

Research Outreach Interdisciplinary Activity to classify olive oil blends integrating multicolor imaging, image processing, and machine learning

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Abstract

This outreach undergraduate research project presents a low-cost method to distinguish the quality of different olive oils. The proposed method is based on an indirect measurement of the chlorophyll molecules present when a green laser diode illuminates the oil sample. Oil blends can be classified into five classes (no olive oil, light olive oil, medium olive oil, olive oil, and extra virgin olive oil) by quantifying the ratio of the red channel versus the green channel along the laser illumination path from a color image. After labeling each oil blend, a convolutional neural network has been implemented and trained to automatically classify oil blends from a color image. The trained convolutional neural network has an accuracy of 90% in identifying and categorizing oil blends. This undergraduate research project introduces students to an interdisciplinary application requiring the combination of optical spectroscopy (i.e., multicolor imaging), image processing, and machine learning. In addition, due to the simplicity of the optical apparatus and computational analysis, high school students could implement and validate their own cost-effective oil-quality classification device.

Keywords:

multicolor imaging, RGB channel split, intensity average, convolutional neural network

Introduction

Olive oil, the natural oil extracted from the fruit of the olive tree, is the main characteristic fat component in the Mediterranean diet, accounting for up to 17-25% of the daily calories. Whereas the American diet is based on meals with a lot of red meat, fast food, fried food, and carbohydrates, the Mediterranean Diet, declared as an Intangible Heritage of Humanity in 2010 by UNESCO, includes a lot of vegetables, fruits, fish, cheese, wine and extra virgin olive oil, which is the central ingredient in the Mediterranean's food pyramid. In the Mediterranean diet, olive oil is used daily in salad dressing, steak, fried food, and even desserts. There are multiple benefits of using olive oil. For example, approximately 73% of the total olive oil content is oleic acid, a monounsaturated fat. Reported studies have shown that oleic oil reduces inflammation and may even have beneficial effects on some cancer-related genes [1-4]. Monounsaturated fats present high resistance to high heat, making extra virgin olive oil a healthy cooking choice for frying. Apart from the fatty acids in olive oil, extra virgin oil is quite nutritious, containing significant antioxidants and modest amounts of vitamins E and K. The antioxidants reduce the risk of chronic diseases [5,6], lower inflammation, and protect blood cholesterol from oxidation. The latter two benefits may lower the risk of heart diseases in several ways [7,8]. For example, olive oil improves blood vessels' flow, helping prevent excessive blood clotting. Also, olive oil reduces blood pressure; hypertensive (e.g., high blood pressure) condition is one of the strongest risk factor for heart disease and premature death. In addition, several studies have been investigated the relationships between olive oil consumption and stroke risk [9,10], showing that people who consume olive oil have a lower risk of stroke. Finally, some pilot studies have shown olive oil may fight Alzheimer's disease [11,12] and cancer cells [13,14], as well as reduce type 2 diabetes [15-17].

Thanks to the several health benefits of extra virgin olive oil, the global olive oil market is expected to grow from \$13.77 billion in 2022 to \$17.79 billion by 2029 [18]. The high demand for extra virgin olive oil has increased the commercialization of fraudulent olive oil (e.g., blends of virgin olive oil with refined olive oil and/or other vegetable oils), requiring external methods to detect adulterated olive oil. The detection of olive oil adulteration is quite

complicated, involving the combination of multiple tests to assess if a blend is adulterated or not. Chromatography/mass spectrometry and spectroscopy are two of the most common methods to determine olive oil authenticity and identity of the adulterants [19-21]. These methods enable us to evaluate the olive oil authenticity and the existence of adulterants based on the determination of free acidity, peroxide value, UV extinction, fatty acid composition, sterol composition, triglyceride composition, wax content, and steroidal hydrocarbons. Alternatively, the DNA analysis of olive using polymerase chain reaction (PCR) can also inform about the olive oil quality [22].

Despite the success of these methods in characterizing olive oil and identifying extra virgin olive oils from fraudulent olive oil blends, they present two major drawbacks: (1) their high price and (2) lack of accessibility among the broad community. In addition, some of these methods, including the PCR-based technique, require some sample preparation to assess the olive oil quality. This outreach research activity presents a low-cost method to distinguish olive oil blends of different quality from an RGB image. The proposed method is based on a quantitative measurement of the autofluorescent signal emitted by the chlorophyll molecules present when a green laser diode illuminates the oil sample. We have identified five different oil blends: no olive oil, light olive oil, medium olive oil, olive oil, and extra virgin olive oil. The advantages of the proposed method are that there is no sample preparation, and the response is quite fast, being instantaneous if one trains a convolutional neural network to classify oil blends from an RGB image automatically. We believe this undergraduate research project encourages translational STEM education research, exposing students to an interdisciplinary research project with knowledge in optical spectroscopy (i.e., multicolor imaging), image processing, and machine learning. In addition, hands-on activities have been demonstrated as an excellent strategy for increasing student engagement, motivation, and engagement [23-25]. Finally, due to the simplicity of the optical apparatus and computational analysis, any person worldwide could implement and validate their own cost-effective oil-quality classification device at home, having a broad impact component within any community.

The paper is organized as follows. In Section 2, we describe the methodology used to classify the quality of oil blends integrating

spectral imaging and image processing. Section 3 is devoted to evaluating the performance of a machine learning model to develop a low-cost oil-quality classification. Finally, in Section 4, we summarize the achievements of this undergraduate research. Acronyms used in this paper are listed in Table 1.

