The McNair Research Journal is a multidisciplinary journal of undergraduate research that is conducted by the McNair Scholars cohort of 2020-2021.
Congratulations to the Ronald E. McNair Scholars Cohort of 2020-2021

When I dare to be powerful—to use my strength in the service of my vision—then it becomes less and less important whether I am afraid
– Audre Lorde

I am no longer accepting the things I cannot change; I am changing the things I cannot accept
– Angela Davis
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15 April 2021

When the inaugural issue of *The McNair Scholars Research Journal of The University of Texas at Austin* was published four years ago, the Division of Diversity and Community Engagement (DDCE) could not have been more proud of the students participating in the McNair Program and their research accomplishments. In this annual publication of the research journal, the McNair Scholars Program continues its record of excellence.

DDCE is honored to have the McNair Scholars Program as part of its portfolio and fully supports the program’s goal of increasing the number of low-income and first-generation college students in graduate school. This goal is consistent with the DDCE’s efforts to create an intellectually and culturally diverse environment at the university.

Therefore, it is my pleasure to offer an introduction to this year’s issue of *The McNair Scholars Research Journal of The University of Texas at Austin*. The students published in this issue are McNair Scholars who were selected to participate in the McNair Summer Research Institute. These student scholars work with faculty mentors who support their research interests and guide them through the research project process that culminates in completing articles for publication in this, the McNair Journal. Not only does the journal offer a steppingstone for the student scholars who want to seek out additional publication opportunities, but the journal also provides a venue for graduate programs to see examples of the student’s work.

As is evident in this issue, the research interests of the 2020 cohort of McNair Program scholars are as diverse as the individual students themselves. This annual publication marks the continuation of what we hope will be a successful pursuit of academic advancement followed by a fulfilling professional career. I have no doubt readers of the journal will recognize the value of the McNair Scholars Program and the opportunity it offers to participating undergraduates whose scholarly accomplishments are a reflection of what represents the best of The University of Texas at Austin.

Dr. LeToya Smith
Vice President
Diversity and Community Engagement
15 April 2021

A Message from the Directors

We are very pleased to present this year’s volume of The McNair Scholars Research Journal at The University of Texas at Austin. This journal is the culminating product of the efforts of our McNair Scholars during their Summer Research Institute. The scholarly research presented here is a testament to the hard work and dedication of our scholars. The McNair Scholars Research Journal represents a persistent tradition of our students achieving academic excellence.

The McNair Scholars Program prepares high-priority students for doctoral studies through involvement in research, faculty mentoring, academic colloquia series, and other scholarly activities. Ever since our first cohort of scholars graduated in 2009 and entered into graduate programs, our program continues to prepare first generation college students from underrepresented backgrounds to diversify the academic environment.

This year’s journal contains the work of Scholars who completed the 2020 Summer Research Institute. We are very proud of the accomplishments of our McNair Scholars, especially considering the added challenges of conducting and completing research during a global pandemic that forced everyone off campus for over a year. We look forward to helping Scholars achieve their academic goals and future endeavors.

We would like to thank all the McNair Faculty Mentors for their support, guidance, and expertise in working with our Scholars. Your participation as faculty mentors has truly enriched the academic careers and enhanced the potential of our students. This program is also dependent on the support of our incredible staff members who work very hard to allow us to put forth a quality program. We would also like to extend appreciation to Dr. LaToya Smith, Vice President for Diversity and Community Engagement for her unwavering commitment and support of the McNair Scholars Program.

With the support of all these individuals and the perseverance of the McNair Scholars, we can continue to demonstrate that, at The University of Texas McNair Scholars Program, “What Starts Here Changes the World!”

Thank you,

Dr. Darren Kelly
Director, McNair Scholars Program
Deputy to the Vice President

Dr. Anthony Brown
Faculty Director
McNair Scholars Program
The present study analyzed the strength of youth client race as a predictor for child- and parent-therapeutic alliance ratings as well as therapist treatment integrity to better understand the therapeutic process for racial minority youth. It was hypothesized that youth client race would demonstrate a strong association with the child- and parent-therapist alliance scores as well as with the therapist treatment integrity to treatment protocol. Specifically, it was hypothesized that youth clients of color and their caregivers would have lower total alliance scores than White youth clients and their caregivers. Lastly, it was predicted that clinicians would show lower treatment integrity with youth clients of color compared to with White clients. Child and parent dyads from 266 clients were all individually examined for their total child-therapist alliance questionnaire scores and parent-therapist alliance questionnaire scores. Therapist treatment integrity was also measured across three clinical sessions for each client for therapist adherence and competence to the Modular Approach to Therapy for Children (MATCH) treatment protocol using the Therapist Integrity in Evidence-Based Interventions (TIEBI) coding system. No significant relationship was demonstrated between client race and therapeutic alliance scores as well as therapist treatment integrity, identifying client race as a weak predictor variable for these therapeutic process elements. Direction for future research should involve examining clinician and client racial match and its association with therapeutic alliance ratings for youth clients.

Race and the Therapeutic Process for Youth Clients

The influence of racial experiences minority youth have is an important consideration to regard when understanding the relationship between youth of color and mental health services. At a disproportionally higher rate, racial minority youth experience more adversities and stressors, such as community violence, poverty, and trauma, than White youth (Okamura et al., 2016). These stressors intensify their vulnerability for developing mental health problems; however, given these associations, youth of color are still less likely to seek out or receive mental health services due to mistrust in the therapeutic process and historical racial biases in the healthcare field (Hwang et al., 2008). Two meaningful elements in the therapeutic process to examine mistrust and biases are in the therapeutic alliance between clinicians and clients, as well as the therapist treatment integrity that measures how competent and adherent the clinician is with their treatment administration. Given the accounts of mistrust from minority youth and racial biases in mental health services, it is critical to focus on the role of race and racial experiences in the establishment of a strong therapeutic alliance and in the manners that therapists deliver treatments and interventions. Only a few studies in the literature, however, have investigated the significance of youth client race on the therapeutic alliance and therapist treatment integrity. The purpose of the present study is to further investigate the role of client race on the therapeutic alliance and therapist treatment integrity in order to close the gap between racial minorities and the healthcare system and identify ways to
improve mental health services for youth of color.

