducted for the current study. Therefore, replications of this study and additional plaque assay trials are necessary to establish validity before any definitive conclusions can be made based on interpre-

tations of the current data. Nevertheless, the results of the current study contribute to the foundation of our proposed phage-based biocontrol formulation. Further investigation is necessary to determine whether Zn^{2+} poses any immediate, non-target consequences for the environment. This is important because if heavy ions, such as Zn^{2+}, have the potential to cause negative non-target environmental impacts, then they should be excluded from further consideration in the development of our biocontrol formulation.

Based on the findings of our study, further phage supplementation plaque assay experiments can continue to be conducted using the cations that were shown to enhance phage virulence against *X. euvesicatoria*. Due to the promising phage virulence activity effects induced by Zn^{2+} and Mg^{2+}, the same plaque assay approach used in the current comparative study can be modified to test the virulence effect induced by supplementation of our purified phage samples with combinations of two or more divalent and/or monovalent cations at concentrations ≤0.1mM. The addition of other cations and/or environmentally safe compounds to our formulation could also be further explored. Following *in vitro* testing, we aim to test a fully developed version of our proposed phage-based biocontrol formulation, on a healthy tomato plant grown under controlled laboratory conditions as part of an *in vivo* study. This would serve as a means to investigate the treatment potential of cation-supplemented bacteriophages in combatting the pathogenicity of *X. euvesicatoria* over time and to identify any negative non-target environmental impacts that may be caused by the cations implemented in our biocontrol formulation. Lastly, an analytical study of our three plaque-forming purified bacteriophage samples, using Transmission Electron Microscopy (a microscopy technique used to observe the surface features of extremely small specimens), could be conducted for morphological characterization, proper phage identification, and appropriate assignment of nomenclature. The long-term goal for the continuation of this research is to enhance our understanding of cation-phage interactions and optimize virus-based agricultural therapeutics for global application.

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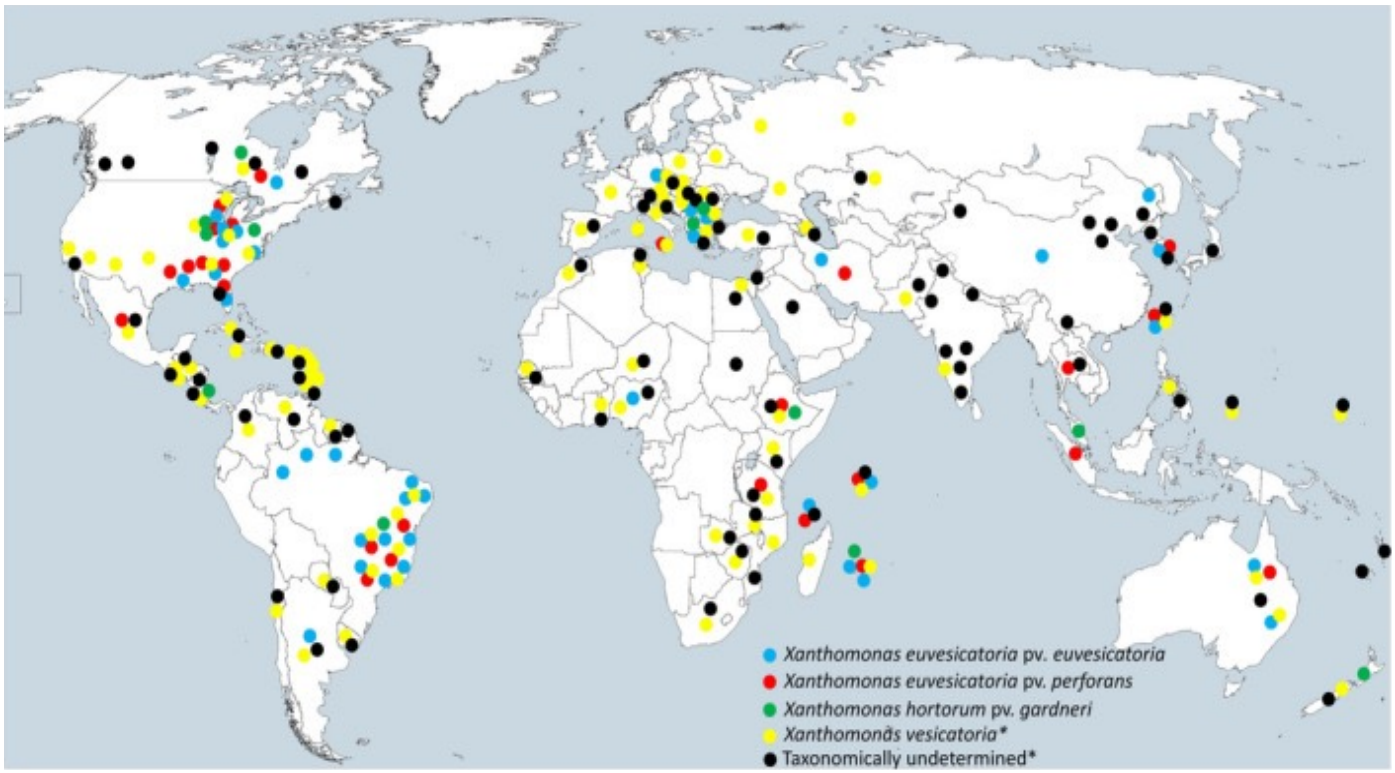

Figure 1: Geographic distribution of Bacterial Spot disease causal agents. This image highlights the widespread nature of this plant disease, as it can affect tomatoes and peppers anywhere in the world where they are grown – regardless of climate. The distribution of taxonomically undetermined Bacterial Spot phytopathogens indicates that these bacteria continue to evolve novel strains, which may lead to the acquisition of more resistance mechanisms against current treatment standards (Osdaghi et al., 2021).

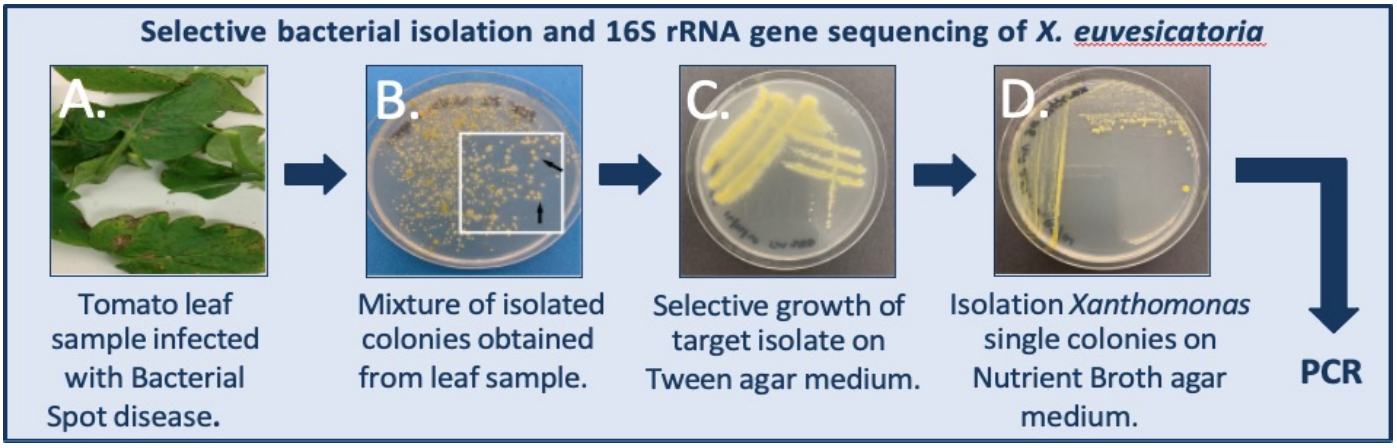

Figure 2: Initial steps to isolate and identify the target bacterium. A tomato plant leaf sample demonstrating symptoms of Bacterial Spot disease (A) was first collected and taken to the lab. Environmental samples underwent a 5-fold 1:10 serial dilution, were plated on nutrient broth agar, and incubated at 28°C for 96 hours to obtain a mixed bacterial culture (B). Bright yellow colonies were then picked and streaked on the semi-selective medium, Tween agar (C). After *Xanthomonas* growth on Tween agar was confirmed, the colonies were isolated and streaked on nutrient broth agar plates (D). The suspect isolate then underwent

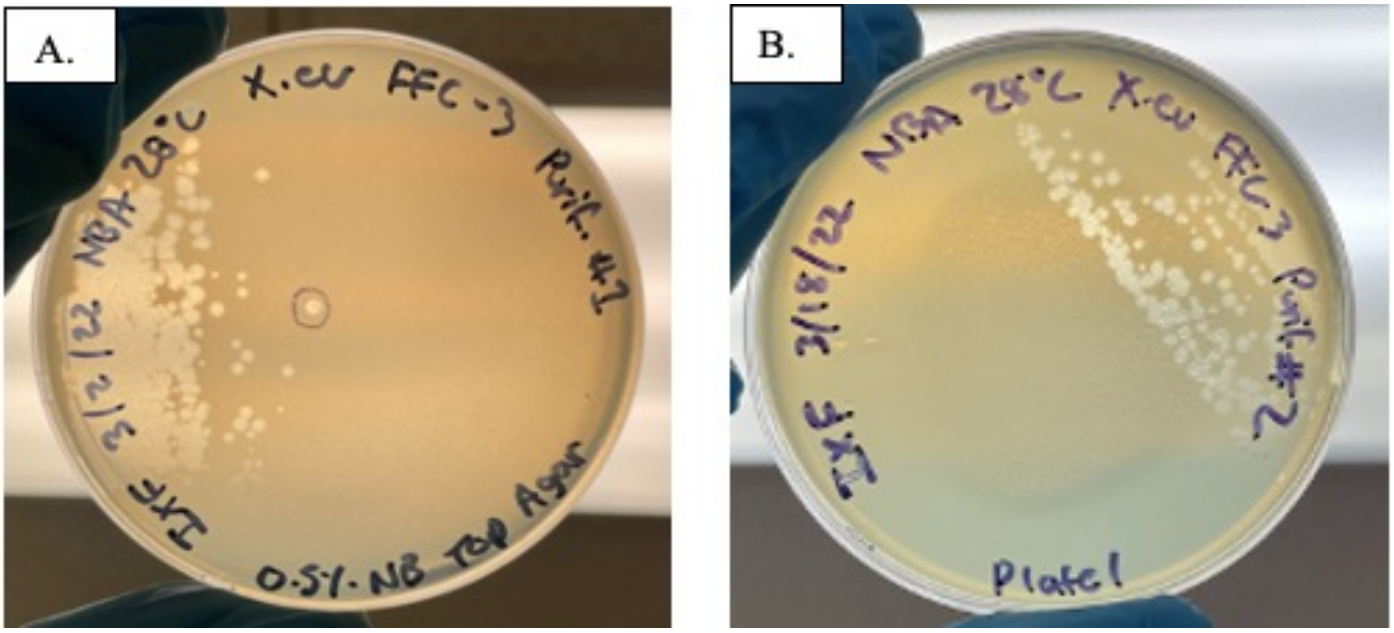

Figure 3: 2-fold streak plate purification results for Phage FFC-3. First round of purification for Phage FFC-3 (A.). Second round of purification for Phage FFC-3 (B.). Plaques appear more isolated and defined after the second round of phage purification (Poxleitner et al., 2018).