Table 1: List of Acronyms

<i>Acronym</i>	<i>Full Name</i>
<i>ID</i>	<i>One Dimension</i>
<i>CNN</i>	<i>Convolution Neural Network</i>
<i>EVO</i>	<i>Extra Virgin Olive Oil</i>
<i>LO</i>	<i>Light Olive Oil</i>
<i>MO</i>	<i>Medium Olive Oil</i>
<i>NO</i>	<i>No Olive Oil</i>
<i>OO</i>	<i>Olive Oil</i>
<i>PCF</i>	<i>Polymerase Chain Reaction</i>
<i>RGB</i>	<i>Red/Green/Blue</i>
<i>STEM</i>	<i>Science Technology Engineering Mathematics</i>

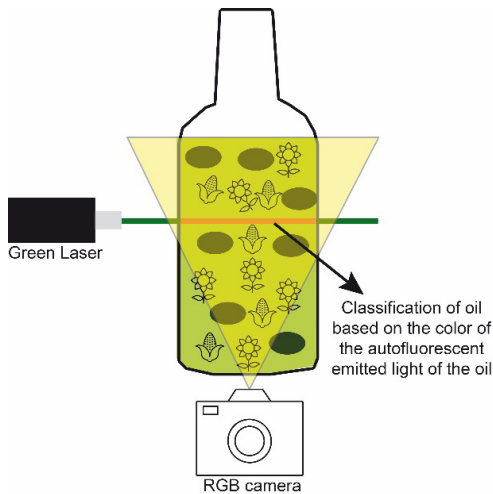


Fig. 1. Scheme of the low-cost imaging system to measure different oil quality

Classification of olive oil based on multicolor imaging

This outreach research project is based on the imaging/sensing of chlorophyll molecules within oil blends. Chlorophyll molecules are autofluorescent molecules that emit light at a higher wavelength when they are excited by light at a particular wavelength. For example, when oil blends are excited by a green illumination beam, the chlorophyll molecules emit light within the red wavelength. Vegetable oils contain varying amounts of chlorophyll molecules and emit light at different color and intensity/power. The higher the number of chlorophyll molecules, the higher the quality of the olive oil blend and the more intense the red light is perceived. We propose to classify the olive oil by indirectly measuring the amount of chlorophyll molecules. In other words, olive oil blends are placed on a glass vessel and are illuminated by a round beam of approximately 4 mm emerging from a green laser diode (CPS532, Thorlabs). The wavelength and power of the green beam are 532 nm and 4.5 mW, respectively. We record the autofluorescent signal by acquiring the RGB images of 50 oil blends using a smartphone camera. We used an adjustable laser stand to ensure the illumination height remains invariant in all recorded images.

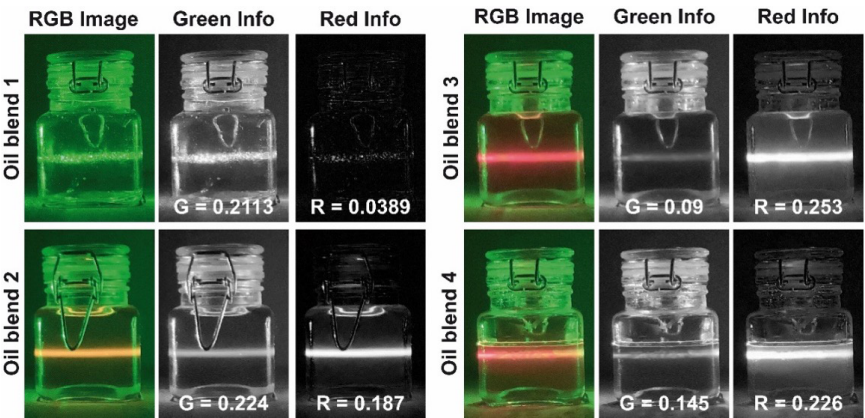


Fig. 2. Spectral decomposition of four oil blends.

As mentioned earlier, the olive-oil molecules are fluorescent molecules, emitting signal within the red wavelength spectrum when they are illuminated with green light. Figure 2 shows the experimental RGB images of four oil blends using the proposed low-cost device (Figure 1). For each RGB image, we have decomposed the color image into the three different channels. Figure 2 shows the corresponding green and red channels for each color image. Clearly, the content on both green and red channels changes for different oil blends. In particular, the red channel has more information when the concentration of olive oil particles in the oil blend is higher. We have estimated the information on both green and red channels by normalizing the mean intensity values within the laser illumination area for each channel. These values are shown in Figure 2.

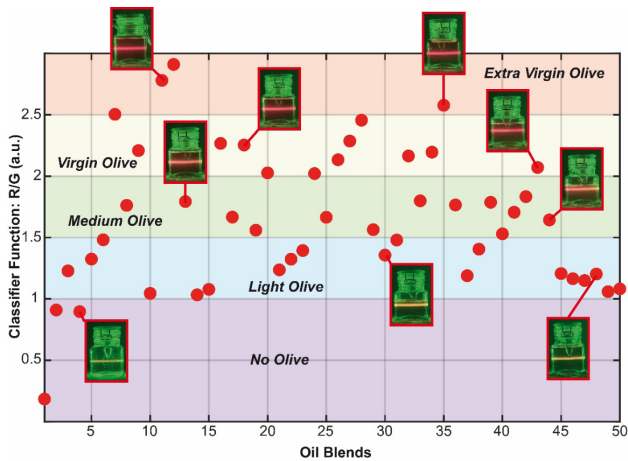


Fig. 3. Classification of different oil blends based on the ratio of the normalized mean intensity values between the red (R) and green (G) channels.