**Disparities in Mental Health Treatment for Minority Youth**

In the literature, there is a deficiency in research on youth clients of color and their treatment outcomes in clinical trials for evidence-based treatments (EBTs). What is frequently seen in the literature is the exclusive use of White clients and families, or at the very least, a severe lack of diverse representation in the participant racial demographic (Courtright, 2016). This can be misleading when interpreting therapeutic outcomes because the strengths of some EBTs can be portrayed as significant but may only be significant to a majority White racial demographic. This presents a substantial disadvantage for racial/ethnic minority youth and their families, as they might not be receiving EBTs that are sensitive enough to their racial experiences to yield considerably positive therapeutic outcomes.

Reasons for the underrepresentation of minorities in clinical trials is the notorious problem of mistrust between minorities and the healthcare system (Substance Abuse and Mental Health Services Administration, 2001). Mistrust in mental health services and in clinicians specifically have led minority adults and even youth to feel disconnected to mental health opportunities. For example, Samuel (2015) conducted interviews with 54 African American adolescent males (ages 15 to 17) in a study to understand the relationship between attitudes towards mental health services, help-seeking, and people of color. Participants were qualitatively interviewed with questions designed to explore their individual feelings about counseling and about counselors. All participants either had mental health services in the past and dropped out or were currently receiving them. From these interviews, when asked questions about mistrust in mental health providers, Samuel found that majority of the participants felt discomfort in going to therapy because they did not trust their therapists enough to talk about their private experiences, especially to White clinicians as many felt uneasy to disclose personal events to a stranger of another racial background. Many also reported that they were hesitant to seek mental health services because they did not want to be given any medicine from clinicians because of the possibility of the drugs having a negative effect on them mentally. These findings reinforce the influence of mistrust on beliefs about mental health services and providers while bringing more attention to the importance of the therapeutic alliance in the treatment and intervention process for minorities.

**Race and Mental Health**

Over the years, awareness of the need for mental health services for children and adolescents has increased dramatically. Much of the recognition, however, is not focused on the groups of youth that need services the most. As much as the population for minority youth has grown and continues to grow, their resources and opportunities for mental health services has been stagnant in comparison. More minority youth and their families live in low-income communities or in severe poverty than White families and their youth (American Psychological Association, 2017). Living in these communities and conditions is associated with having higher opportunities for exposure to community violence, neglect, and abuse (Eckenrode et al., 2014). In addition, youth and families of color experience structural or societal racism which describes the institutional principles that form systems in a society that disadvantage people of color while favoring White people (Gee & Ford, 2011). Such examples of structural racism include redlining, which limits homeowner opportunities for people of color, and white supremacy ideology, which has historically advanced White people’s opportunities for power and wealth while hindering the chances of people of color. These systemic risk factors, alongside direct risk factors, have consequently made youth of color
more susceptible to developing mental health problems such as depression and anxiety.

In an effort to illustrate the high prevalence rate of anxiety and depression in minority adolescents, Okamura et al. (2016) led a study that included 428 youth varying between age 8 to 18. Through a parent-report questionnaire, the ethnicities of each child were measured and included Japanese American, Filipino American, Chinese American, Native Hawaiian, and White. Researchers used the Revised Child Anxiety and Depression Scale (RCADS) to measure self-reports of anxiety and depressive symptoms that aligned with various disorders such as separation anxiety disorder and major depressive disorder, while the Revised Child Anxiety and Depression Scale-Parent (RCADS-P) was used to measure parent-reports of anxiety and depressive symptoms in their children. The results of this study demonstrated significantly higher ratings of anxiety and depressive symptoms for youth from Chinese American, Japanese American, and Filipino parents compared to the ratings of White parents suggesting that minority youth experience more depressive and anxiety symptoms than White children.

Therapeutic Alliance

Ameliorating the therapeutic alliance has been among the many solutions that have been proposed in response to the disparity between people of color and mental health services. The concept of the therapeutic alliance and the client/clinician relationship has been thoroughly researched to better understand the components of the therapeutic process that promote successful treatment outcomes. The collaborative efforts of the therapeutic alliance between the therapist and client are essential in establishing an accord on what the treatment objectives are, what efforts will be made by both therapist and client to attain these objectives, and how they can both create a positive working environment for progress and success to occur (Ardito & Rabellino, 2011). Researchers like Labouliere et al. (2017) have studied the specific effects of the therapeutic alliance on early predictors of therapy outcomes for youth clients. In Labouliere et al.’s study, 38 adolescents with depression underwent cognitive-behavioral therapy and were asked to complete the Beck Depression Inventory during their first session and their fourth session to measure depressive symptoms. Each therapy session was recorded to allow for observational coding of the therapeutic alliances using the Alliance Observation Coding System for the first and fourth sessions. Results from this study indicated that the therapeutic alliance in the first session was a meaningful predictor of depression scores in the fourth session, supporting the importance of establishing a strong and positive therapeutic alliance especially in the early sessions of treatment to yield positive therapeutic outcomes.

Therapist Treatment Integrity

Therapist treatment integrity is also another area of the therapeutic process that has been among proposed solutions for advancing mental health services for minority youth clients. Therapist treatment integrity refers to the degree to which an intervention is delivered by the therapist as intended. This includes the extent to which the therapist adheres to the intervention protocol as well as the therapist’s level of competence on the intervention and how to deliver it beneficially. It has been suggested that treatment integrity strongly correlates with treatment outcomes as client improvements are indicative of the intervention components and how well therapists deliver these components (Perepletchikova & Kazdin, 2005). As therapist treatment integrity has been considered to influence treatment outcomes, researchers have assessed ways to improve treatment outcomes for racial/ethnic minority clients.