Plaque Formation After Supplementation with K^+, Na^+, Zn^{2+}, & Mg^{2+}

Purified Phage Sample	Plaque-forming conditions after KCl supplementation	Plaque-forming conditions after NaCl supplementation	Plaque-forming conditions after $ZnCl_2$ supplementation	Plaque-forming conditions after $MgCl_2$ supplementation
FFC-3	No plaques	• 10.0mM: $1.0x10^5$ PFU/mL	• 0.001mM: $1.15x10^6$ PFU/mL • 0.01mM: $1.7x10^6$ PFU/mL • 0.1mM: $7.0x10^5$ PFU/mL • 1.0mM: $3.0x10^5$ PFU/mL • 10.0mM: $4.0x10^5$ PFU/mL	• 0mM: $6.5x10^5$ PFU/mL • 0.001mM: $2.0x10^6$ PFU/mL • 0.1mM: $5.5x10^5$ PFU/mL • 1.0mM: $1.0x10^5$ PFU/mL • 10.0mM: $5.05x10^6$ PFU/mL
FFC-8	No plaques	• 0.01mM: $1.0x10^6$ PFU/mL	• 0.001mM: $9.75x10^7$ PFU/mL • 0.01mM: $9.6x10^7$ PFU/mL • 0.1mM: $5.65x10^7$ PFU/mL • 1.0mM: $5.11x10^7$ PFU/mL • 10.0mM: $3.79x10^7$ PFU/mL	• 0mM: $1.82x10^7$ PFU/mL • 0.001mM: $1.13x10^7$ PFU/mL • 0.01mM: $9.93x10^6$ PFU/mL • 0.1mM: $1.42x10^7$ PFU/mL • 1.0mM: $2.15x10^7$ PFU/mL • 10.0mM: $2.01x10^7$ PFU/mL
FFC-11	• 0.01mM: $1.0x10^7$ PFU/mL	• 0.01mM: $1.0x10^7$ PFU/mL	• 0.001mM: $1.1x10^6$ PFU/mL • 0.01mM: $7.0x10^5$ PFU/mL • 0.1mM: $1.0x10^6$ PFU/mL • 1.0mM: $5.0x10^5$ PFU/mL • 10.0mM: $7.0x10^5$ PFU/mL	• 0mM: $6.0x10^5$ PFU/mL • 0.001mM: $1.0x10^5$ PFU/mL • 0.01mM: $5.0x10^5$ PFU/mL • 1.0mM: $6.0x10^5$ PFU/mL • 10.0mM: $3.0x10^5$ PFU/mL

Table 1: Plaque assay plate results for Phages FFC-3, FFC-8, & FFC-11 under all cation supplementation conditions. Four separate plaque assays were performed to test each of the four cationic salts. Each plaque assay tested 18 total conditions (3 phages × 6 cation concentration levels) against *X.euvesicatoria*. Observable plaque formation is an indicator of phage virulence activity and used to calculate the viral titer in PFU/mL. The larger the viral titer value, the greater the number of plaques that formed (Lee, 2020).

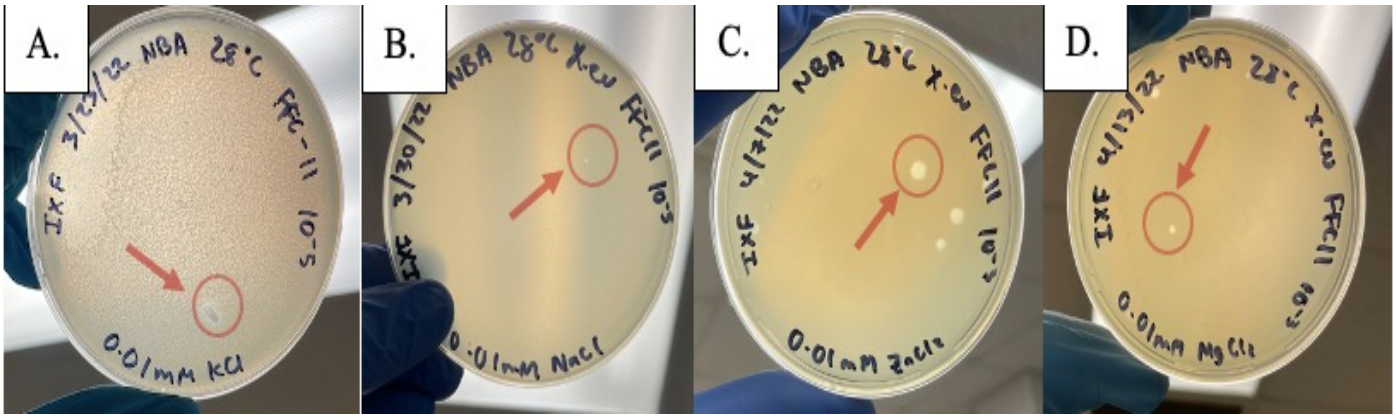

Figure 4: Visualization of plaque assay results for Phage FFC-11 after supplementation with each cation (0.01mM each). The four images above depict the plaque assay results for Phage FFC-11 for the 0.01mM cation concentration condition. Phage FFC-11 yielded: one plaque of low turbidity with a diameter size of 6.0mm after supplementation with K^+ (A.), one plaque of low turbidity with a diameter size of 1.0mm after supplementation with Na^+ (B.), seven lytic plaques with a diameter size of 4.0mm, for the largest plaque present, after supplementation with Zn^{2+} (C.), and five lytic plaques with a diameter size of 3.5mm, for the largest plaque present, after supplementation with Mg^{2+} (D.).

Dietary Restrictions as a Source of Food Insecurity among FGCU Students, Faculty, and Staff

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Introduction

Food insecurity is a household and personal economic and social condition that results from limited access to adequate food (USDA, 2022). In 2021, 10.2 percent (13.5 million) of U.S. households were food insecure, and 3.8 percent of the households experienced high-level food security (USDA, 2022). A number of factors such as income, employment, race/ethnicity, education, regionality, and disability can influence food insecurity (Nord, 2007). When money is limited or not available to purchase food, the likelihood of food insecurity rises (Nord et al., 2010; Sharkey et al., 2011). Unemployment also affects a household's food security status negatively. For example, households with unemployed adults are 12% to 15 % more likely to be food insecure than adults with full-time employment (Nord et al., 2014).

Food insecurity can affect people of all ages and socio-economic backgrounds. For example, children with unemployed parents are at higher rates of food insecurity than children with employed parents (Coleman-Jensen and Nord, 2013). In 2021, 6.2 percent of U.S. households with children were food insecure; these families were unable to provide sufficient nutrition for their children (Coleman-Jensen et al., 2022). The prevalence of food insecurity increased from 2020 to 2021 for households with no children, especially for women and elderly people who are living alone (Coleman-Jensen et al., 2022).

Institutional barriers, such as systemic racism and discrimination, can also result in food insecurity. Minority populations in the United States are more likely to be food insecure (Nord et al., 2014). Disabilities increase the likelihood of food insecurity due to increased household costs and reduced incomes (Coleman-Jensen and Nord, 2013). Food insecurity is additionally influenced by regional demographics, with large cities containing higher percentages than rural areas and suburbs (Nord et al., 2009). Economic challenges and unemployment affect a household's food security status negatively. Households with unemployed adults are 12% to 15 % more likely to be food insecure than adults with full-time employment (Nord et al., 2014).

Effects of Food Insecurity

Food insecurity can have long-term physical and mental health effects. People with low incomes and limited access to food may skip meals, which creates a risk for excessive fatigue, loss of productivity, and a decrease in cognitive function (Whittel et al., 2019). Even mild amounts of food insecurity that coincide with occasionally skipping meals can have detrimental effects. Households with low food security reported experiencing adverse mental health conditions about their food situation, including anxiety (Nord, 2007). Over one-third of U.S. adults with low income have high stress and anxiety due to food insecurity (Wolfson et al., 2021) as illustrated by a parent from the San Francisco Bay Area: "It can get difficult and sometimes even scary...I empathize for people who have gone into the store and stolen a steak. You want to survive. What do you do when you have no food?" (Leung et al., 2022). For these women, food insecurity was a major source of ongoing anxiety and stress (Weaver and Hadley, 2009; Stebleton et al., 2020).

Food insecurity also produces adverse health effects, including increased rates of iron deficiency, acute infection, and chronic illness. The presence of food insecurity also increases the risk of developmental and mental health problems such as anxiety, depression, post-traumatic stress disorder (PTSD), and suicidal tendencies (Stuff et al., 2004; Seligman et al., 2010; Silverman et al., 2015; Whittel et al., 2019). Mental health conditions increase the risk of overeating or undereating (Hall et al., 2015). In addition, short-term health issues can develop into long-term complications when food insecurity is present (Leddy et al., 2020).

Food insecurity impacts not only the health of individuals, but also of their families and society episodically. For example, 38% of the U.S. popula-

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tion experienced an increase in food insecurity when COVID-19 started, which can become a compounding factor (U.S. Census Bureau, 2020; Leddy et al., 2020). During the pandemic, food insecurity increased the risk of chronic diseases, including diabetes and cardiovascular disease, which then placed individuals at increased risk of COVID-19 complications (Chow et al., 2020; Zhou et al., 2020). It is necessary to address food insecurity in order to ensure the health of individuals and of the communities surrounding them Food insecurity has a ripple effect that impacts not only the health of individuals but also their families and society at large. It is necessary to address food insecurity in order to ensure the health of individuals and of the communities surrounding them.

Food Insecurity on College Campuses

The challenge of food insecurity is not limited to people who experience unemployment, poverty, disability, or food shortages. Food insecurity can also affect college and university students, staff, and faculty in the United States (Phillips et al., 2018). Studies on college campuses reported that 14% - 59% of students faced food insecurity during their college career (Chaparro et al., 2009; Patton-López et al., 2014; Geines et al., 2014; Henry, 2017; Phillips et al., 2018). Students with financial challenges were more likely to deal with food insecurity (Broton et al., 2014). Race/ethnicity also plays a role in food insecurity on college campuses, as students of color were more likely to experience food insecurity (Patton-López et al., 2014).

The Consequences of Food Insecurity on Students

Despite increasing awareness of food insecurity and hunger on college campuses, the effect of food insecurity on college campuses is often overlooked (Broton et al., 2018). Hunger negatively impacts students' education (Dubick et al., 2016) and can reduce students' achievement, which undermines educational benefits as a result of health disparities (Raskind, Haardörfer, and Berg 2019). One of the students at the University of Maine at Farmington mentioned that "being hungry affected my concentration, and there were also social costs to being low income" (Stringer et al., 2020). Food insecurity also appears to impact academic performance among post-secondary students (Raskind, Haardörfer, and Berg 2019). Food-insecure students at community colleges in Maryland were more likely to earn C's than food-secure students who earned A's (Maroto et al., 2015; Payne-Sturges et al., 2017). Food insecurity is associated with poorer academic performance, which may undermine educational investment and impede social progress (Broton et al., 2018).

The prevalence of food insecurity is a growing public health problem for college students, with the potential for adverse effects on both physical and psychological health (Payne-Sturges et al., 2017). Food-insecure students also reported more frequent depression symptoms that disrupted their scholarly work (Silverman et al., 2015; Gundersen and Ziliak, 2015; Payne-Sturges et al., 2017; Whittel et al., 2019). For instance, a college student experiencing food insecurity in the U.S. shared "*I have never held a lot of weight on my body but I have lost weight just in a way where it's like...I am just not going to eat lunch, or I will just go to bed hungry*" (Stebleton et al., 2020). Psychological health issues as a result of food insecurity increase the rate of depression and anxiety (Bruening et al., 2016), as one student from the University of California Berkeley described. "*When you are so stressed about food all the time, that takes a lot of mental power*" (Meza et al., 2019). Based on the findings of several researchers, food insecurity has been shown to have adverse effects on individuals' physical and mental health.