As a classifier function to discriminate the quality of the oil blend, we have used the ratio of the normalized mean intensity values between the red and green channels (e.g., R/G). Figure 3 plots this ratio for the fifty tested oil blends. Based on this ratio, we have classified oil blends as: ‘No Olive Oil’ if $R/G < 1$; ‘Light Olive Oil’ if $1 \leq R/G < 1.5$; ‘Medium Olive Oil’ if $1.5 \leq R/G < 2$; ‘Olive Oil’ if $2 \leq R/G < 2.5$; and ‘Extra Virgin Olive Oil’ if $R/G \geq 2.5$.

Automatic classification of olive oil quality by training a CNN model

This outreach research project combines spectral imaging and machine learning to develop a low-cost oil-quality classification device. After labeling the RGB images using a proposed classifier function, explained in Section 2, we have used the labeled dataset to train a Convolutional Neural Network (CNN). Figure 4 shows the architecture of the proposed CNN, which consists of two convolutional layers, two max-pooling layers, a flattening layer, and a dense layer. The convolution layer acts as a filter and extracts features from the RGB input image. Feature extraction is provided by creating a filter of some size (we use a 3×3 filter in our CNN model) and performing an element-wise multiplication starting from the top left corner of the image. Then, the values are summed up to obtain a pixel value, which is stored in a new matrix. In our CNN model, the convolutional layer has a size of 32, meaning that we have used 32 randomly generated filters to extract 32 feature matrices. After applying convolutions, the newly-generated matrices undergo max pooling. Max pooling is used to reduce the image size while maintaining features of high importance. This step is performed by selecting the maximum value from the matrix of a specified size. For example, we have used a 2×2 matrix in our model. After max pooling, the matrices go through another layer of convolution and max pooling to improve the accuracy of the CNN, see Fig. 4. Next, the generated matrices go through a flattened layer, which converts the multi-dimensional matrix to a single-dimensional matrix. The resultant 1D array is the input of a dense layer, which is a simple layer of neurons that receives feedback from all the neurons of the previous layer and classifies images based on output from convolutional layers.

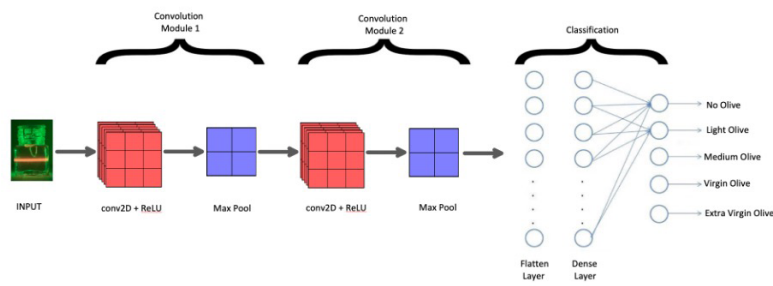


Fig. 4. Architecture of the CNN model to automatically classify oil blends from RGB images.

After labeling the RGB images using the proposed classifier function (R/G), we have split the dataset into training and testing dataset for evaluating the performance of our convolutional neural network to classify oil blends from RGB images. The dataset was split randomly by 80% of the RGB images for the training dataset (e.g., a total of 40 labeled images) and 20% of the color images for the testing dataset (e.g., a total of 10 unlabeled images). Figure 5 shows the results of our trained neural network on a testing dataset. Our neural network has an accuracy of 90%, being able to classify 9 images out of the 10 images. The proposed neural network fails to classify blends as No Olive Oil (NO) because the training dataset only has two blends in this region. It is important to mention that the accuracy of the CNN model depends on the testing dataset, reducing its classification power if the oil blends in the testing dataset are closer to the boundary between two classes. In this scenario, the CNN model may lead to a different classification label than the R/G ratio. For example, we have labeled the oil blend as olive oil since $R/G = 2.49$ (OO), but the CNN model may classify that oil blend as extra virgin oil (EVO). We could overcome this issue by providing a better method to label the images and by increasing the number of images within the dataset, especially the images on the borders of labels. Note that one can improve the label of the images by measuring the R/G ratio within the whole oil content.

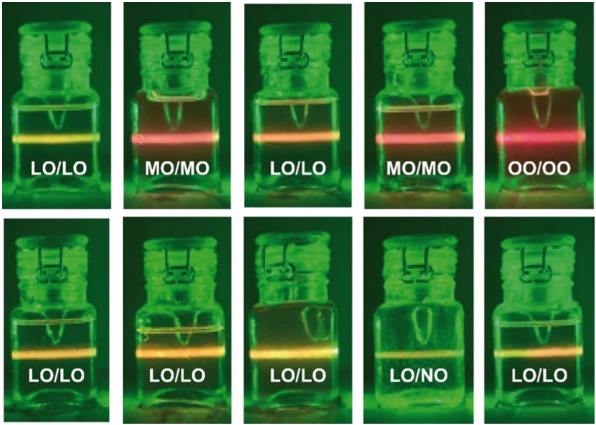


Fig. 5. Classification of ten oil blends after training a CNN model. The classification label is reported as CNN/metric where the metric is the R/G ratio. NO: No Olive Oil; LO – Light Olive Oil; MO – Medium Olive Oil; OO – Olive Oil; EVO -Extra Virgin Olive Oil