Cultural adaptations to treatments and interventions have been examined as an impactful
component to improving treatment integrity and overall treatment outcomes for minority clients (Lee et al., 2015). The role of cultural competence and cultural adaptations in treatments is to incorporate culturally oriented approaches to the implementation and delivery of treatments (Huey et al., 2014). These approaches have been used to mitigate treatment barriers caused by culture-related deterrents such as mistrust and negative help-seeking attitudes from racial/ethnic minority clients. In a meta-analysis study evaluating the efficiency of cultural-competent evidence-based practices for racial minority clients, both youth and adults, Griner and Smith (2016) assessed 76 studies with over 25,000 total participants. Of these participants, 31% identified as African American, 31% identified as Hispanic/Latinx, 19% as Asian American, 11% as Native American, 5% as European American, and 3% as Other. Many of the culturally adapted interventions analyzed varied in adaptations, but majority of the interventions incorporated cultural values and beliefs into the implementation of the intervention. The results from this study produced an effect size of $d=0.45$, suggesting a positive effect in favor of culturally adaptive interventions on minority clients’ treatment outcomes.

Present Study

As it has been shown, the therapeutic alliance and therapist treatment integrity have important functions in the therapeutic process and on treatment outcomes. Nevertheless, given the accounts of mistrust from minority youth and racial biases in mental health services, it is critical to focus on the role of race in the establishment of a strong therapeutic alliance and in the manners that therapists deliver treatments and interventions. Interestingly, however, research on this has been conflicting.

From Eliacin et al.’s (2018) study, there is support in the argument that race should be of regard when understanding the therapeutic working relationship. 152 African American and White veterans who sought out mental health services participated in this study and were asked to complete the Working Alliance Inventory-Short form (WAI-SR) that measured participant ratings of their therapeutic relationship with their clinician. Scores from the WAIS-SR indicted a significant difference of ratings between participants of difference races as African American participants rated the strength of their therapeutic alliance substantially lower than that of the White clients. In opposition to this study and similar studies, researchers like Wintersteen et al. (2005) have shown no difference in therapeutic alliance ratings from participants of different races. In their study, therapeutic alliance ratings were amassed from 600 adolescents over the age of 15 with substance use disorder using the Working Alliance Inventory after at least two therapy sessions were completed for each youth. Findings from this study did not show race as having an influence on different participant reports of strong therapeutic alliances.

Given the scarcity of concrete research evidence both for and against the significance of client race on the therapeutic alliance of youth clients, and almost no research on the relationship between client race and therapist treatment integrity, the current study will further investigate the role of race on the therapist/client therapeutic alliance and on therapist treatment integrity. Secondary data analysis will be conducted deriving from primary data collected from youth clients and caregivers during the randomized clinical trial of Child STEPs (Weisz et al., in press). Parent and child therapeutic alliance questionnaires and treatment integrity components will be analyzed for effects associated with the race of participants. It is hypothesized and predicted that youth and parents of color will have lower therapeutic alliance scores than White youth and parents supporting evidence that racial experiences impact the therapeutic alliance. It is also expected for therapists to exhibit weaker treatment integrity with minority youth clients due to the lack of
cultural adaptations in the intervention, thus supporting the need for more culturally tailored evidence-based practices in order to improve treatment outcomes for youth of color.

Methods

Participants

The present study uses a sample of 266 youth, ages 7 to 15 (M = 10.81, SD = 2.48), and their caregivers from a larger randomized control trial that focuses on the presence of expert consultation in the implementation of Child STEPS psychotherapy (Weisz et al., in press). All youth in the study were pursuing mental health services from community clinics for either depression, anxiety, trauma, or conduct problems. 48.1% of the youth sample were female while 51.9% were male. The sample consisted of 31.6% of youth identifying as White/Caucasian, 26.3% as Black/African American, 25.6% as Latino/Hispanic, 13.5% as Multiracial, 1.1% as “Other,” and less than 1% as Asian.

Clinicians from the primary study were selected from four community mental health clinics. Of the 42 clinicians in this study, 37 clinicians were female while only 5 were male. 29 clinicians identified as White/Caucasian, 7 identified as Hispanic/Latinx, 2 identified as Black/African American, 2 identified as “other,” 1 identified as Multiracial, 1 did not provide their racial identity, and 0 identified as Asian. Ages of clinicians averaged to 35.39 years (SD = 10.34) with an average of 5.54 years (SD = 5.60) of therapeutic training after completing their undergraduate schooling. The clinicians also averaged 5.86 years (SD = 6.67) of professional experience. All clinicians received training in the Modular Approach to Therapy for Children (MATCH) treatment protocol and participated in providing services to at least one youth client and their family. Professional careers were diverse among clinicians. 21 clinicians were social workers, eight were marriage counselors, six were counselors, six were psychologists (including one school psychologist), and one clinician was a behavioral health clinician.

Measures

Child-Therapist Alliance: The Child-Therapist Alliance survey was used to examine the positive and negative qualities of the working relationship between the child and the therapist from the child’s perspective. The survey consisted of 9 statements (see example in Appendix A) that described positive and negative feelings and thoughts that the child could have experienced while engaging with their therapist. A sample statement is as followed: “I look forward to meeting with my therapist.” Each statement required a response from a 4-point Likert scale, ranging from “Very true” to “Very false,” that gauged the child’s agreeance with the statement. Each child was asked to complete the survey after their completion of therapy.

Parent-Therapist Alliance: The Parent-Therapist Alliance survey was completed by caregivers after the final session of therapy to determine their level of positive and negative attitudes towards their child’s therapist. The survey contained 9 statements in which parents were asked to select from a 4-point Likert scale how relatable each statement was with their experiences throughout the therapy process. The scale ranged from responses such as “Not like me” to “Very much like me.” For reference, the first statement asked, “I looked forward to meeting with my child’s therapist. Is this statement…” See Appendix B for example.