The Role of Dietary Restrictions on Food Insecurity

Unemployment, poverty, disability, and food shortage all contribute to food insecurity. However, it is unclear whether dietary restrictions can also lead to food insecurity. Dietary restrictions limit what an individual can eat based on food requirements, which may vary from a result of allergies, cultural and religious belief systems, and/or lifestyle choices. Food allergies arise when individuals show an immune response to consumed food (Boyce et al., 2011). Common food allergies include milk, wheat, eggs, peanuts, soy, tree nuts, shellfish, fish, and sesame (Sicherer and Sampson, 2018; Food and Drug Administration, 2023;). People who have dietary restrictions from allergies can experience mild to life-threatening allergic reactions (i.e., anaphylaxis shock) if they consume the wrong food (Bock et al., 2007; Hard-

ley, 2016). There are an estimated 220 million people across the globe who are suffering from food allergies (Warren et al., 2020; Fiocchi et al., 2021). In the United States, approximately 8% of children and 11 % of adults suffer from food allergies (NIAID, 2023). Despite the limited information, many scientists believe that the prevalence of food allergens is rising (Hadley, 2006). For example, celiac disease is a complex disease that is triggered by the consumption of an emerging food allergy from gluten; 62% of adults from the University of Chicago shared experience of fatigue, headache, and iron deficiency anemia due to wheat allergy (Hilary et al., 2017). Food allergies require modified lifestyles, such as strict avoidance of allergens and vigilant examination of ingredients in recipes and packaged foods (Jafri et al., 2021). Issues associated with food allergies could be mitigated partially with proper food labeling, which would help consumers identify items that should be avoided (Fiocchi et al. 2021; Food and Drug Administration, 2023). In addition, proper labeling of ingredients would also prevent individuals from accidental ingestion of allergens.

The dietary restriction from lifestyle choices such as vegan, vegetarian, and pescatarian diets are increasing (Phillip, 2005; Radnitz et al., 2015; Bayte et al., 2022). A vegetarian diet requires the avoidance of meats and meat products (AND, 2016; Dagnelie and Mariotti, 2017; Hargreaves et al., 2023). By comparison, a vegan diet excludes all animal-based food products, and vegans only eat plant-based foods (Clarys et al., 2014; Dagnelie and Mariotti, 2017; Hargreaves et al., 2023). In the United States, 6% of the population follows a vegetarian diet and 3% of the population follows a vegan diet (Funk and Kennedy, 2016). Despite the growing number of vegans, vegetarians, pescatarians, and other dietary preferences, individuals with these dietary needs still face challenges obtaining required food items (Aschemann-Witzel et al., 2020; Banyte et al., 2022). The dietary needs that result from personal preferences are becoming diverse; it is, therefore, essential to create access to food that meets their dietary requirements.

Religious and cultural beliefs, such as halal and kosher, can also create dietary restrictions because believers must follow specific guidelines when eating. Religious communities such as Muslim, Jewish, Buddhist, and Adventist adhere to strict dietary practices (Maffei, 2014). For example, halal is an Arabic word meaning permissible or lawful, and the diet is pursued as part of the daily lifestyle of Muslims regardless of ethnicity, race, or national origin (Maffei, 2014). People with halal dietary restrictions avoid pork, alcohol, and dead animals and only eat meals that are prepared according to Islamic law. As evidenced in the Qur'an: "He has only forbidden you to eat carrion, blood, and swine" (The Quran, Verse 2:173). Anything that is not considered halal falls under the category of either makrooh (doubtful) or haram (forbidden) (Maffei, 2014). The slaughtering of animals that are permissible to eat for Muslims such as cattle and sheep, must be done in the name of Allah in order for the meat to be halal (Mumuni et al., 2018). Over one-fifth of the world population is Muslim which is projected to rise from 1.8 billion in 2019 to around 3 billion by 2060 (Pew Research, 2019). In addition, over 3.45 million Muslims live in the United States (Mohamed, 2017). Despite this large population, many national and international food companies do not provide halal foods, which limits food options (Kamarulzaman et al., 2016). Therefore, it is important to create a halal food supply chain to ensure the availability of halal food in the market to accommodate the Muslim population in the U.S.

While dietary restrictions are commonplace, it is unclear whether dietary restrictions can lead to food insecurity. This study aims to understand how dietary restrictions affect food insecurity in places where food is readily accessible and reasonably priced, such as a university campus. Additionally, the study explores the relationship between how dietary restrictions and the physical and mental health impacts of food insecurity impact college students, faculty, and staff, in terms of academic performance and professional development. Understanding the detrimental effects of dietary restriction on food insecurity could help alleviate the issue of lack of meal options by improving proper labeling of food, expanding food options for individuals with vegan, vegetarian, and pescatarian diets, as well as implementing meal options for those who practice religious dietary restrictions such as halal. Overall, the relevance of this study is to improve education and address the importance of catering to the diverse dietary-restricted population along with

promoting inclusivity.

Methodology

To understand the role of dietary restriction among college students, faculty, and staff, I conducted a mixed-method self-perception survey of students, faculty, and staff at Florida Gulf Coast University (FGCU), Fort Myers, Florida. The data were collected through an online (Formstack) survey, where participants responded to a combination of quantitative and qualitative questions (Appendix A). The survey consisted of seven questions (six quantitative and one qualitative) and was split into multiple parts. The first part of the survey focused on people's personal experiences with and self-perception about food insecurity (i.e., four quantitative and one qualitative question). The second part of the survey focused on people's understanding of food insecurity and well-being (i.e., two quantitative questions). Those two questions of the second part of the survey addressed the direct correlation between diet and a person's mental and physical well-being. The last part of the survey allowed participants to share individual identifiers, such as names and emails. This section was voluntary. The analyses excluded individual identifiers Participants could remove themselves from the study at any point without penalty for discontinuing the survey. In addition, participants could skip any questions that they did not want to answer.

Recruiting Participants

Participants were recruited through the Eagle Link (the FGCU website/app that students, staff, and faculty use to learn about opportunities across campus). The survey was also sent out by the Office of Student Involvement via university-wide email. The Office of Student Involvement shared this survey to support students learning, leadership development, and student success outside of the classroom.

Data were collected from February to April 2022. All willing participants who are 18 years of age or older at FGCU were invited to participate in the study. There were 324 people who participated in the study. The participants of the study included students, faculty, and staff.

Data Analysis

To determine the role of dietary restrictions, I first calculated the percentage of individuals with dietary restrictions and the types of dietary restrictions experienced on campus. I additionally quantified whether people had difficulty finding food on campus due to their dietary restrictions, as well as how frequently respondents reported skipped a meal because of their dietary restrictions. In addition, I calculated the proportion of individuals who were food insecure due to their dietary restrictions.

To evaluate qualitative responses, the in vivo coding from the grounded theory was used to understand participants' experience with dietary restrictions-related food insecurity as well as to avoid any personal interpretations while coding, as in vivo codes can provide a crucial check on anticipating what is significant (Charmaz, 2006). The qualitative responses to the question, "How does skipping a meal because of limited food options affect your ability to learn or work?" were categorized using the inductive content analysis method (Cavanagh, 1997; Elo and Kyngas 2008). This approach was utilized to refine words into concise content-related categories and to provide a means of describing phenomena, improving understanding, and generating knowledge (Cavanagh, 1997; Elo and Kyngas, 2008). These responses were categorized on a scale of "High," "Moderate," "Minor," and "Never" to determine the level of food security.

- "High" food insecurity indicated respondents who experienced physiological issues (e.g., migraine headache, stomachache, and problems with digestion) or psychological issues (e.g., anxiety, depression, frustration, or burnout).
- "Moderate" food insecurity included participants who described concentration difficulties and/or fatigue (e.g., feeling weak, dizzy, and lower energy).
- "Minor" food insecurity included participants who described food access issues, such as difficulty finding food on campus or needing to bring homemade food.
- "Never" included respondents who had a dietary restriction but did not describe an issue with skipping a meal.

Only respondents who identified a dietary restriction were included in this analysis to determine the relationship between dietary restriction and food insecu-

rity.

To determine the relationship between the perception about food insecurity at a national and institutional level relative to a participant's dietary restrictions, the two-sample permutation t-test was used to compare participants with dietary restrictions and those without dietary restrictions. The null hypothesis was described when there were no differences between a person's perception of food insecurity at FGCU food insecurity regardless of their dietary restriction ($P > 0.05$). The alternative hypothesis is that dietary restriction is associated with a person's perception of food insecurity at FGCU, which was described when there was a difference between the two samples ($P < 0.05$). In addition, the linear regression analysis was used to compare participants' perceptions about institutional versus national levels of food insecurity.

Ethical Consideration

The study protocol was approved by The Institutional Review Board (IRB) of Florida Gulf Coast University. This survey was not created initially as a formal research study. Therefore, IRB approval was sought and received after the survey was completed (IRB protocol # S2022-56). As a result, demographic information regarding participants was not required and only provided if participants wanted additional information. In addition, participants did not sign a consent form.

To ensure the anonymity and confidentiality of the participants, results were analyzed only after personal identifiers were removed. In addition, analyses were conducted at the global level instead of individual respondents.

Results

Dietary Restriction

A total of 324 people participated in this study, which represented 1.9% of the overall population of FGCU. Among all the participants of the study, 70.8% (N = 217) identified some form of dietary restriction. Among participants who identified dietary restrictions, 59.9% (N = 130) identified one dietary restriction, and 40.1% (N = 87) identified two or more restrictions, averaging 2.47 dietary restrictions per individual. The most common form of dietary restriction among the participants was from allergies (62.1%, N = 195), the second largest form of dietary restriction was from personal preference (31.8%, N = 100), and the remaining restrictions were from religious/cultural belief systems (6.1%, N = 19).

Among participants with allergies (Figure 1), a large percentage of the participants with the dietary requirements were dairy-free (29.1%, N = 102) and gluten-free (16.3%, N = 57). A smaller percentage of the participants with dietary restrictions as a result of allergies were fish/shellfish-free (6.35%, N = 22) and nut-free (4%, N = 14). The majority of the respondents who identified dietary restrictions from personal preferences were vegan (11.1%, N = 39) or vegetarian (9.7%, N = 34). The remaining participants with dietary needs from personal preference were pescatarians (7.7%, N = 27). People with dietary restrictions as a result of cultural/religious beliefs (e.g., halal and kosher) made up the smallest percentage of the sample (6.1%, N = 19). Participants with halal dietary restrictions made up 3.4% (N = 12) of the overall participants. A small proportion of the respondents followed the kosher diet (2%, N = 7). No participants identified a third religious or cultural belief that resulted in a dietary restriction. The remaining respondents with dietary restrictions identified a variety of considerations, such as keto, low-fat, low-carb, sugar-free, and pineapple-free (10.3%, N = 36). Results of the survey revealed that 29.15% (N = 107) of respondents did not have any dietary restrictions.

Issues with Finding Food on Campus

Among all respondents including individuals with and without dietary restrictions, more than half of the participants (57.7%, N = 186, Figure 2A) described difficulties finding food on campus. Within these groups of people who have difficulties finding food, (45.4%, N = 144) of the participants described having some issues finding food on campus. While the remaining (12.3%, N = 42) participants shared that they could not find any appropriate food options because of their dietary restrictions. A total of (42.3%, N = 111) of the respondents with and without dietary needs shared that finding food was not a challenge on campus. Some respondents (20.7%, N = 63) identified that they could find food options on campus but knew of people who had difficulties finding food as a result of dietary restrictions. Other participants with or without dietary restrictions said they could find

food on campus without issues (21.6%, N = 69).

Skipping a Meal due to Dietary Restrictions

In the study, the majority of the people who identified at least one dietary restriction reported skipping a meal at least once a week (66%, N = 214, Figure 2B). Among people with dietary restrictions, 22.2 % (N = 72) identified skipping meals three or more times a week because they did not find the food that met their dietary needs. More than a quarter of the participants skipped meals one to two times a week (25.3%, N = 82), and a smaller percentage (18.5%, N = 60) reported skipping meals once every few weeks. Among people with at least one dietary restriction, 34% (N = 110) shared that they never skipped a meal because they had no difficulties finding food on campus.