Conclusions

This undergraduate research project demonstrates a low-cost method to identify a oil quality combining optical spectroscopy and machine learning. The quality of vegetable oil blends can be measured by estimating the number of chlorophyll molecules. The higher the number of chlorophyll molecules, the higher the quality of the vegetable oil blend. Chlorophyll molecules are fluorescent molecules since they emit light within the red wavelength when excited by a green illumination source. Here, we have taken advantage of this phenomenon and built a simple optical spectrometer to evaluate the quality of 50 vegetable oil blends. Our spectrometer consists of a green laser diode that illuminates a glass container with the vegetable oil blend and a smartphone camera to record the emitted autofluorescent signal through RGB images. We have separated each channel from the RGB images and quantified the autofluorescent signal by dividing the intensity average of the red channel over the green channel along the laser illumination path. This ratio correlates to the number of chlorophyll molecules in the vegetable oil blend. The higher the amount of red signal, the higher the ratio value, the higher the number of chlorophyll molecules, and, therefore, the higher the quality of the vegetable oil blend (i.e., extra virgin olive oil). A no-olive oil blend should not contain chlorophyll molecules, providing a ratio value below the unity. Based on this ratio, we have classified and labeled the oil blends into five categories: no-olive oil, light olive oil, medium olive oil, olive oil, and extra virgin olive oil. Finally, we have used this labeled dataset to automatically identify the quality of vegetable oil blends based on recorded RGB images by training a CNN model. We trained and tested our model with 40 and 10 samples (80/20), respectively. The accuracy of the trained model is 90%, failing to classify no olive oil blends due to the low number of trained images in that class. Also, the CNN model fails to classify blends within the boundary between two classes. Future work should be focused on improving the model's accuracy by increasing the number of dataset and finding a more accurate method to label the images.

This research project introduces students to an interdisciplinary application of complex topics, including spectral imaging, image processing, and machine learning. We believe this research experience is also suitable for high school students interested in pursuing a STEM degree.

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The Correlation Between Perceived Discrimination and Social Anxiety in College Students Who Identify as LGBTQ

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Abstract

Discrimination can have many adverse effects on a college student. Stress, anxiety, depression, suicidal ideology, and social motivation are some of the negative impacts to the psychological well-being of those exposed to discrimination. Social interaction anxiety in relation to sexual orientation or gender identity may impact social motivation in college students. The motivation to engage in socialization on campus may be hindered by an individual's experience with discrimination. Though a diverse student body may help lower instances of discrimination, students may still be influenced by stigmas within these groups which may impact physical and psychological behaviors. The author of the current study explored the relationship between discrimination and social interaction anxiety in 38 self-identified lesbian, gay, bisexual, transgender, and queer (LGBTQ) undergraduate students. Participants completed a survey assessing experiences of perceived discrimination and levels of social anxiety. The results from the current pilot study portrayed a weak and direct correlation between perceived discrimination and social interaction anxiety, $r = .31$, $p < 0.03$ (one tailed), $r^2 = .10$. The data suggests that discrimination is an issue that sexual minority undergraduate students face which relates to their levels of social motivation.

Keywords:

Discrimination, socialization, isolation, motivation

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Introduction

Discrimination may have a negative impact on a student's social motivation for various reasons. Socialization and forming diverse social groups are important factors in a college student's social development (Pescaru, 2018). Developing supportive and diverse friend groups in college is important in building strong social skills. Students may enter college with certain knowledge on how to socialize or recognize society's expectations for them based off the environment in which they were raised (Meyer, 2003). Students may realize, especially in their first year of college, that how they socialize may differ from many of their peers. As young children, most students are indirectly socialized through interactions with parents, peers, and teachers that are marked for expectations for aspects of their society such as their role and status within society (Ely & Gleason, 2017). The development of social skills often carries through into adulthood, and these skills aid in the development of strong relationships with peers, co-workers, and significant others. Social relationships can be strained or abandoned in students who experience discrimination as they may lose the motivation to interact with others outside of their own groups (Ely & Gleason, 2017).

The lack of social motivation may potentially be associated with feelings of isolation, stress, anxiety, depression, and suicidal ideology as a response to acts of discrimination (Rohde et al., 2015). Accomplishing strong social skills comes when students feel safe to express themselves within their friend groups and in the classroom. Implementing safer spaces for students to freely express concerns may contribute to increases in social motivation (Ward et al., 2011). LGBTQ students that experience racial and sexual discrimination may have higher numbers of isolation if they feel unsafe in their campus community. Sidaros (2017) states that "combatting discrimination against sexual minorities therefore emerges as a matter of public health" (p. 8). Persistent exposure to discrimination may be associated with feeling the need to conform to social expectations or perceived expectations of how a person is to behave or think. A diverse student body within a college or university can play an important role in forming social groups on campus. "Research supports that a diverse campus environment is necessary to equip students to be successful in the 21st century and beyond" (Chen, 2017, p. 17). Students that feel out of place due to their sexual orientation exhibit a lower sense of motivation and connectedness

with their peers (Frost et al., 2022). A sense of openness and willingness to speak about social issues that are of concern to students may lessen these feelings of isolation.

Universities that have a diverse student body, faculty, and staff may have a more open culture of speaking about social issues (Abacioglu et al., 2020). Students that feel there is a disproportionate amount of diversity within the campus may find it difficult to talk about race related issues and the same concept may apply to any group, including LGBTQ students (Tate & Bagguley, 2017). True diversity within the campus involves focus, not just on the student body, but on the institution which also includes administrators, faculty, and staff (Chen, 2017).