Therapist Integrity in Evidence-Based Interventions: The Therapist Integrity in Evidence-Based Interventions (TIEBI) coding system measures therapist adherence and competence to the procedures of the (MATCH) treatment protocol. Adherence was measured by observing whether
clinicians implemented any of the 22 evidence-based skills from the protocol in each five-minute segment that fell under either content or process skills. Content skills represent strategies clinicians use in therapy to directly help clients with their problem, while process skills represent skills that clinicians use to strengthen their rapport with clients. Competence was also measured by ratings of skillfulness for any of the 22 MATCH skills ranging from ratings of 0 (not present) to 4 (expert).

Analysis

A total of 266 child-caregiver dyads were used to analyze child- and parent-therapist alliance questionnaire scores as well as client race. Alliance scores were coded and totaled for each child and caregiver questionnaire. Answers from positively phrased questions were coded to their corresponding Likert scale number, while answers with negative phrasing were reverse coded for consistency in scoring resulting in higher alliance scores meaning stronger therapeutic alliance reports while lower alliance scores meant weaker therapeutic alliance reports.

Three audio or visual recordings of clinical sessions per client were observed, coded, and averaged for therapist treatment adherence percentages and competence to the MATCH treatment protocol using the TEIBI coding system. To retrieve adherence percentages, for each session, the number of five-minute segments where a MATCH skill was used by a clinician was totaled and then divided by the length of the session in minutes. This number was then averaged across the three observed sessions. To retrieve competence ratings, the skillfulness rating for each MATCH skill were averaged across the three clinical sessions. Competence ratings of 0 were not included in analysis as it represented no use of the certain strategy within each clinician session, thus inhibiting the clinician to show competence for the skill.

Six primary single linear regression models were used in the present study to analyze the direct relationship between client race and the three outcome variables: (a) child-therapist alliance scores, (b) parent-therapist alliance scores, and (c) therapist treatment integrity. Client race as a predictor variable was examined between two categories: White and Nonwhite. With these categories, child- and parent-therapeutic alliance scores were then individually analyzed using single linear regression models their individual association with client race. Therapist treatment integrity was also divided into four separate linear regression models. Two individual models observed the association between client race and competence for either content skills or process skills, while two other models observed the relationship between client race and adherence percentages for content or process skills.

Results

Therapeutic Alliance

The direct relationship between client race and child- and parent-therapist alliance scores was measured to observe the strength of client race as a predictor for therapeutic alliance scores. Using an alpha level of .05 to establish areas of significance, child-therapist alliance scores demonstrated no significant relationship with client race between White and Nonwhite clients \([F(1,123) = 1.059, p < 0.306]\) with an \(R^2\) of .009 as seen in Table 1. Parent-therapist alliance scores also demonstrated no significant relationship with client race \([F(1,126) = 0.651, p < 0.421]\) with an \(R^2\) of .005 as seen in Table 2. These results overall illustrate client race as a weak predictor variable for the alliance scores of child clients and their caregivers. The relationship between client race and alliance scores was also examined by parting client race into individual racial categories of White/Caucasian, Black/African American, Latino/Hispanic, Asian, Multiracial, and Other. The
results of this analysis similarly yielded no significant relationship with alliance score for child-therapist alliance \( [F(1,123) = 3.597, p < 0.060] \) with an \( R^2 \) of .028 as seen in Table 3, as well as parent-therapist alliance \( [F(1,126) = 3.199, p < 0.076] \) with an \( R^2 \) of .025. However, lower p-value are seen which could demonstrate a potential trend towards significance.

**Therapist Treatment Integrity**

When analyzing the association between client race and therapist treatment integrity, no significant relationship is shown. The relationship between client race and therapist adherence to process skills yielded an \( R^2 \) of .000 \( [F(1,192) = 0.003, p < 0.960] \) as seen in Table 4. Client race and therapist adherence to content skills produced an \( R^2 \) of .001 \( [F(1,192) = 0.146, p < 0.703] \). Therapist competence for content skills in relation to client race showed an \( R^2 \) of .001 \( [F(1,186) = 0.070, p < 0.791] \). Lastly, no significant relationship was shown between client race and therapist competence for process skills as \( R^2 \) of .001 \( [F(1,175) = 1.059, p < 0.306] \).

**Discussion**

The purpose of the present study was to further examine the strength of youth client race on therapeutic alliance scores and therapist treatment integrity. It was hypothesized that youth client race would demonstrate a strong association with the child- and parent-therapist alliance scores as well as with the therapist treatment integrity to treatment protocol. Specifically, it was hypothesized that youth clients of color and their caregivers would have lower total alliance scores than White youth clients and their caregivers. Concerning therapist treatment integrity, it was hypothesized that clinicians would show lower treatment integrity with youth clients of color compared to with White clients.

Across therapeutic alliance and therapist treatment integrity, no significant relationship was found between each variable and their association with client race, illustrating an overall weak relation between client race and the outcome variables. This contrasts several studies in the literature that have shown support for client race acting as a predictor variable for how youth clients felt about their relationship with their therapists (Eliacin et al., 2018), while agreeing with other studies demonstrating no significance in client race as a predictor variable for therapeutic alliance and treatment integrity (Wintersteen et al., 2005). Specifically, the lack of significance in the results of this study could be the outcome of a low statistical power in the study given the sample size and limited client diversity or an indication that there are other elements in the therapeutic process that can influence the strength of the therapeutic alliance and therapist treatment integrity for youth racial minority clients.