Respondents' Experience of Food Insecurity Due to Dietary Restriction

A total of 214 participants with dietary restrictions responded to a qualitative question about how skipping a meal affected their abilities to study, learn, and work. Qualitative responses were categorized into four levels of food insecurity: "High" = Mental and physical detrimental effects, "Moderate" = Issues with concentration and activities, "Minor" = Inconveniences and reallocated time issues, and "Never" = No identifiable food insecurity.

Among those participants, (32.1%, N = 35) reported experiencing high levels of food insecurity (Figure 3). Respondents who experienced high-level food insecurity had physiological issues (e.g., headache, stomachache, issues with digestion, and the effect of completing academic work) and psychological problems (e.g., anxiety, depression, frustration, and stress/burnout). One of the participants of the study described "It [skipping a meal] causes stomach aches and pain that lasts throughout the entire day, even after eating much later. This distracts me when I am in class, doing schoolwork, or working." Another respondent shared that "headaches and stomach aches are frequent," which indicates that those respondents experienced "High-level" food security on campus because of their dietary restrictions.

More than two-fifths of the participants described moderate-level food insecurity (45%, N = 49). Moderate-level respondents described difficulties with engagement in work, experiencing symptoms such as lack of concentration, feeling weak, reduced ability, low energy, weakness, and dizziness. Several respondents shared that skipping meals resulted in difficulty with concentration and/or fatigue. As one of the many participants expressed, "Skipping a meal causes me to focus more on my hunger rather than my studies." Another participant described "I feel woozy and weak," indicating "Moderate-Level" food insecurity.

Less than a fifth of the respondents had a minor level of food insecurity (15.6%, N = 17). Those participants had difficulties finding food on campus and chose to either go off campus, bring food from home, or skip meals. In addition, some participants with dietary restrictions shared that difficulties in finding food on campus led them to look for alternative meal options off-campus. One respondent shared, "I am forced to drive off campus during break hours to find better meal options which are time-consuming," which denotes a "Minor-level" food insecurity. Finally, only a small percentage of respondents "Never" encountered food insecurity on campus because of their dietary restrictions (7.3%, N = 8).

Respondents' Perceptions about the Extent of Food Insecurity On-Campus and Nationally

The presence or absence of dietary restrictions did not affect a participant's perception of how many dealt with food insecurity at FGCU (Figure 4: 3A, p = 1, iterations = 51). All of the participants thought that food insecurity was an issue at FGCU; affecting roughly a third of all students, faculty, and staff. In addition, every participant thought that food insecurity was a national issue, regardless of whether the respondent had dietary restrictions or not (Figure 4: 3B, p = 0.486, iterations = 107). Respondents thought that roughly 40% of people across the country experience food insecurity.

Level of Food Insecurity Relative to Participants' Experience by Perception

The degree of participants' experience of food insecurity at FGCU did not affect their perception of food insecurity on campus. Participants who experienced food insecurity thought that roughly 35% of people at FGCU experienced food insecurity (Figure 4: 4A, P = 0.34, iteration = 1546). People who experienced a high level of food insecurity as a result of dietary restrictions perceived similar issues across

campus to those who did not experience food insecurity on campus due to their dietary restrictions. The degree of participants' experience of food insecurity due to their diet did not affect their perception of nationwide food insecurity as well. Participants who experienced food security due to dietary restrictions predicted roughly 45% of the people experienced food insecurity nationally (Figure 4: 4B, P = 0.523, iterations = 616). People who experienced high-level food insecurity perceived that food insecurity is a larger issue nationally than the participants who did not experience food security because of their dietary restrictions.

Discussion

Food options at FGCU are abundant, accessible, and moderately priced. There are at least seven dining locations (five commercial locations and two cafeterias), many vending machines, and a food pantry at FGCU. Many students can obtain food or discounts on food through scholarships. The price of food is also relatively affordable for students who do not have meal subsidies. All things being equal, there should be few to no food insecurity issues on campus. However, this study shows that dietary restrictions can lead to food insecurity in places where food is otherwise abundant and accessible. Dietary restrictions are limitations on the types of food that an individual can eat. For example, people with food allergies cannot consume food items that produce allergic reactions. As a result, people with dietary restrictions can experience food insecurity if there is a lack of appropriate options specific to their dietary requirements. Although there are massive surpluses of food that are accessible and affordable, many individuals with dietary restrictions still have trouble obtaining food because they cannot find the required options.

In this study, more than 2/3 of respondents described having at least one dietary restriction. The most common forms of dietary restriction result from food allergies, personal preferences, and/or religious/cultural belief systems. A large number of the respondents of this study described having food allergies, such as dairy, gluten, and/or nut allergies. In addition, 1/3 of the participants had dietary restrictions from personal preference and/or lifestyle choices, such as vegan, vegetarian, and pescatarian. Finally, a smaller number of the participants described religious or cultural practices that resulted in dietary restrictions, such as halal and kosher. Regardless of the specific consideration, dealing with one or more dietary restrictions affected participants' ability to access food when required food options were not available on campus.

This study showed that food allergies were a big issue on campus among those people who dealt with dietary restrictions. A large number of the participants in this study were lactose and gluten-intolerant. Other food restrictions included nuts-free, fish-free, and shellfish-free diets. Food allergies negatively impact individuals, resulting in mild to life-threatening allergic reactions if they consume unsuitable food (Bock et al., 2007; Hardley, 2016). To reduce the risk of accidental consumption and allergic reactions, labeling food is extremely important. At FGCU, some food items such as chips, protein bars, and cookies, are clearly marked with known allergens. In addition, dining locations such as Chick-fil-A include disclaimers about the use of peanut oil. However, many food options do not come with this information. Limited meal options with complete and accurate information about allergies make it challenging to find reliable food on campus. Proper labeling of food helps consumers to identify the food they should avoid (Fiocchi et al. 2021; Food and Drug Administration, 2023). At FGCU, some foods that are prepared individually or pre-packaged in Starbucks, Brahma Express, Boar's Head, and Yo-Kai Express, do not have proper labels regarding allergens, which creates insecurity in purchasing food for people with allergies. As a result, allergic individuals are forced to either bring their own food to campus or skip meals on campus.

Dietary restrictions from lifestyle choices such as vegan, vegetarian, and pescatarian also face trouble accessing food. The number of people who practice vegan, vegetarian, or pescetarianism is increasing (Phillip, 2005; Radnitz et al., 2015; Bayte et al., 2022) and roughly ⅓ of participants in this study identified these types of dietary restrictions. Despite the growing number of vegans, vegetarians, pescatarians, and other dietary preferences, individuals with these dietary restrictions still face challenges obtaining food items that conform to their diet (Aschemann-Witzel et al., 2020; Banyte et al. 2022). On college campuses

like FGCU where food is plentiful, meal options for vegans, vegetarians, and other diets are still limited. Some meals such as chicken sandwiches and beef ramen are problematic and easily identifiable for vegan and vegetarian diets. However, other food items such as gummy bears and marshmallows may seem acceptable but are made from animal-derived products and are not clearly labeled in most cases. With a large number of people pursuing diet preferences based on lifestyle choices, finding appropriate meals is a challenge in places with limited options.

Religious dietary restrictions (such as halal and kosher) are practiced by a significant number of respondents worldwide, although a small number of individuals pursue these religious practices and associated diets on campus. Halal, for example, is a dietary restriction from a religious/cultural belief system that is followed by Muslims. Individuals with halal dietary requirements are forbidden from eating foods that are against Islamic laws (e.g. pork, alcohol, blood, and carrion). Finding halal food is not an issue in countries such as Afghanistan, Bangladesh, Iran, Qatar, Turkey, India, Nigeria, and Ethiopia where Muslims represent the majority or a large proportion of the population. However, issues emerge when practitioners of these religions are small minorities within a community. Although one-fifth of the world's population is Muslim (1.8 billion) and over 3.45 million Muslims live in the U.S. (Mohamed, 2017 and Pew Research, 2019), a small percentage of participants identified as Muslims who had halal dietary requirements at FGCU. Muslims represent a small proportion at FGCU, and there are no halal-certified meals available at any of the on-campus dining facilities. As a result, individuals with halal dietary needs experience challenges in accessing reliable food and must either bring their own food to campus or skip meals.

The issue of accessing halal food is particularly prominent on university campuses in the U.S. with small Muslim populations. Dearborn, home to the University of Michigan, is the seventh largest city in Michigan with a large Muslim population of roughly 500,000 (Arab Americans Institute Foundation, 2018) as a result finding halal food is not a challenge there (Roodbar & Veeck, 2021). In Fort Myers, Florida where FGCU resides, the Muslim population is particularly small compared to Dearborn. Therefore, finding halal food is problematic in this area, especially on college campuses like FGCU, where Muslims are a small minority.

The results of this study show that dietary restrictions can result in food insecurity. Participants of this study who described having dietary restrictions shared difficulty accessing reliable food on campus. As a result, dietary restrictions can produce food insecurity in the same way that poverty, unemployment, or disability can result in food insecurity. People experiencing poverty and unemployment cut the size of meals or skip meals because of the lack of money to buy sufficient food similar to individuals who are unemployed, disabled, or racially minoritized (Coleman-Jensen and Nord, 2013; Nord et al., 2014; USDA, 2022;). Resulting in a similar outcome, the respondents with dietary restrictions at FGCU skipped meals at least once a week because of the limited access to food that satisfied their dietary requirements. The results suggest that there is a strong relationship between an individual's dietary restriction and skipping meals.

Based on the findings of the study, dietary restrictions related to food insecurity can also affect the physical and psychological health of individuals as well as their academic success. Food insecurity produces adverse health effects, including increased rates of iron deficiency, acute infection, chronic illness, as well as developmental and mental health problems such as anxiety, depression, PTSD, and suicidal tendencies (Stuff et al., 2004; Seligman et al., 2010; Silverman et al., 2015; Whittel et al., 2019). While data associated with measurable physiological effects were not collected as part of this study, participants who skipped meals as a result of dietary restrictions reported having difficulties with health and well-being. Some individuals described serious physical and mental health effects, such as stomach aches, migraine headaches, and anxiety. Other participants described issues associated with academic success, such as difficulties attending classes, studying, or working because of feeling dizzy, fatigued, and weak. Finally, some participants identified problems with time management because of challenges in finding appropriate food options. In all cases, these individuals suffered the negative effects of limited food options that were

appropriate for their diets. The study indicated that food insecurity related to dietary restrictions was a large issue at FGCU because of the number of people challenged by this consideration.

While dietary restrictions resulted in food insecurity among many participants, some participants with dietary restrictions did not deal with food insecurity. There are several factors such as disability, racial identity, and age that increase the likelihood of food insecurity (Nord et al., 2009; 2014; Coleman-Jensen et al., 2013; 2022) but do not always result in food insecurity. At FGCU, a large majority of the participants had dietary restrictions and dealt with food insecurity. However, dietary restrictions did not result in food insecurity in every case; 7.3 % of participants with dietary restrictions had no trouble finding food on campus.

The study also showed participants' perception of food insecurity was higher than the actual rate of food insecurity. According to the U.S. Department of Agriculture, 10.2% (13.5 million) people were food insecure in the U.S. (USDA, 2022). However, participants in this study believed that 35 - 40% of people dealt with food insecurity. This difference could be explained if USDA estimates are wrong. The USDA might underestimate the degree of food insecurity because dietary restrictions are not part of the calculation. In addition, the USDA may underestimate the issue because many people with dietary restrictions do not recognize that they are also dealing with food insecurity, despite missing meals and suffering adverse effects. Alternatively, participants' perceptions of food insecurity may be inaccurate. In this study, the majority of the participants had dietary restrictions and dealt with some form of food insecurity on campus. As a result, they may overestimate the issue based on their personal experiences. Either way, this subject matter needs additional work.