Students that feel their experience of discrimination is not of importance to others may start to move away from their friend groups, avoid conversations, and ultimately isolate themselves as a form of coping. Thus, discrimination has the potential to lead to feelings of isolation and marginalization (Arday, 2017). Stevens et al. (2018) conducted a study on the effects of discrimination on academic performance and found that “discrimination was experienced by 5- 15% of students, with all racial/ethnic minority groups examined” (p. 665). Black, Hispanic, Asian, American Indian, Native American, and multiracial students reported higher levels of discrimination compared to their White counterparts (Stevens et al., 2018, p. 665). Students who are victims of racial discrimination may suffer negative impacts to physical health, mental health, academics, and social development. In relation to studies on racial discrimination, LGBTQ students also face frequent acts of discrimination on campuses nationwide (Russell et al., 2021). Heterosexism maintains a sexual stigma related to behavior that is not in alignment with non-heterosexual behaviors. The cultural ideology of heterosexism on campus may range from “derogatory comments to violence and tend to have negative perceptions of the campus climate” (Woodford et al., 2018, p. 421). The impact of these negative perceptions may include isolation from friend groups as well as involvement in activities on campus. This study aims to explore the effects of perceived discrimination in social interaction anxiety in lesbian, gay, bisexual, transgender, and queer (LGBTQ) undergraduate students. It is expected that there will be a relationship between perceived discrimination and social interaction anxiety.

Discrimination

Discrimination is “the unfair or prejudicial treatment of people and groups based on characteristics such as race, gender, age, or sexual orientation” (American Psychological Association, 2020, Dictionary of Psychology). Often, fear or a lack of knowledge are the driving forces behind these learned discriminatory thoughts. A better understanding of others through knowledge is one way to shift these paradigms. Accomplishing a better understanding may require diversity within the student body and education on other cultures, lifestyles, and sexual orientation. Students that experience discrimination may also experience negative impacts to their mental and physical health. Chronic exposure to discrimination can lead to chronic stress. Additionally, perceived discrimination has been linked to issues including anxiety, depression, obesity, high blood pressure, and substance abuse (Pascoe, 2009, p. 531).

Microaggressions, which can also affect a student’s desire to be social among peers, are intentional or implicit negative or derogatory insults toward minority groups (American Psychological Association, 2020, Dictionary of Psychology). Although microaggressions may seem unintentional, they can be deeply offensive and have the potential to lead to psychological distress in individuals. Transgressors of microaggressions are typically unaware of their negative slights against race or sexual orientation. “Almost all interracial encounters are prone to microaggressions” (Sue et al., 2007, p. 271). Society can condition individuals with biased and discriminatory thinking. Microaggressions stem from this indirect societal conditioning. Education on microaggressions is necessary in helping individuals understand and recognize the issue. An understanding of what a microaggression is, what they look or sound like, and the negative effect they have on the person may help in decreasing micro-aggressive instances. Diversity and inclusion training in all departments within a campus community could reduce the use of microaggressions. Although there are mental health clinicians on campuses nationwide to help victims of discrimination cope with the effects, microaggressions may still be present within that safe space. Robinson and Rubin (2015) explored the connection between microaggressions and post-traumatic stress disorder (PTSD) and found that there is a correlation between microaggressions and PTSD. Robinson and Rubin (2015) suggest that “there may

be a link between homonegative microaggressions and traumatic stress symptoms, which may demonstrate the potential for insidious trauma to be a factor in LGB minority stress” (p. 57). The correlation between microaggressions and stress symptoms is a significant factor in expressing the need for greater diversity and inclusion on campuses.

Racial discrimination is “the differential treatment of individuals because of their membership in a particular racial group. Discrimination in most cases is the behavioral manifestation of prejudice and therefore involves unfair, negative, hostile, or injurious treatment” (American Psychological Association, 2020, Dictionary of Psychology). Victims of racial discrimination may experience psychological distress such as anxiety and depression (Pascoe, 2009, p. 531). College students with these experiences may feel that they must isolate themselves from social groups and may use isolation to cope with the experience of discrimination. In a study conducted on the internalization of racial discrimination and anxiety in black college students, the authors found that students that experienced anxiety in relation to racial discrimination, were dependent upon the student’s acceptance or internalization of white student’s actions and beliefs (Sosoo et al., 2020, p. 580). Symptoms of psychological distress and internalization may also be present in LGBTQ students in response to exposure to discrimination.

The American Psychological Association defines homophobia as “dread or fear of gay men and lesbians, associated with prejudice and anger toward them, that leads to discrimination in such areas as employment, housing, and legal rights and sometimes to violence” (American Psychological Association, 2020, Dictionary of Psychology). There is a correlation between blatant victimization, microaggressions and low self-esteem, stress, and anxiety (Seelman et al., 2017, p. 112). Rates of suicide and suicidal thoughts are higher among LGBTQ students than those of their heterosexual counterparts (Haas et. al, 2011). Mental health issues may be linked to the experience of discrimination as a perceived lack of support. Studies show that “LGBT youths are four times more likely, and questioning youths are three times more likely, to attempt suicide” (Sidaros, 2017, p. 8).

Stigmas may be one of the most prevalent factors in acts of discrimination and have the potential to decrease on college

campuses. “The negative social attitude attached to a characteristic of an individual that may be regarded as a mental, physical, or social deficiency. A stigma implies social disapproval and can lead unfairly to discrimination against and exclusion of the individual” (American Psychological Association, 2020, Dictionary of Psychology). The behavior of stigmatizing others may also be acquired through inaccurate representations in the media and social media. Though some students may isolate themselves from social groups because of discrimination, some may also feel forced to isolate and neglect social relationships because of stigmas. Research findings suggest that mental health issues are more prevalent among LGBTQ college age students (Woodford et al., 2018, p. 421). Diversity on college campuses may lower the amount of discrimination, combat stigmatization, and, in turn, lower psychological distress among ethnic and LGBTQ students. Though diversity has the potential to help, “People in diverse settings experience intersecting forms of stigma that influence their mental and physical health and corresponding health behaviors” (Turan, 2019, p. 17). Stigmas have a negative impact on an individual’s life. Once stigmas have been aimed toward an individual, the negative impact of the experience may introduce new stigmas in reference to the psychological distress they experience.