Interestingly, however, when analyzing specific child race and its relationship with child- and parent-therapist alliance, a potential trend could be seen as results began to approach significance. This could possibly be due to the lower therapist alliance scores observed from multiracial clients compared to the other racial groups. An explanation for this, and a potential direction for future research, could be in the racial match between clinicians and clients that could influence the strength of the therapeutic alliance and treatment outcomes. When matching clients and clinicians by race, positive treatment outcomes could be yielded as a result of reciprocated comprehension of their racial background and the reciprocated understanding of the impact that their racial experiences can have on one’s mental health (Cabral & Smith, 2011). This can also lessen the margin for racial biases or cultural misunderstandings that can interfere with the establishment of the therapeutic alliance. However, in the literature examining therapist race and racial congruency with clients, there is a great presence of racial incongruency between clients of
color and therapists as there are statistically more White therapists than there are other-race therapists (Lin et al., 2018). In the present study, there was a significant lack of therapists identifying as multiracial as only one clinician identified as both African American/Black and Latino/Hispanic. This racial incongruency between clients and clinicians, especially for multiracial clients, could be identified as a probable reason for lower therapeutic alliance scores for this racial group.

Despite the lack of statistical findings, this project hopes to contribute to the existing body of research surrounding multicultural psychotherapy and adolescent psychology by providing more empirical foundation for future research endeavors to better understand the therapeutic experiences of youth clients and ways to improve the gap between racial minority youth and mental health services.
References


Table 1: Child-Therapist Alliance Scores by Client Race
Table 2: Parent-Therapist Alliance Scores by Client Race
Table 3: Child-Therapist Alliance Scores by Specific Race
Table 4: Therapist Adherence to Process Skills by Client Race
Appendices

Appendix A

Child-Therapist Alliance

I feel like my therapist was on my side and tried to help me.

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Appendix B

Parent-Therapist Alliance

I looked forward to meeting with my child’s therapist. Is this statement…

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<td>Not like me</td>
<td>A little like me</td>
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The Role of Parental Racial Discrimination Experiences in Children’s Academic Achievement in Black Families

Grace Dennis
The University of Texas at Austin
Fatima Varner, PhD, Faculty Mentor

Recent research has found that Black boys are held to lower educational expectations despite indications of previous academic performance. These findings contrast with previously established trends of high parental expectations. Research and theory posit that concerns surrounding heightened risks of racial discrimination for Black boys may explain parents’ lowered educational expectations. The present study examined the relation between parents’ experiences of racial discrimination, parents’ educational expectations, children’s educational expectations and children’s academic achievement. In addition, the influence of child sex on the proposed associations between parents’ racial discrimination experiences and educational expectations was investigated. Regression analyses using public data from the National Longitudinal Study of Youth were conducted to test for moderated mediation. Parents’ racial discrimination experiences were tested as the study’s primary predictor, parents’ educational expectations and children’s educational expectations were tested as mediating variables and children’s academic achievement was tested as the study’s primary outcome. In addition, child sex was tested as a moderating variable for the proposed association between parents’ racial discrimination experiences and children’s academic achievement. Total net family income was used as a statistical control. Analyses revealed that parents’ previous experiences of racial discrimination were indeed linked to their children’s future academic achievement. However, this association was not explicated by the study’s proposed mediators. Analyses further exhibited significant differences in parents’ educational expectations, children’s educational expectations and children’s academic achievement by child sex. This study’s findings establish that racial discrimination has a significant and lasting impact on child achievement. Our findings additionally demonstrate that Black boys face an increased vulnerability in education.

Introduction

Parental behaviors and beliefs are influential factors in a child’s academic achievement (Castro et al., 2015). Eccles and Wigfield’s (2002) Expectancy-Value Theory has been used to explain how parental expectations for success can influence children’s own expectations, behaviors and eventual achievement. A meta-analysis of parental educational expectations has shown that parents generally hold high expectations, despite their children’s academic performance (Pinquart & Ebeling, 2020). However, recent research has shown that Black boys are held to lower parental educational expectations when compared to Black girls, even when controlling for academic performance (Wood et al., 2007). Previous research has posited that concerns for heightened racial discrimination risks may explain this trend (Varner & Mandara, 2013). Coll et al.’s (1996) Integrative Model for the Study of Developmental Competencies in Minority Children, states that ethnic minorities may adopt adaptive behaviors and beliefs in
response to racially discriminatory experiences. These adaptations may additionally impact children’s outcomes. Although the influence of sociocultural factors on children’s academic achievement has been studied in previous literature (Noguera, 2003; Whaley & Noel, 2011), the possible association between parents’ racial discrimination experiences and their children’s academic achievement remains largely unexplored. The purpose of the current study is to examine how parents’ experiences with racial discrimination, parents’ educational expectations and children’s educational expectations are related to children’s academic achievement among Black Americans. The role of child sex on the association between parents’ racial discrimination experiences and educational expectations will also be investigated.

Parents’ Discrimination Experiences and Educational Expectations

The Expectancy-Value Theory proposes that cultural milieu (i.e., a cultural environment) can influence the beliefs and behaviors of children’s socializers. These beliefs and behaviors may then affect children’s own beliefs, behaviors and achievement (Eccles & Wigfield, 2002). In a recent revision of Expectancy-Value Theory, Eccles and Wigfield (2020) stated that sociocultural factors are foundational and omnipresent in all components of the model. Although Expectancy Value Theory has been extensively used to investigate gender and ethnic differences in achievement, Eccles and Wigfield believe that the influence of race, ethnicity and culture on socializers’ (e.g., parents’) and children’s expectancies and values has been understudied. Eccles and Wigfield (2020) further named experiences of discrimination as a powerful, yet insufficiently researched influence on children’s achievement and socializers’ beliefs.

Congruent with this theory, the Integrative Model for the Study of Developmental Competencies in Minority Children states that macrosystemic factors, such as discrimination, can lead to inhibiting or promoting environments (Coll et al., 1996). However, divergent from Expectancy-Value Theory, Coll et al.’s (1996) model elucidates the specific pathways that individual characteristics, such as gender and race, interact with macrosystems and influence children’s achievement (Coll et al., 1996). According to this model, an individual’s race can make them more susceptible to experiences of discrimination. Recent research demonstrates how pervasive racial discrimination is in the lives of Black individuals, with the majority of surveyed adults reporting that they have previously experienced racial discrimination related to employment, during police interactions or in public (Bleich et al., 2019). Analogously, the majority of surveyed adolescents reported a racially discriminatory experience at least once in the past year (Seaton et al., 2008).