There are some limitations to this study. The sample size is small as it represents only 1.90% of the overall campus population. The result, therefore, may not be representative of the population as a whole, even if the present findings allowed an understanding of how dietary restriction could also result in food insecurity when food is affordable and accessible. In addition, the survey was not undertaken with research in mind. The survey was produced originally as part of an effort to engage FGCU's food service company. After preliminary results were examined, I decided to fully analyze the project as research. Ultimately, a follow-up study with a more developed survey should be utilized. Despite the limitation, the results of the study provide an initial understanding of dietary-restricted as well as the challenges dietary-restricted people experience that can lead to food insecurity.

Implication

At this stage of the project, I became aware that dietary restrictions can create food insecurity. To alleviate the challenge of dietary restrictions related to food insecurity, college campuses can play a significant role by ensuring reliable and healthy meal plans on campus. Considering the adverse physical and mental health effects and compromises to academic performance, it is extremely important to assess the role of dietary restrictions on food insecurity to provide quality education and assistance to ameliorate the ongoing issue.

To reduce the challenge of food insecurity, quality education should be a top priority at FGCU. Many people on campus are not familiar with dietary restrictions, such as allergies, preferences, and religious/cultural belief systems, and the effects that these restrictions can have on health and academic performance. We must, therefore, develop an education program to make people more aware of the challenge of food insecurity and dietary restrictions. For example, the creation of informational flyers in partnership with FGCU campus dining would educate people and, therefore, help to address dietary restrictions-related food insecurity.

To address this issue, I partnered with the FGCU campus dining to discuss the findings of this study and develop strategies to alleviate the prevalence of diet-related food insecurity. FGCU campus dining took the matter seriously and created on-campus dietary guides for individuals with vegan and vegetarian diets as well as allergies (Figure 5). The reason for creating the campus guides was to help individuals navigate the available meal options for those who have dietary requirements from personal choices, as well as allergens. Those dietary guides are available in all the dining locations on campus. In addition, I created a flyer to help people better un-

derstand halal and kosher diets (Figure 6). Together, these are important first steps that will further support all students, faculty, and staff at FGCU.

The goal of this study was to examine the role of dietary restrictions on food insecurity and its detrimental physical and mental health effects on the college population including students, faculty, and staff. While the results of the study were compelling, this subject matter needs additional research to future understand the prevalence of diet-related food insecurity on campuses and elsewhere. Research is also required on the necessity of intervention, such as creating more dietary guidelines and strategies to reduce dietary restrictions-related food insecurity, because the prevalence of food insecurity among college students is higher than the national average (Conrad et al., 2022). Conducting further research would be beneficial to overcome this issue not only in a particular university like FGCU, but other institutions of higher education across the nation.

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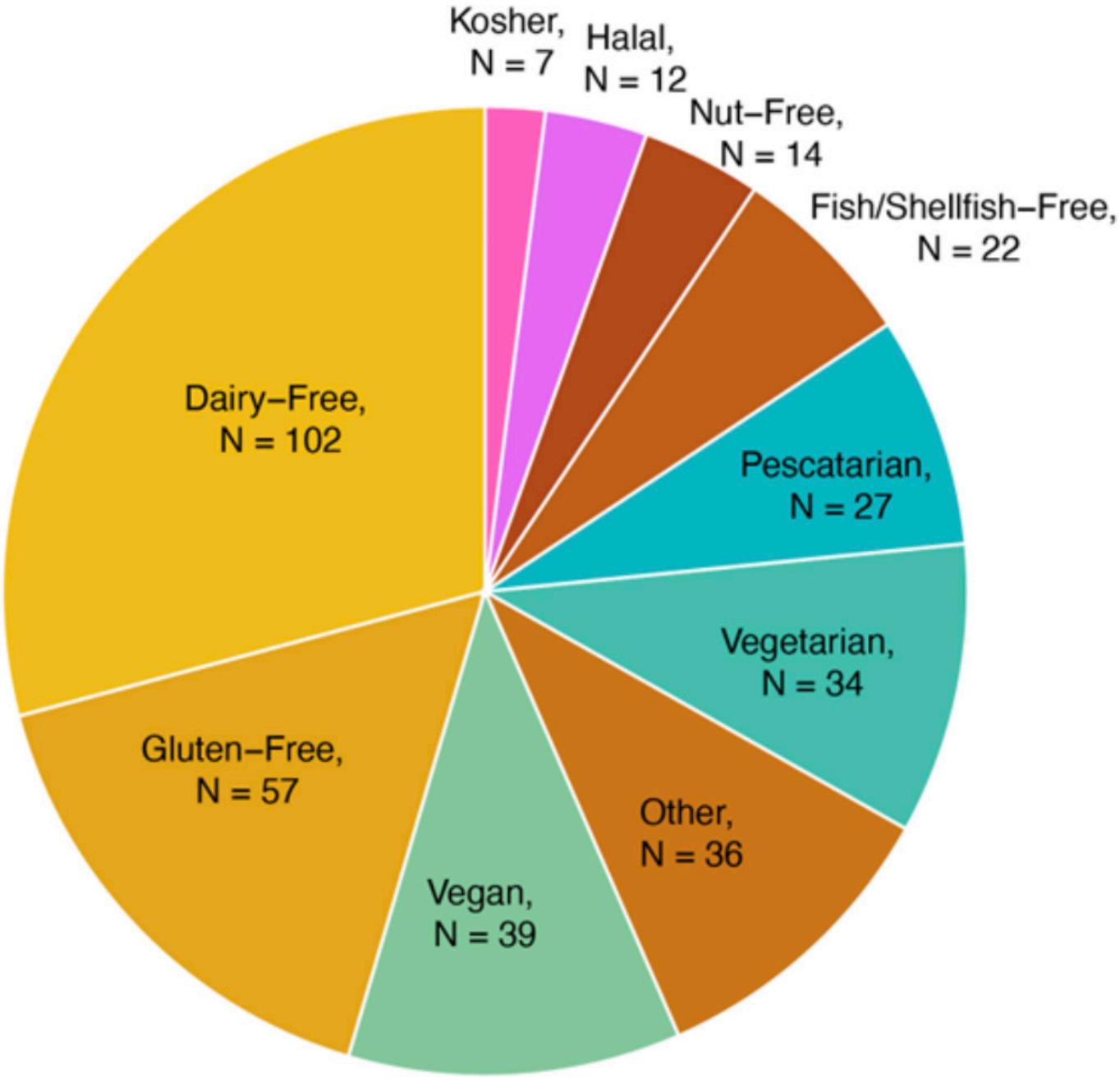

Figure 1: The dietary restrictions identified in an FGCU campus-wide survey in 2022 among students, faculty, and staff. Allergies are described as dietary restrictions that result from food intolerance (orange hues, N = 195) such as gluten-free and lactose-free. Personal preferences (teal hues, N = 100) described people who practice vegan, vegetarian, and/or pescatarian diets, and religious/cultural belief systems (pink hues, N = 19) described participants who practiced halal or kosher.
Dietary restrictions were self-diagnosed; participants could choose multiple options from the survey question

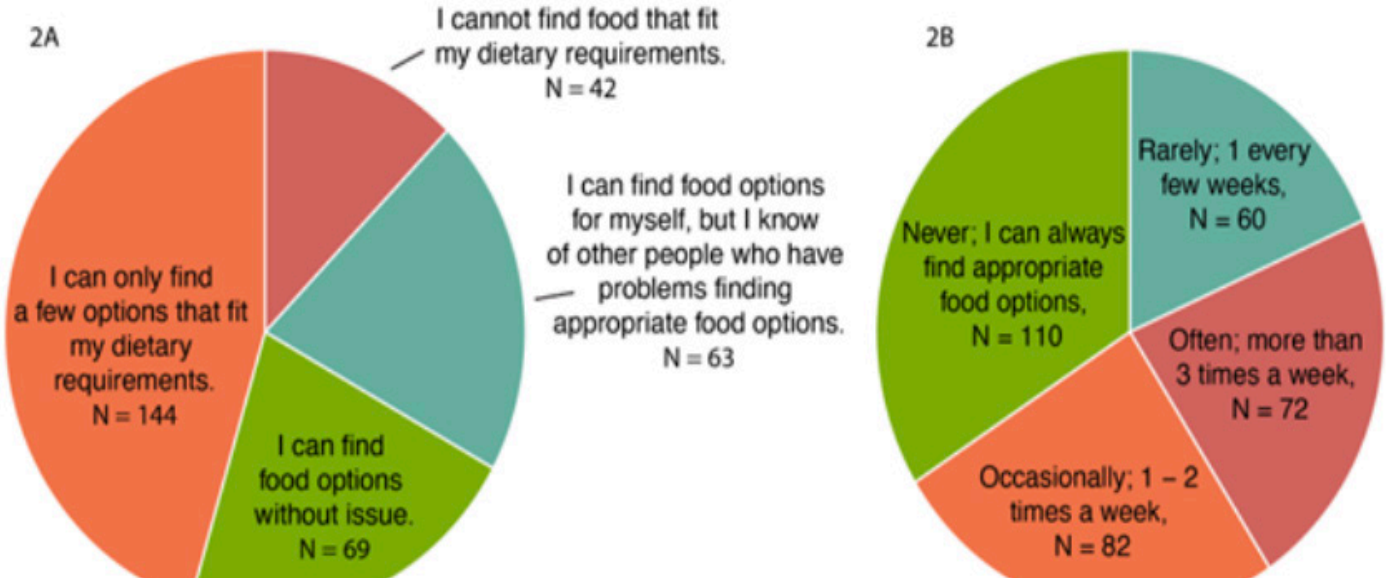

Figure 2: Figures identify participants' access to food at FGCU; 2A shows whether participants could find appropriate food and 2B shows how often participants skipped meals because of limited food options. All participants, including those with or without dietary restrictions, were included in this analysis.

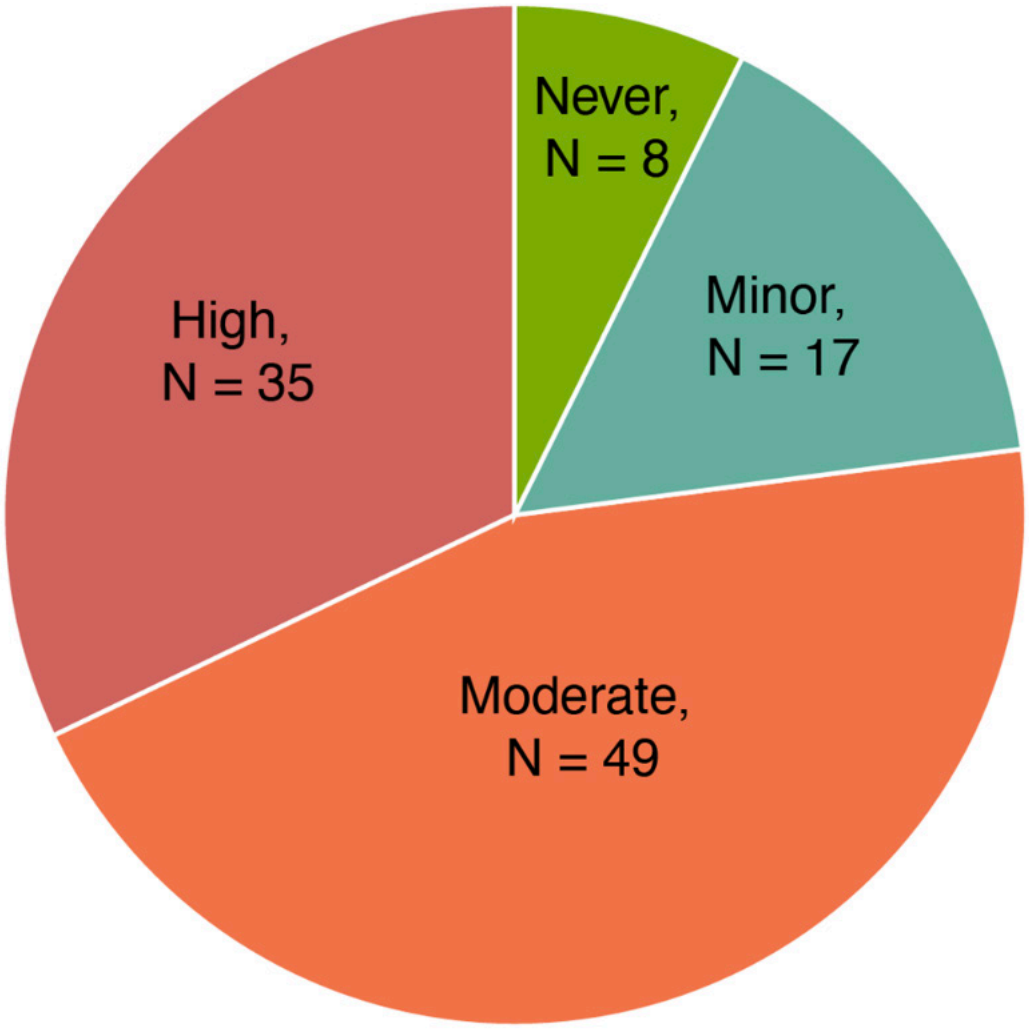

Figure 3: The level of food insecurity that respondents with dietary restrictions experienced on campus due to their dietary requirements. Participants who experienced a higher level of food security described going through physiological issues (headaches, stomachaches, and digestion problems) and mental health issues (anxiety, depression, and frustration). Participants who never experienced food insecurity did not describe any issues.