Social Interaction Anxiety

Socialization is defined by the American Psychological Association as, “the process by which individuals acquire social skills, beliefs, values, and behaviors necessary to function effectively in society or in a particular group” (American Psychological Association, 2020, Dictionary of Psychology). Students may feel more comfortable, after experiencing discrimination, to socialize within groups of the same ethnicity or groups of other LGBTQ members. However, they may abandon diverse social groups after just one experience with discrimination or perceived and actual stigmas. Socialization among college students may help them cope with and relieve the stress caused by experiences with perceived discrimination. The connection students make with each other is an important factor in navigating a new environment, people, and living arrangements. Students may develop deep friendships that can be long lasting (Jones & Abes,

2004). Unfortunately, some of these relationships are based off the commonality of discrimination. Deeply connected relationships may play a role in coping with the distress caused by discrimination.

Motivation, a process which causes people to engage or disengage, can be affected by discrimination. In order to maintain social relationships college students must have the motivation to continue to engage. Social motivation may be diminished when blatant discrimination or microaggressions are experienced. Moving further from friend groups, avoiding conversation, and isolating are indicators of a lack of motivation to be social. Stress, in the context of discrimination, may be a factor in a student's disengagement in socialization.

Stress induced social avoidance is a term used to describe the effects of discrimination related stress on socialization (Haller & Bakos, 2002). Studies have been conducted where the authors found that perceived stress may have the same effect on social motivation. The effect of perceived stress is indicated by a study in 2021 in which the authors found that a "greater perceived stress on a given day predicted significantly decreased social interaction—measured by the amount of face-to-face conversation—the following day" (DaSilva et al., 2021 p. 1760). Whether stress is perceived or experienced, the effect on student's motivation to be social is negatively impacted.

Discrimination and Social Interaction Anxiety

Discrimination has many negative effects on a student's socialization. The impact discriminatory experiences have on a student's desire to socialize with others is harmful to their mental health. Students that feel as though they are being discriminated against, even if the discrimination is perceived, may start to isolate themselves as a means of coping from the stress of the experience. The effects of isolation as a coping mechanism may result in mental health issues, poor coping skills, and a lack of motivation. Socialization is important in developing strong relationships with family, friends, peers, co-workers, and community. The quantity and quality of social relationships influence physical health, mental health, behaviors, and mortality risk (Umberson & Montez, 2010). A student's response to discrimination may include anxiety, stress, and depression. In addition to using isolation as a means of coping, isolation may also serve as a defense mechanism. Whether isolation is used for coping

or a defense mechanism the effect it has on a student's psychological well-being can be serious. The lack of motivation to continue to socialize with others may also affect the student academically, increasing the amount of stress and feelings of anxiety and depression. Adults that may be more socially connected tend to be healthier and live longer than others that are isolated and are less socially connected (Umberson & Montez, 2010). Schools that have greater diversity on campus may see decreases in the number of students who are discriminated against. Potentially, this could lead to an increase in positive perceptions of the campus. Some ways schools can accomplish a more diverse environment are to enroll students from different ethnicities, sexual orientations, and gender identities. Hiring diverse faculty, staff, and administrators could increase feelings of understanding and acceptance, decreasing discrimination. This may create a positive environment for socialization among the student body and student-teacher relationships.

Methodology

The participants in this pilot study consisted of undergraduate students: 38 students and included members of the campus group pride alliance. In order to be a participant in this study, students had to volunteer to take the anonymous survey. The opportunity to participate was based on nonrandom purposive sampling. Individuals under the age of 18, and those who identified as heterosexual were excluded from participation in this study. In order to recruit participants, fliers were posted around campus and handed to professors to hang in their classrooms. The fliers contained information on the study and how to voluntarily participate. The fliers were also provided to the pride alliance group on campus. Fliers were also posted on the university app. There was no interaction with potential participants for the recruitment process and the fliers were the only source used for recruitment.

Participants

Women between the ages of 18 and 24 comprised 81.6% of the sample ($n = 31$), White persons represented 76.3% of the sample ($n = 29$), African American persons represented 15.8% of the sample ($n = 6$), and Hispanic and Latino persons representing 7.9% ($n = 3$). The total number of participants in the study was ($n = 38$). The majority

of participants, 42.1%, identified as bisexual (n = 16) with 34.2% identifying as queer (n = 13).

Measures

Social Interaction Anxiety Scale (SIAS)

The Social Interaction Anxiety Scale (SIAS) (Mattick & Clark, 1998) is a self-report questionnaire that assesses social interaction anxiety. The instrument measures various types of social interactions and the level of difficulty the individual has with these interactions. The SIAS consists of 20 questions and tracks social anxiety symptoms. Participants read the items listed on the scale and respond based on the relatedness to their feelings of anxiety and social interaction behaviors. All items are scored on a 5-point Likert-type-scale with scores ranging from zero to four, with zero being a low association and four being a high association with social interaction anxiety. A low score on the SIAS instrument suggests there is a low risk for social interaction anxiety, and higher scores indicate higher anxiety as it relates to social interaction.

The overall reliability of the SIAS instrument is good with Cronbach's alphas with a range of .88 – .93 (Mattick and Clark, 1989), which displays strong internal consistency. Convergent validity was reported as $r = .86$ which portrays a strong correlation with other measures for anxiety. The convergent validity of SIAS to other measures of anxiety suggests that the SIAS accurately measures social interaction anxiety (Peters, 2000). The reliability and validity of the SIAS makes it appropriate for use in testing anxiety as it relates to social interaction. An example question from the instrument is as follows, "I get nervous if I have to speak with someone in authority (teacher, boss, etc.)", (Mattick & Clark, 1998, p. 1).