As suggested by the Integrative Model, these experiences can create inhibiting environments (Coll et al., 1996). For example, in the academic sphere, Black children are frequently subjected to disproportionate discipline (Gilliam et al., 2016; Spilt & Hughes, 2015), lower academic expectations from teachers (Ferguson, 2007; McKown & Weinstein, 2008) and racially based discriminatory experiences (Fisher et al., 2000; Wang & Huguley, 2012). As non-passive agents, families adapt to these environments and may change their behavior and beliefs (Coll et al., 1996). In particular, many Black parents report feelings of fear related to their children experiencing racial discrimination in the educational system (Williams et al., 2017). Parents additionally report uncertainty about the promotive abilities of their children’s schools and resources. Due to these worries, some parents have responded with adaptive behaviors and beliefs, such as creating their own educational environments (Williams et al., 2017), promoting
racial socialization messages (Hughes, 2003; Hughes et al., 2006) or lowered educational expectations for their children (Varner & Mandara, 2013).

Parents’ Discrimination Experiences and Children’s Achievement

The concept that experiences of racial discrimination can influence parenting practices and beliefs has been supported by prior research (Anderson et al., 2015; Brody et al., 2008; Hughes, 2003; Hughes et al., 2006) and theory (Eccles & Wigfield, 2002; 2020; García Coll et al., 1996). Experiences of racial discrimination have been linked to lower levels of mental health, physical health (Paradies et al., 2015) and positive parental practices in Black adults (Anderson et al., 2015; Brody et al., 2008; Varner et al., 2020). In addition, parental experiences of racial discrimination have been associated with increased depressive symptoms and lower levels of psychological well-being in children (Ford, Hurd, Jagers, & Sellers, 2013). Despite the numerous identified impacts of racial discrimination on parenting and child outcomes in recent literature, a clear link between parents’ experiences of racial discrimination and children’s achievement has not yet been established.

Expectancy Value Theory (Eccles & Wigfield, 2002) offers insight into this prospective association. It asserts that aspects of parents’ cultural milieu, may inform their educational expectations, children’s educational expectations and children’s eventual achievement through relayed behaviors and messages. Research has indeed found a direct link from parents’ cultural milieu (i.e., racial discrimination) to lower educational expectations (Varner & Mandara, 2013). As stated by Expectancy Value Theory, these lowered educational expectations may be linked to lowered academic achievement. As previous research has already demonstrated the adverse role of parental racial discrimination experiences on child outcomes (Ford, Hurd, Jagers, & Sellers, 2013), this study aims to investigate its relation to children’s academic achievement.

Parents’ and Children’s Educational Expectations

According to Expectancy Value Theory, parents’ expectations for their children’s success may influence children’s personal expectations (Wigfield & Eccles, 2000; 2002). Evidence for this association has been supported by several studies. For example, Kirk et al.’s (2011) research revealed that parental educational expectations for academic completion predicted children’s own expectations (Kirk et al., 2011). In addition, several longitudinal studies reported similar findings of a relation between parental expectations and children’s expectations of educational attainment (Rutchick et al., 2009; Trusty et al., 2003). This association appears to have a lasting effect based on results from Yamamoto & Holloway’s (2010) research. In their longitudinal study of 884 children, the relation between parents’ and children’s expectations was still evident after five years. These findings persisted even after controlling for children’s academic achievement. Trusty’s (2002) research revealed comparable results in Black families and their related expectations, while also controlling for academic achievement. Although the association between parents’ and children’s educational expectations has been investigated in previous literature, this study aims to increase current knowledge of this relation in Black families.

Educational Expectations and Children's Academic Achievement

In corroboration with Expectancy-Value Theory, parents’ educational expectations have been correlated to their children's later achievement (Yamamoto & Holloway, 2010). Children whose parents hold higher educational expectations have been shown to have higher grades, further educational attainment and greater levels of academic engagement and motivation.
Predictably, a review of research has found significant evidence of a positive correlation between parents’ expectations and children’s achievement in European American families (Yamamoto & Holloway, 2010). This association has been established in Black families as well, as parental expectations were positively linked to children’s academic outcomes (Benner & Mistry, 2007; Gill & Reynolds, 1999; Halle et al., 1997; Sirin & Rogers-Sirin, 2004).

Similarly to parents’ expectations, children’s educational expectations were found to be associated with higher levels of academic achievement (Ensminger & Slusarcick, 1992). Recent research indicates that middle and high school-aged children with higher expectations obtain further levels of educational attainment, perform better at school (Mello, 2008; Ou & Reynolds, 2008) and are more academically engaged and motivated (Beal & Crockett, 2010; Domina et al., 2011). In a study of Black adolescents, educational expectations were one of the strongest predictors of academic performance (Sirin & Rogers-Sirin, 2004). With the demonstrated importance of academic expectations on children’s educational attainment in literature, it is essential to understand what may influence individuals’ educational expectations. This study aims to increase current knowledge on the underlying factors that influence parents’ educational expectations for their children.

**Child Sex and Educational Expectations in Black Families**

Expectancy-Value Theory states that parents’ educational expectations may be partly influenced by gender stereotypes (Eccles & Wigfield, 2002). Considerable research on child achievement has focused on Eurocentric gender stereotypes (Eccles & Wigfield, 2020). However, the Eurocentric belief that males are more intellectually capable than females (Bian, Leslie, & Cimpian, 2017; Gálvez, Tiffenberg, & Altszyler, 2019; Rivera & Tilesik, 2019) is frequently not applied to Black boys. Black boys are often perceived as less intellectually competent than Black girls (Noguera, 2003) and are often assumed to possess attributes that are inconsistent with academic achievement (Hall, 2001; Wright, 2009).