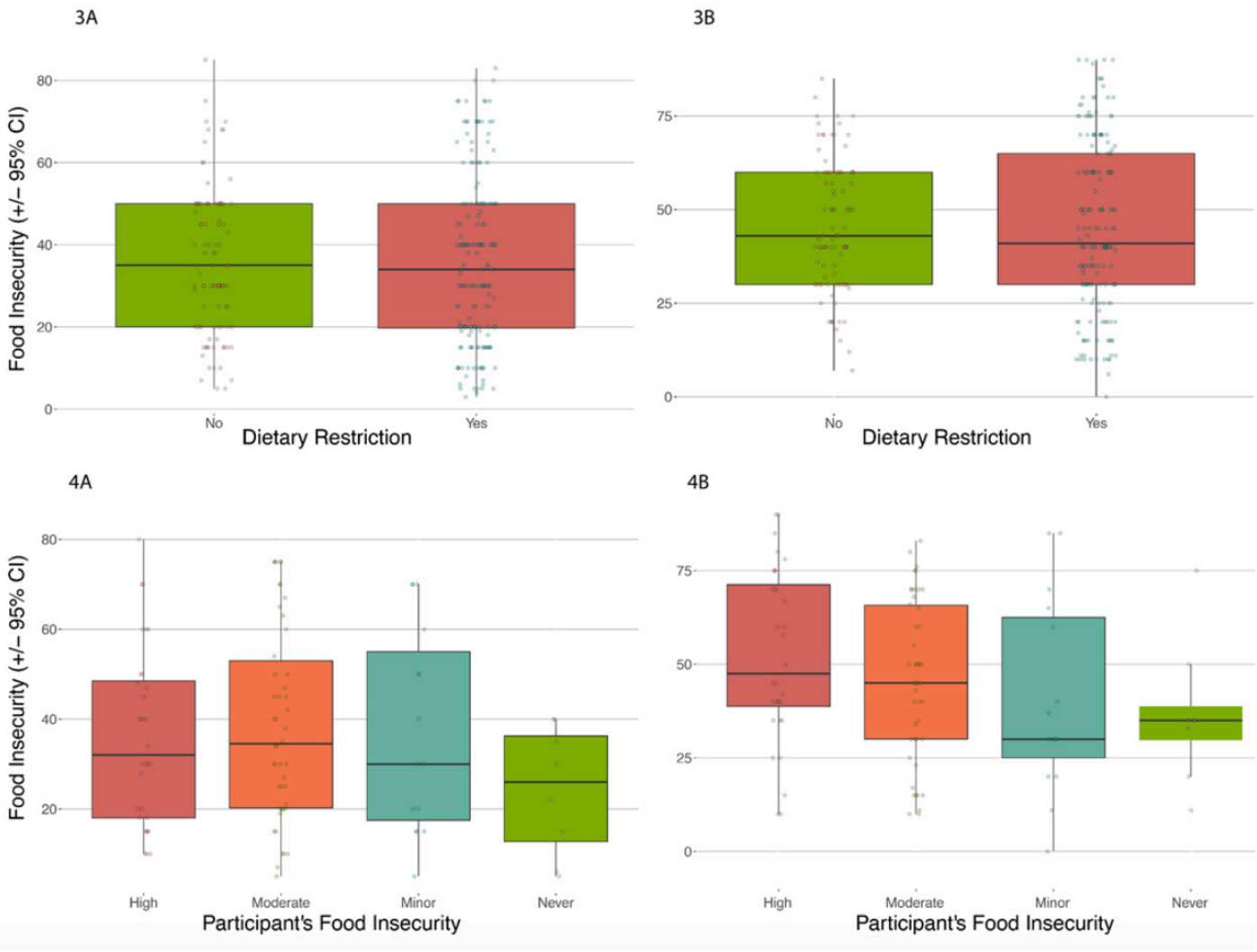

Figure 4: Figure illustrates participants' perception about the extent of food insecurity affecting people at FGCU (a) and nationally (b) relative to whether the participant experienced dietary restrictions and relative to their level of food insecurity at FGCU (c) and nationally (d).

Figure 5: An allergy guide to Florida Gulf Coast University (FGCU) that provides all the food options available for allergens in on-campus dining locations.

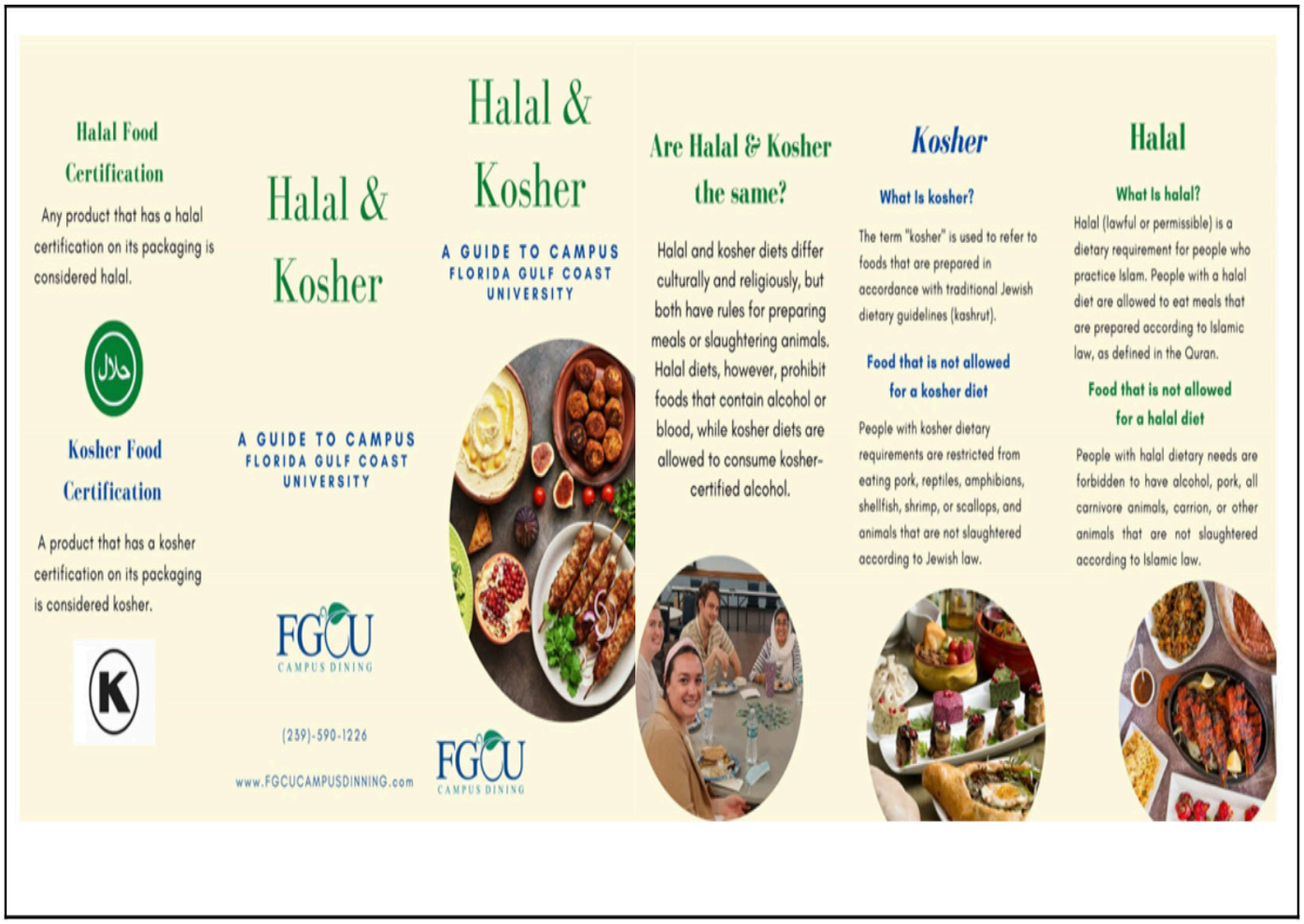

Figure 6: Educational campus guide to FGCU that provides a primary understanding of the halal and kosher dietary restrictions and the differences between these for dietary requirements.

DOI:

Appendix A

Do you have problems finding appropriate food options on campus?

- Yes, I cannot find food that fits my dietary requirements.
- Yes, but I can only find a few options that fit my dietary requirements.
- No, I can find food options without issue.
- No, I can find food options for myself, but I know of other people who have problems finding appropriate food options.

How often do you skip a meal because you can not find an appropriate dietary option?

- Often; more than 3 times a week
- Occasionally; 1 - 2 times a week
- Rarely; 1 every few weeks
- Never; I can always find appropriate food options

How does skipping a meal because of limited food options affect your ability to study, learn, and/or work?

Nationally, what percentage of people experience food insecurity issues? (Write a number between 0 to 100).

At FGCU, what percentage of people experience food insecurity issues? (Write a number between 0 and 100).

These questions will gauge your understanding about food insecurity and well-being

Is there a direct correlation between one's diet and mental well-being?

- Yes
- No
- Unsure

Is there a direct correlation between one's diet and physical well-being?

- Yes
- No
- Unsure

Name (Optional): First Name: Last Name:

Email (Optional)

Provide your name and email if you would like to learn about halal and/or future events.

A Longitudinal Examination of Obsessive-Compulsive Symptom Severity as a Predictor of Posttraumatic Stress Disorder Development

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Obsessive-compulsive disorder (OCD) and posttraumatic stress disorder (PTSD) are two conditions that greatly impact the psychological functioning of affected individuals. OCD is characterized by a repetitive cycle of obsessions and compulsions, which may cause affected individuals to feel as though they do not have control of their own mind or actions. Obsessions are unwanted and intrusive thoughts, images, or feelings; and compulsions are behaviors that an individual employs to subdue an obsessive thought or decrease feelings of distress (International OCD Foundation, 2023). PTSD arises in response to traumatic life events and is similarly characterized by intrusive memories and increased reactivity to distressing stimuli (American Psychological Association [APA], 2022). Like individuals with OCD, people with PTSD may engage in behaviors intended to suppress or avoid thoughts or feelings related to the traumatic experience (Pinciotti et al., 2022). Both PTSD and OCD are notoriously debilitating conditions that can greatly disrupt the lives of individuals affected by the disorders (APA, 2022). Additionally, both conditions are associated with significant economic and societal burdens. In a 2014 study by Hollander and colleagues, over 700 individuals with OCD completed a survey in which many individuals reported negative impacts of their symptoms on their psychosocial functioning as well as additional financial strain (Hollander et al., 2014). A 2018 study estimated the total excess economic burden of PTSD in the U.S. to be $232.2 billion, corresponding to $19,630 in costs annually per individual with PTSD (Davis et al., 2018). OCD and PTSD affect people of all genders, ages, races, ethnicities, and backgrounds. Approximately 2-3% of the population is affected by OCD (Sasson & Zohar, 1996), equating to 1 in 100 adults and 1 in 200 children in the U.S. (International OCD foundation, 2023). It is estimated that 5% of adults in the U.S. have PTSD (U.S. Department of Veteran Affairs, 2023). Research also indicates high comorbidity of OCD and PTSD, with rates of co-occurrence ranging from 19% to 41% (Pinciotti et al., 2022). It is estimated that over half of individuals diagnosed with OCD have experienced at least one potentially traumatic event (Pinciotti et al., 2022). The 12-month prevalence for OCD in individuals with PTSD is estimated to be about 30% (Dykshoorn, 2014), which is significantly higher than the 1.1%-1.8% 12-month prevalence of OCD in the general population (Dykshoorn, 2014).