The Discrimination Scale

The Discrimination Scale is a self-reporting questionnaire which assesses perceived discrimination in adults (Williams, et al., 1995). The instrument measures how often an individual feels they are treated differently or unfairly due to their gender, gender identity, and sexual orientation. The Discrimination Scale consists of seven questions and measures participants perceived discrimination in daily life. All items are scored on a 6-point Likert-type- scale with scores ranging from zero to four, with zero being no perceived associations

with discrimination daily to four being a high perceived daily association with discrimination.

The reliability estimates of the discrimination scale yield a high internal consistency ($\alpha = .92$) (Gonzales, et al., 2016). Convergent validity was indicated by increased levels of perceived discrimination in measuring levels of anger, distress, and hostility (Gonzalez, et al., 2016). Divergent validity was indicated by the lack of association between the discrimination scale and resilient coping (Gonzales, et al., 2016). An example question of the instrument is as follows, “I am treated with less respect than others” (Williams, et al., 1995).

Procedure

The purpose of this research was to examine the correlation between experiences with perceived discrimination and social interaction anxiety. It was expected that experiences with discrimination would cause some level of social interaction anxiety in college students. Students from the university, overseen by the research advisor, were asked to participate voluntarily in an online study following approval from the IRB, and were recruited through fliers posted on campus and on the university’s app with approval from the university. IRB approval was received before data collection began. Students that volunteered to participate were then directed to the online google form anonymous survey. All parts of the survey were available for participants through the online google form link. For anonymity purposes, no identifying information was asked, collected, or recorded. The informed consent was reviewed by participants prior to taking the survey and included in the link to fully inform all participants of the risk, purpose, process, and benefits of the research study. Once participants agreed to the terms of the informed consent, they were able to continue to the survey questions. The demographic questionnaire, SIAS, and Discrimination Scale followed for voluntary participant completion through the google survey link.

Participants needed approximately 10 to 20 minutes to review the informed consent and complete the questionnaire. Participants had the opportunity to exit the survey at any time. Once participants completed the survey, they could access a debriefing form which thanked them for their participation in the study.

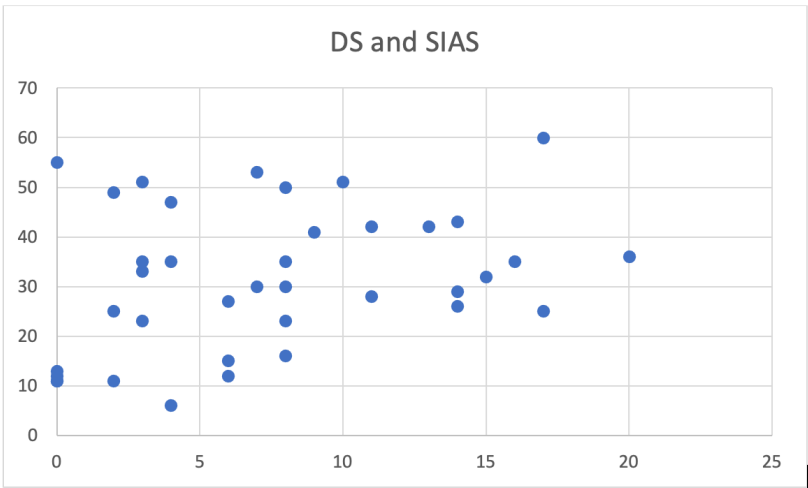
Data Analysis

Frequency reports for demographic information were created and analysis was computed with SPSS version 28.0. Means and standard deviation for the SIAS and the Discrimination Scale scores were included in a descriptive analysis. A Pearson’s r correlation coefficient was used to test the hypothesis and any correlation between discrimination and levels of social interaction anxiety. A linear regression was run to assess for prediction between discrimination and social interaction anxiety.

Results

Tests of assumptions were run to assess for outliers in the data linearity between the independent and dependent variables. The

Figure 1: Scatterplot Depicting the Correlation Between Discrimination and Social Interaction Anxiety



Note: The X axis represents the Discrimination Scale (DS) and the Y axis represents the Social Interaction Anxiety Scale (SIAS).

scatterplot showed slight linearity between the independent and dependent variables (see Figure 1). There also were no outliers in the data. It was expected that there would be a significant correlation between perceived discrimination and social interaction anxiety among LGBTQ students. The average score of perceived discrimination was $M = 7.45$ ($SD = 5.58$) and the average score of social interaction anxiety was $M = 31.53$ ($SD = 14.54$). (See table 1)

Results found a weak direct correlation in the sample $r = .31$, $p = 0.03$ (one tailed). Further, $r^2 = .10$, meaning the variables share 10 percent of the variability in their distributions. (See table 2) The regression, however, showed no significance, thus the results are not predictive $F(1, 38) = 3.87$, $p > .05$, $r = .31$, $r^2 = .10$. Based on these findings, a correlation did exist between the amount of perceived discrimination and social interaction anxiety in LGBTQ students.