Lower educational expectations for Black boys are not only held by teachers (Gershenson et al., 2016; Ross & Jackson, 1991) but have been reported by Black parents as well (Wood et al., 2007). Generally, research has shown that parents assume high educational expectations for their children (Pinquart & Ebeling, 2020). However, several recent studies have shown trends of lower parental educational expectations for Black boys, even when controlling for their academic performance (Varner & Mandara, 2013; Wood et al., 2007; Wood et al., 2009). Investigators have suggested that parents’ beliefs surrounding racial discrimination may be influencing these findings (Varner & Mandara, 2013).

Previous research indicates that parents’ gendered experiences of discrimination are connected to their parenting practices (McNeil et al., 2016; Varner et al., 2020). Qualitative interviews with Black mothers demonstrate that they specifically fear for their sons’ safety, potential exposure to discrimination and the influence their race and sex will have on their experiences (Dow, 2016; Thomas & Blackmon, 2014; Williams et al., 2017). Fears about children’s exposure to discrimination have been substantially linked to mothers’ academic expectations (Varner & Mandara, 2013). Specifically, aspects of mothers’ cultural milieu (i.e., racial discrimination) were linked to lower educational expectations for Black children (Varner & Mandara, 2013). Their findings provide a possible explanation for previous reports of lower parental educational expectations for Black boys (Wood et al., 2007; Wood et al., 2009). This
study aims to extend previous findings by investigating the role of child sex in the proposed association between parents’ racial discrimination experiences and their educational expectations for their children.

**The Present Study**

The purpose of this study was to test a proposed model of children’s academic achievement that integrates Expectancy-Value Theory (Eccles & Wigfield, 2002) and Coll et al.’s (1996) Integrative Model. This proposed model is shown in Figure 1. This study specifically investigates: (a) the association between parents’ experiences of racial discrimination, parents’ educational expectations, children’s educational expectations and children’s academic achievement and (b) the moderating role of child sex on the association between parents’ racial discrimination experiences and educational expectations. These potential relations were studied in a sample of 3,174 Black mothers and 3,193 of their children.

This study broadens previous motivation and achievement-related research, which has focused heavily on Eurocentric perspectives (Eccles & Wigfield, 2020) or interracial comparisons of White and Black children (Wigfield et al., 2004), by focusing on factors specific to Black families. Previous research has shown that parental practices and beliefs (Benner & Mistry, 2007; Castro et al., 2015; Davis-Kean, 2005; Jeynes, 2005, 2007) influence child achievement. However, research on ethnic minorities and the influence of their cultural milieu on child achievement is lacking (Eccles & Wigfield, 2020).

On the basis of Expectancy-Value Theory (Eccles & Wigfield, 2002) and Coll et al.’s (1996) Integrative Model, a negative association between parents’ reports of racial discrimination experiences and children’s academic achievement was hypothesized. An additional prediction was that parents’ and children’s educational expectations would mediate the association between parents’ racial discrimination experiences and their children’s academic achievement. Given recent research on parents’ lowered educational expectations for Black boys (Varner & Mandara, 2013) and disproportionate parental worries regarding Black boys’ exposure to racial discrimination (Dow, 2016; Thomas & Blackmon, 2014; Varner & Mandara, 2013; Williams et al., 2017), it was further anticipated that child sex would moderate the relation between parents' racial discrimination experiences and educational expectations. So that mothers who reported racial discrimination experiences would hold lower expectations for boys than girls.

**Methods**

**Participants**

The sample consisted of 3,174 Black mothers from the original NLSY and 3,193 of their children who had data collected over expectation and achievement-related variables during specific age ranges. Of the included child participants, 50.7% were males (n = 1619). The average net family income was $28,251 (SD = $34,553) when children were between 0 to 14 years old.

**Procedure**

This study used data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the Children and Young Adults subset of the NLSY79 (NLSY79-CYA). Both surveys were administrated by the U.S. Department of Labor and collected information from a nationwide sample on a variety of measures including labor force involvement, attitudes, family life,
psychological and physical health, aptitude and academic achievement. The NLSY79 gathered data from a sample of individuals between the ages of 14 to 21 years old in 1979 (N = 12,686, 49.53% women) with an intentional oversampling of African Americans and Hispanic Americans. These participants were interviewed annually from 1979 to 1994, with continued surveying occurring biannually after 1994. In 1986, the NLSY-CYA began gathering data from the children of the women who were surveyed for the NSLY79. Mothers reported on their children’s development, their parenting and their expectations for their children. Once children reached age 10, they completed self-report surveys. Child measures were assessed biennially.

Measures

**Racial Discrimination experiences.** In the NLSY79, parents’ racial discrimination experiences were measured using 1-item from a self-report measure to assess if a participant had previously experienced discrimination while seeking employment. These experiences were recorded for mothers in 1979 and 1982. Participants were asked: “Have any of the following things ever caused you any problems in getting a good job -- discrimination on the basis of race.” Participants were asked to code “1” for “yes” and “0” for “no”. For this study, mothers’ responses were recoded as “1” if they answered “yes” for either recorded measure in 1979 or 1982. The full measure is located in Appendix A.

**Parents’ educational expectations.** Mothers’ educational expectations for their children were assessed from 1988 to 2014. Participants with school-aged children were prompted to estimate the future academic attainment of their children in a 1-item self-report measure. They were asked, “Looking ahead how far do you think your child will go in school? Will he/she…” Participants were then presented with the following answers and respective codes: “Leave high school before graduation (1), graduate from high school (2), get some college or other training (3), graduate from college (4), get more than four years of college (5), or something else [please specify] (6).” For this study, mothers’ responses of “something else” were recoded as “missing”. To increase the number of viable measurements and to establish temporal precedence, parents’ responses were averaged across a three-year period when their children were 8 to 10 years old. The full measure is located in Appendix B.