Existing research on OCD and PTSD comorbidity has largely examined the role of trauma exposure in the development of obsessive compulsive (OC) symptoms. More specifically, several studies have investigated how the development of certain compulsions can be linked to the type of trauma experienced. A series of case studies revealed that several patients struggling with compulsive checking behaviors had experienced or witnessed a traumatic death before the onset of their symptoms (Subramanian and Mayur, 2018). Similarly, Badour and colleagues found that contamination-based OC symptoms, such as hand washing, showering, and avoidance rituals, are significantly correlated to feelings of disgust following an interpersonal trauma such as a physical or sexual assault (Badour et al., 2012). It has been theorized that compulsions are adopted in an attempt to manage trauma-related distress, but become overgeneralized to other life experiences, and the relief one feels when engaging in compulsions reinforces their use (Sasson et al., 2004; Dykshoorn, 2014). Taken together, literature investigating the comorbidity of OCD and PTSD converges to suggest that exposure to a traumatic stressor may result in compulsive coping behaviors, which serve to maintain both OC symptoms and posttraumatic stress symptoms (PTSS). Additionally, particular trauma types may confer risk for the development of certain compulsions. However, no research to date has considered whether pre-existing vulnerability to OC symptoms, such as a tendency towards catastrophic appraisals of events or propensity to engage in avoidant or neutralizing behaviors,

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may contribute to the onset or maintenance of PTSS following a traumatic event, or following particular types of traumatic events.

While it is well-established that trauma type and PTSS severity interact to predict OC symptom development, it is also plausible that OC symptoms and trauma type interact to predict PTSS severity. Traumas of different types are known to confer differential risk for PTSS, and interpersonal traumas, such as physical and sexual assault, are associated with more severe PTSS and higher suicide risk among PTSD patients (Thomas, Owens, and Keller, 2021; Yoo et al., 2018). This trend has also been observed in a sample of patients with treatment-resistant OCD; over 39% of the sample met criteria for PTSD, with interpersonal trauma being more predictive of PTSD severity than non-interpersonal trauma (Gurshuny, 2007). Additionally, interpersonal traumas, as compared to non-interpersonal traumas, are associated with elevated feelings of disgust, which share significant associations with PTSS (Badour and Feldner, 2014) and certain contamination-based OC symptoms (Badour et al., 2012). Furthermore, individual differences in disgust propensity and sensitivity appear to be related to PTSS severity (Badour and Feldner, 2014). Collectively, literature suggests that the type of trauma experienced may be predictive of the development of trauma-related compulsions and PTSS severity. More specifically, trauma types that evoke feelings of disgust, such as interpersonal traumas, may result in specific compulsive behaviors or changes in cognitions that may make an individual more likely to develop PTSS. However, an empirical study is required to test this claim.

OC symptoms may also confer risk for the development of PTSS by dampening distress tolerance. Distress tolerance is defined as the perceived capacity to withstand negative emotion (Zvolensky et al., 2010). Distress tolerance has been identified as a transdiagnostic cognitive-behavioral risk and maintenance factor for an abundance of psychological symptoms and disorders, including PTSD and OCD (Akbari, 2021). Low distress tolerance has been associated with exacerbation of OC symptoms, as a longitudinal investigation conducted in 2013 revealed that lower baseline distress tolerance predicted a higher number of daily obsessions (Macatee et al., 2013). Interestingly, this relationship was specifically observed in individuals with a higher frequency of negative life events (Macatee et al., 2013). Poor distress tolerance has also been shown to predict obsessions even when controlling for other highly relevant variables such as depression, anxiety, anxiety sensitivity, and obsessive beliefs (Cougle et al., 2011). A reciprocal relationship has also been observed; a 2011 study by Cougle and colleagues suggested that individuals with obsessive tendencies may be more likely to experience low tolerance for negative emotions. Participants in a non-clinical sample who reported elevated obsessions demonstrated poorer distress tolerance while viewing sad films (Cougle et al., 2011). Research indicates that low distress tolerance is also associated with elevated PTSS and may increase the risk for development of PTSD following exposure to a traumatic event, due to the diminished ability to tolerate the emotional impact of the trauma (Akbari et al., 2021). Taken together, these findings indicate that OC symptoms are associated with low distress tolerance, and low distress tolerance results in greater PTSS severity post-trauma. However, it remains unclear whether distress tolerance mediates the relationship between existing OC symptoms and the development of PTSS over time.

In sum, existing literature has identified high rates of comorbidity between OCD and PTSD. The two disorders share symptoms such as intrusive thoughts and resulting avoidance behaviors. Trauma type plays an important role in the development of both OC symptoms and PTSS. Moreover, OC symptoms are associated with low distress tolerance, and low distress tolerance is predictive of PTSS development. While much of the literature points to trauma exposure as an etiologic factor in the development of OC symptoms, research has yet to examine whether vulnerability to OC symptoms predisposes a trauma-exposed individual to the development of PTSS. The present study aims to address this gap in the literature by investigating whether OC symptoms predict PTSS severity longitudinally in a dataset collected from treatment-seeking community members over the course of 3-5 years. Additionally, the study will investigate whether the type of trauma experienced interacts with OC symptoms to predict PTSS severity over time, and whether distress tolerance mediates

this longitudinal relationship.

Hypothesis 1

We hypothesize that baseline OC symptoms will significantly predict PTSS at long-term follow-up, after controlling for covariates and other known risk factors for PTSS.

Hypothesis 2

Our second hypothesis is exploratory in nature and aims to investigate how trauma type plays a role in the findings of our first hypothesis. We hypothesize a significant interaction between baseline OC symptoms and trauma type, such that the relationship between baseline OC symptoms and PTSS at long-term follow-up will be stronger for individuals who experienced an interpersonal trauma than for those who experienced a non-interpersonal trauma.

Hypothesis 3

Our third hypothesis investigates how distress tolerance interacts with the relationship between obsessive-compulsive symptoms and posttraumatic stress symptoms. We hypothesize that distress tolerance reported at three-month follow-up will mediate the longitudinal relationship between baseline OC symptoms and PTSS at long-term follow-up.

Methods

Participants

The current study included a sample of N = 92 individuals, originally recruited for a larger randomized controlled trial of four web-based interventions for anxiety and mood symptoms (N = 303). For the original study, eligible participants were required to be at least 18 years of age, fluent in English, and report elevations on self-report measures assessing suicide risk (i.e., scores at least 1 SD greater than the community average on the Anxiety Sensitivity Index-3 [ASI-3], Taylor et al., 2007; or 1 SD greater than the community average on the perceived burdensomeness or thwarted belongingness scale of the Interpersonal Needs Questionnaire-Revised [INQ-R], Van Orden et al., 2012). Participants with unmedicated bipolar or psychotic disorders, imminent suicidal intent, or an unstable medication schedule were excluded from the original study to avoid disruptions to study participation. Eligible participants in the current study reported experiencing at least one traumatic event in their lifetime. Of the participants included in the current study, forty-eight identified as female (52.2%) and forty-four identified as male (47.8)%). Participants' ages ranged from 18 to 79 (M=38.80, SD=16.35). Approximately half of participants identified as Caucasian/White (55.4%), followed by African American/Black (32.6%), Asian (2.2%), and Other (9%). Most participants identified as Non-Hispanic (90.2%).

Materials

Posttraumatic Diagnostic Scale (PSD; Foa et al., 1997)

The PDS-5 is a 24-item self-report that assesses PTSD symptom presence and severity. The current study used a checklist of the first 12 items to assess whether participants had been exposed to any of the listed traumatic events such as natural disasters, combat, life-threatening illness, etc.

Posttraumatic Stress Disorder Checklist – Civilian Version (PCL-C; Weathers et al., 1993)

The PCL-C is a 17-item self-report measure used to assess DSM-IV criteria for PTSD. Participants were asked to rate on a 5-point Likert scale (1 = Not at all to 5 = Extremely) the level at which they have been bothered by various problems in the past month (e.g. disturbing memories and dreams, strong negative beliefs and feelings, irritable behavior, risk-taking, etc.). In the present study, Cronbach's alpha for the PCL-C was 0.93, indicating excellent internal consistency.

Distress Tolerance Scale (DTS; Simons and Gaher, 2005)

The DTS is a 15-time self-report measure. Participants were asked to rate on a 5-point Likert-style scale (1 = strongly disagree to 5 = strongly agree) to what degree they believe they can withstand emotional distress. In the current study, Cronbach's alpha for the DTS was 0.90, indicating excellent internal consistency.

Dimensional Obsessive-Compulsive Scale (DOCS; Abramowitz et al., 2010)

The DOCS is a 20-item self-report survey that

assesses the severity of OCD symptoms. Participants were asked to report on a 5-point Likert-type scale the frequency and extent to which they experience OCD symptom dimensions (contamination, responsibility for harm and mistakes, symmetry/ordering, and unacceptable thoughts). In this study, Cronbach's alpha for the DOCS was 0.96, indicating excellent internal consistency.

Procedure

Prior to data collection, all research procedures were approved by the local institutional review board (IRB) (protocol number 2013.11270 for baseline to 1-year follow-up and 2019.29708 for long-term follow-up). Participants were recruited from the surrounding community using newspaper ads, flyers, and media outlets. Before their baseline appointment those interested in the study completed a telephone screener to determine eligibility. During the baseline visit participants provided informed consent, completed a series of self-report questionnaires, and a semi-structured clinical interview. Each participant was randomly assigned to one of four intervention conditions included in the original study, an anxiety sensitivity (AS) intervention, a mood-focused condition, a combined AS and mood-focused condition, or a repeated contact control. Each treatment was administered once a week over a span of three weeks. The first session entailed computerized psychoeducation and cognitive bias modification and the second and third sessions included just cognitive bias modification. For the control condition, participants were assessed for suicide risk at each session. Treatment condition was included as a covariate in the data analyses. Self-report measures were completed by participants at baseline, 3-month follow-up, and long-term follow-up (approximately 3-5 years after the baseline appointment).

Results

Preliminary Analyses

SPSS software (version 28.0) was used for all data processing and statistical analyses. Study variables were examined for skewness and kurtosis, and all variables fell within an acceptable range. Observed outliers present in data were brought to the fence. Item-total correlations and Cronbach's alpha were used to determine the reliability and internal consistency of the self-report questionnaires. As expected, OC symptoms and PTSS were significantly correlated at all time points. Means, standard deviations, and zero-order correlations for the primary study variables are displayed in Table 1.