Table 1:
Summary of Descriptive Data Social Interaction Anxiety and Discrimination

Instrument	M (SD)	95% CI	
		LL	UL
SIAS (total)	31.53	26.75	36.3
DS (total)	7.45	5.61	9.25

Note. CI= confidence interval; LL= lower limit; UL; upper limit;
DS= Discrimination Sale
Measure 1, SIAS = Social Interaction Anxiety Scale and Measure 2,
DS = Discrimination Scale

Table 2:
Summery of Correlations for Scores on the SAIS and DS

Measure	1	2
1. SIAS	-	0.31
2. DS	0.31	-

Measure 1, SIAS = Social Interaction Anxiety Scale and Measure 2,
DS = Discrimination Scale

Discussion

Discrimination, even when perceived, may have serious social implications for college students. University students that identify as a member of the LGBTQ community may find comfort within their in-groups when it comes to discussions regarding discrimination. Through shared experiences, they may be better able to cope with

experiences of perceived or blatant discrimination. However, there are some students who may find it difficult to cope with these experiences, resulting in higher risk for psychological distress. Feelings of psychological distress are not unique to members of the LGBTQ community attending college. Feelings of anxiety induced by experiences of perceived discrimination and social interactions can make the transition into college life difficult and stressful. While there may be progress in the general acceptance of LGBTQ in society, there is still a lot of work to be done concerning discrimination against sexual minority persons. Students that experience stress and anxiety because of discrimination may isolate to cope with related feelings of psychological distress. The lack of socialization can be harmful to their physical and mental health in adulthood. Umberson and Montez (2010) state that adults that are more socially connected tend to live longer and healthier lives. The social experiences in college may have a negative or positive impact on a student's future relationships.

Implicit and explicit attitudes may be associated with social interaction anxiety. Implicit and explicit attitudes may create a fear of negative evaluation from peers. Greenwald and Banaji (1995) state, "implicit attitudes are introspectively unidentified (or inaccurately identified) traces of past experience that mediate favorable or unfavorable feeling, thought, or action toward social objects" (p. 8). Explicit attitudes are attitudes that are consciously endorsed once reflected upon (Teachman & Allen, 2007). The experience of discrimination through implicit or explicit attitudes may not only lead to feelings of fear of negative evaluation of peers, but also feelings of shame, stress, and exclusion. Further, these feelings may enhance the need to isolate from others to avoid negative feelings. Experiences with discrimination increase sensitivity to rejection and are linked to social anxiety (Mahon et al., 2021). Students that attend universities that are more diverse in their staff, students, and teachings may not experience as much perceived discrimination as those that attend schools that are not as diverse. Having the opportunity to openly discuss negative experiences with discrimination in a space that feels safe, and with others that have similar experiences may encourage students to be open to talking about their feelings and experiences rather than avoiding them.

The current pilot study took into consideration the feelings of perceived discrimination as it relates to being a member of the

LGBTQ on campus. Specifically, the level of social interaction anxiety experienced in correlation to perceived discrimination. It was found that levels of social interaction anxiety were higher among LGBTQ students that also reported higher levels of perceived discrimination. As expected, there was a correlation between the levels of social interaction anxiety and perceived discrimination. Though the results show a correlation between social interaction anxiety and discrimination, it cannot be said that discrimination is the direct cause of social interaction anxiety due to the lack of significance in the linear regression. Reasons for these results may be due to a variety of reasons. First, the geographical location which has a general conservative approach in reference to the acceptance of sexual minority groups. Second, the university from which the participants attended was a small private institution in which a majority of students grew up in a conservative location. Third, the university itself lacked diversity within the faculty, staff, and student population. Finally, the size of the university may have been a factor. At the time of the study there were less than 3,000 students in attendance. This is important because students that identify as a member of the LGBTQ community may feel that they are more likely to be noticed by those who oppose any sexual orientation that does not identify as heterosexual. The study's small sample size may have played a role in the lack of significance in the linear regression. The low sample size also may have contributed to the slight skew in the data for social interaction anxiety. The Discrimination Scale was limited in the number of questions and may have only covered a small and general set of instances pertaining to perceived discrimination. A more comprehensive scale may have been beneficial in understanding the relationship between social interaction anxiety and the type of discriminatory behavior associated with these negative experiences. The group of participants was specific to LGBTQ students and this study did not assess other areas of discrimination such as race or gender discrimination. Due to the exclusion criteria for participants and the small sample size, this study may lack external validity.

Future studies may consider not limiting the effects of discrimination on a specific group of individuals but opening the study to any student belonging to any minority group. Opening the study to any student that belongs to a minority group may help further the study on discrimination and provide researchers with a

better understanding as to which groups experience higher amounts of perceived discrimination, and which groups may have levels of social interaction anxiety as it relates to perceived discrimination. Schools that have little diversity would benefit from further research in this area. Secondly, it may be beneficial to understand the impact of perceived discrimination in comparison to blatant discrimination.

Further studies may provide the empirical evidence needed on discrimination and the negative impact it can have on a student's social process. With this empirical evidence schools can start to address acts of discrimination and put programs in place to potentially lessen the amount of discrimination on their campus. The more empirical information there is on the effects of discrimination on socialization, the greater the need may be for schools to make a better effort to create a more diverse space for minority students. Students impacted by discrimination, whether blatant or perceived, may benefit from having others within their campus community to talk to about their experiences. Creating spaces for students to discuss experiences with discrimination openly may positively impact the mental health of minority students. Students who are able to utilize healthier ways of coping by talking with others about their experiences may have a greater sense of community, which could potentially mean having less fear of negative evaluation from peers, stress, anxiety, and exclusion. Students that have a greater feeling of support from those on campus would likely be more willing to participate in social gatherings, class, and friend groups. Students may also be able to live healthier, both emotionally and physically due to less stress and anxiety when interacting socially. The importance of research on this topic is to educate the public and reduce stigmas around sexual orientation and to create educational spaces that promote diversity and inclusion to reduce social anxiety in students that identify as LGBTQ. Further research on the effects of perceived discrimination on social interaction may create some solid ground for psychologists to continue to address the need for diversity on campuses through the understanding of the emotional and physical effects it can have on an individual or group of individuals.

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