Table 1

TItle: Person correlations, means, and standard deviations for main study variables

	1	2	3	4	5	6	*M (SD)*
1. BL DOCS	-	-	-	-	-	-	22.49 (16.32)
2. BL PCL-C	.57**	-	-	-	-	-	46.35 (16.22)
3. M3 DOCS	.73**	.52**	-	-	-	-	14.80 (14.19)
4. M3 PCL-C	.48**	.75**	.71**	-	-	-	36.06 (17.30)
5. LTFU DOCS	.69**	.45**	.73**	.46**	-	-	13.13 (11.76)
6. LTFU PCL-C	.48**	.60**	.46**	.63**	.54**	-	24.49 (20.09)

Note. BL = Baseline, M3 = Month 3 follow-up, LTFU = long-term follow-up; DOCS = Dimensional Obsessive-Compulsive Scale; PCL-C = Posttraumatic Stress Disorder Checklist; **p < .01.

Primary Analyses

First, hierarchical linear regression was conducted to determine whether baseline OC symptoms significantly predicted PTSS at long-term follow-up, over and above the contributions of baseline PTSS, treatment condition, and trauma load. Refer to Table 2 for full results. At step 1, baseline PTSS (t=6.74, B=0.72, p<.001) was positively associated with long-term follow-up PTSS, but treatment condition (t=1.40, B=2.17, p=.167) and trauma load (t=1.27, B=1.05, p=.208) were not. At step 2, baseline OC symptoms (t=2.03, B=0.25, p=.046) were positively associated with long-term follow-up PTSS. These results indicate that baseline OC symptoms predicted long-term follow-up PTSS over and above the variance explained by baseline PTSS, treatment condition, and trauma load.

Table 2

Title: Hierarchal linear regression examining variance explained in long-term follow up PTSD symptoms

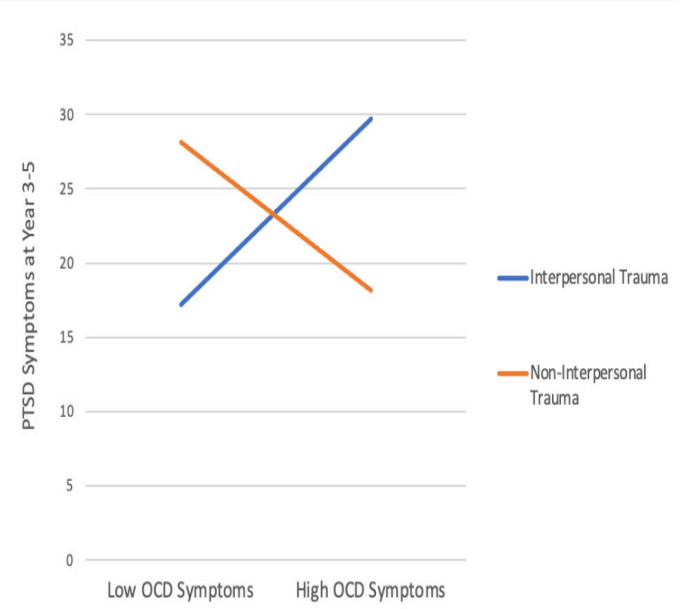
Step	Predictor	*t*	*B*	*P*	R^2	*F*	*p*
1		-	-	-	0.39	19.00	<.001
	BL PCL-C Total	6.74	0.72	<.001	-	-	-
	Treatment Condition	1.40	2.17	.167	-	-	-
	Trauma Load	1.27	1.05	.210	-	-	-
2		-	-	-	0.42	15.78	<.001
	BL DOCS	2.03	0.25	.046	-	-	-

Note. BL = Baseline, M3 = Month 3 follow-up, LTFU = long-term follow-up; DOCS = Dimensional Obsessive-Compulsive Scale; PCL-C = Posttraumatic Stress Disorder Checklist.

Next, a linear regression was conducted to examine whether OC symptom severity and type of trauma experienced (interpersonal or non-interpersonal) interacted to predict long-term follow-up PTSS. The baseline OC symptom severity and trauma type variables were mean-centered and multiplied to create the interaction term, and all three variables were included in the regression model, along with the covariates of baseline PTSS, treatment condition, and trauma load. Results indicated a significant interaction between baseline OC symptoms and trauma type when predicting long-term follow-up PTSS (B=.69, p=.009), while also covarying for baseline PTSS (B=.56, p<.001), treatment condition (B=2.53, p=.097), and trauma load (B=1.14, p=.198).

To probe the interaction, two simple slope regressions were conducted. The two simple slope regressions specifically examined the conditional effects of baseline OC symptoms on long-term follow-up PTSS in participants who reported a history of interpersonal trauma as well as those who reported experiences of non-interpersonal trauma (e.g., one standard deviation above and below the mean on the mean-centered trauma type variable). Findings are displayed in Figure 1. Results showed that the effect of OC symptoms on long-term follow-up PTSS was significant among individuals who reported experiencing interpersonal trauma (B = .38, p = .004). Among individuals who reported experiencing non-interpersonal trauma, baseline OC symptoms did not significantly predict long-term follow-up PTSS (B = -.31, p = .201). Taken together, baseline OC symptom severity had a greater effect on the development or maintenance of PTSS for individuals who experienced interpersonal trauma, as compared to those who experienced non-interpersonal trauma.

Figure 1



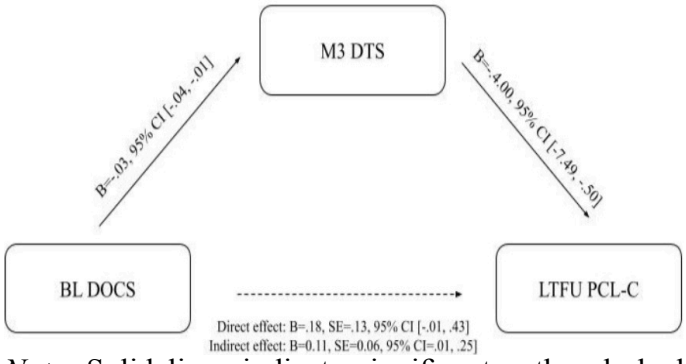
Title: Trauma type as a moderator of the longitudinal relationship between OCD and PTSD symptom severity

Exploratory Analyses

Distress tolerance reported at month 3 was examined as a potential mediator of the relationship between baseline OC symptoms and long-term follow-up PTSS. Findings are illustrated in Figure 2. Results showed that baseline OC symptoms significantly predicted month 3 distress tolerance, and month 3 distress tolerance significantly predicted long-term follow-up PTSS. When accounting for month 3 distress tolerance in the model, there was no longer a significant direct effect of baseline OC symptoms on long-term follow-up PTSS, indicating that month 3 distress tolerance fully mediated the relationship between baseline OC symptoms and long-term follow-up PTSS.

Figure 2

Title: Month 3 distress tolerance as a mediator of the relationship between baseline OCD symptoms and long-term follow-up PTSS



Note. Solid lines indicate significant paths; dashed lines indicate non-significant paths; BL = Baseline, M3 = Month 3 follow-up, LTFU = long-term follow-up; DOCS = Dimensional Obsessive-Compulsive Scale; DTS = Distress Tolerance Scale; PCL-C = Posttraumatic Stress Disorder Checklist.

Discussion

The findings from this study provide novel insight into the relationship between OCD and PTSD. Prior research has found that trauma exposure confers risk for OC symptom development (Badour et al., 2012; Subramanian & Mayur, 2018), possibly as a result of individuals developing compulsive rituals to manage their trauma-related distress (Sasson et al., 2004; Dykshoorn, 2014). The present study is the first to examine whether OC symptom severity might confer vulnerability for later PTSS development or maintenance. Consistent with our first hypothesis, baseline OC symptom severity significantly predicted PTSS at long-term follow-up after accounting for the effects of baseline PTSS, trauma load, and treatment condition. These findings indicate that OC-related symptomatology may represent a risk factor for trauma-related symptoms, or a barrier to recovery from traumatic stress over time.

In line with our second hypothesis, a significant interaction was observed between baseline OC symptoms and trauma type when predicting long-term follow-up PTSS severity. More specifically, the relationship between baseline OC symptom severity and long-term follow-up PTSS was significant for individuals who reported interpersonal trauma exposure, and not significant for individuals who reported non-interpersonal trauma exposure. These findings are consistent with previous research suggesting that interpersonal traumas are associated with more severe PTSS among individuals with treatment-resistant OCD (Gurshuny, 2007). These results also dovetail with previous research indicating that interpersonal traumas are associated with higher disgust, and that disgust sensitivity is positively correlated with PTSS (Badour and Feldner, 2014). Interestingly, we also observed a negative, but nonsignificant, relationship between baseline OC symptom severity and long-term follow-up PTSS among individuals with non-interpersonal trauma exposure, such that higher baseline OC symptom severity was associated with lower follow-up PTSS in this group. It may be possible that the individuals who experienced non-interpersonal traumas in the present study were less vulnerable to developing PTSS or were better able to recover from traumatic stress over time, leading to a negative relationship between OC symptoms and PTSS severity over time. However, further research is needed to better understand the relationship between non-interpersonal trauma and OC symptom severity on the development or maintenance of PTSS.

Consistent with our third hypothesis, distress tolerance reported at the 3-month follow-up fully mediated the relationship between baseline OC symptoms and long-term follow-up PTSS. These findings align with previous research suggesting that distress tolerance plays a significant role in the development of both OCD and PTSD (Macatee et al., 2013; Vujanovic and Zegel, 2020; Akbari et al., 2021). The results of the present study further the existing literature by suggesting that low distress tolerance may be the mechanism by which OC symptoms and PTSS influence each other over time, and posit that individuals with high OC symptom severity and poor distress tolerance may be particularly vulnerable to the effects of PTSS. These findings have important clinical implications as well, highlighting the importance of intervening in low distress tolerance in order to prevent the development of one or both disorders.

The findings of the current study must be considered along with possible limitations. First, participants in the present study were recruited from a previous study for which they were randomly assigned to treatment conditions. Although the effect of the treatments received by participants were controlled for in our statistical analyses, it is possible that the treatment conditions assigned to participants affected their reports of symptoms experienced at follow-up

appointments. Second, the data used in this study was originally collected in a study conducted in 2012, and therefore some methodologies used in the original study may be outdated. Specifically, the posttraumatic stress disorder checklist was used to assess for PTSD criteria according to the DSM-4, which has significant differences from the DSM-5 in the assessment of PTSD. Due to the use of archival data, the assessment of symptomatology used to collect the data presented in this study may not accurately reflect the assessment procedures of modern studies that use DSM-5 criteria. Third, it should be considered that the original study experienced a significant amount of attrition over time as 92 of the original 303 participants completed the study in entirety. Considering approximately 1/3 of participants who initially completed the baseline visit also participated in each follow-up visit, a substantial portion of participant data was excluded from the final results. Consequently, our findings may not fully represent individuals who had to discontinue their participation due to various reasons such as severe symptomatology and other external factors.

Despite the limitations present, the results of this study provide novel findings about the relationship between OCD and PTSD. Our results demonstrated that OC symptom severity significantly predicts later PTSS, over and above baseline PTSS and trauma load. Additionally, it was found that baseline OC symptoms are more predictive of later PTSS among individuals who experienced interpersonal traumas, as compared to those with non-interpersonal traumatic experiences. Furthermore, distress tolerance was found to fully mediate the relationship observed between OC symptoms and later PTSS, suggesting that distress tolerance may be an important mechanism of OCD-PTSD comorbidity. Taken together, the results of this study advance our understanding of the relationship between OCD and PTSD symptoms. However, future research should replicate the current study in order to address the limitations present. Specifically, studies may aim to utilize more recent measures that employ criteria in the DSM-5, as well as collect original data to mitigate potential confounding factors present in archival data, such as the influence of participant treatment and unrelated assessment methodology. Additionally, future studies should aim to address the issue of attrition over time by increasing retention throughout a replicated longitudinal study. Moreover, further research is needed to identify other potential mechanisms of OCD and PTSD comorbidity, in order to further elucidate our understanding of these two disorders and inform the development of novel treatment approaches.

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