**Children’s educational expectations.** Children’s educational expectations were assessed using a 1-item self-report measure beginning in 1988. Children at the age of 10 or older were asked about the highest level of education they expected to attain in the future. The item asked, “How far do you think you will go in school? Do you think you will:” Participants were then presented with the following answers and respective codes: “Leave high school before graduation (1), graduate from high school (2), get some college or other training (3), graduate from college (4), get more than 4 years for college (5), do something else? [please write what] (6).” For this study, children’s responses of “something else” were recoded as “missing”. To increase the number of viable measurements and to establish temporal precedence, children’s responses were averaged across a two-year period when children were 11 to 12 years old. The full measure is located in Appendix C.

**Children’s academic achievement.** Children’s academic achievement was assessed through the Mathematics, Reading Recognition and Comprehension subtests of the Peabody Individual Achievement Test (PIAT; Dunn & Dunn, 1981; Dunn & Markwardt, 1970). PIAT subtests were administered to all children starting at the age of five. For the Mathematics subtest, children answered a series of multiple-choice questions centered on early mathematics skills. For
the Reading Recognition subtest, children were required to read a series of words and vocally identify them. For the Reading Comprehension subtest, children were required to read specific sentences and select a visual that matched their meaning. The PIAT is considered a valid and reliable measure of academic ability, with higher scores signifying higher academic achievement (Mott & Baker, 1995). Further information regarding PIAT subtests can be assessed at Dunn and Dunn (1981) and Dunn and Markwardt (1970). For this study, scores for each subtest were averaged across a two-year period when children were 13 to 14 years old. This was done to increase the number of viable measurements and to establish temporal antecedence by measuring children’s academic achievement scores after measurements of parents’ and children’s educational expectations.

**Child sex.** Child sex was assessed using a 1-item parent-report measure. Mothers were asked to indicate the sex of their children from the years of 1986 to 1992 and 2002 to 2016. Male children were coded as “0” and female children were coded as “1”.

**Family Income.** Family income was assessed using a compound income variable from the NSLY79. Income from mothers and their household members (related by blood or marriage) were included. Family net income ranges were coded as the following: $1 to $999 (1), $1,000 to $1,999 (1000), $2,000 to $2,999 (2000), $3,000 to $3,999 (3000), $4,000 to $4,999 (4000), $5,000 to $5,999 (5000), $6,000 to $6,999 (6000), $7,000 to $7,999 (7000), $8,000 to $8,999 (8000), $9,000 to $9,999 (9000), $10,000 to $14,999 (10000), $15,000 to $19,999 (15000), $20,000 to $24,999 (20000), $25,000 to $49,999 (25000) and $50,000 or higher (50000). For this study, income codes from when children were 0 to 14 years old were averaged to create a total net family income variable.

**Design**
This study included 3,174 Black mothers from the National Longitudinal Survey of Youth 79 and their 3,193 children who were participants in the NLSY-Child & Young Adult Survey. The study’s primary predictor was parents’ racial discrimination experiences during youth (i.e., from the ages of 14 to 22) measured in 1979 and 1982. Parents’ educational expectations for their children from the ages of 8 to 10 and children’s educational expectations from the ages of 11 to 12 were conceptualized as mediating variables. The study’s primary outcome was children’s academic achievement, which was evaluated from the ages of 13 to 14. Regression analyses were used to test for moderated mediation.

**Statistical Plan**
The data was analyzed using PROCESS Macro version 3.5 (Hayes, 2020) in SPSS to conduct regression analyses to test for moderated mediation. A separate analysis was conducted for each dependent variable (i.e., type of academic achievement) Parents’ educational expectations and children’s educational expectations were both tested as mediating variables on the association between parents’ racial discrimination experiences and children’s academic achievement. Child sex was tested as a moderating variable for the associations between parents’ racial discrimination experiences and children’s academic achievement, as well as between racial discrimination and maternal academic expectations, maternal expectations and child expectations.
and child expectations and achievement. The averaged total net family income from when children were between the ages of 0 to 14 years old was used as a statistical control.

Results

Descriptive statistics and correlation results. Before testing the full model, as seen in Figure 1, we examined the correlations between the study’s variables. The means, standard deviations and correlations of the study’s variables are shown in Table 1. Mothers’ educational expectations, children’s educational expectations, children’s PIAT math scores, children’s PIAT recognition scores and children’s PIAT comprehension scores were all significantly and positively correlated. Girls had higher maternal and child academic expectations, PIAT math scores, PIAT recognition scores and PIAT comprehension scores. In contrast to all other measures, children’s PIAT recognition scores did not significantly differ by child sex. In addition, mothers’ racial discrimination experiences were only significantly correlated to children’s PIAT recognition scores. The association between mothers’ racial discrimination experiences and children’s PIAT recognition scores was significant and negatively directed.

Moderated Mediation PIAT Math Results

Children’s PIAT Math Scores. Hypothesis 1 stated that mothers’ discriminatory experiences would be negatively associated with their children’s academic achievement scores. Regression analyses using Process MACRO 3.5 (Hayes, 2020) were conducted for each dependent variable. The average family net income when children were between the ages of 0 to 14 was tested as a covariate. Figure 2 depicts the proposed moderated mediation model for children’s PIAT math scores, along with coefficient and probability values for the direct effects of the study’s variables (as differentiated by child sex). Around 25% of the variance in children’s math scores (F(8,2173) = 90.36, R^2 = .25, p < .001) can be accounted for by the variables in our model. In agreement with hypothesis 1, mothers’ racial discrimination experiences (B = -4.47, SE = 1.08, p < .001) were significantly and negatively related to children’s math scores. In addition, mothers’ educational expectations (B = 3.91, SE = .45, p < .001) and children’s educational expectations (B = 3.55, SE = .40, p < .001) were significantly and positively related to children’s math scores. Lastly, net family income (B = .00, SE = .00, p < .001) was significantly related to children’s math scores. There was a significant interaction between child sex and children’s educational expectations for children’s math scores (B = -1.43, SE = .67, p = .012). This positive association between children’s expectations and math scores was stronger for boys (B = 3.37, SE = .40, p < .001) than girls (B = 1.91, SE = .40, p < .001). Child sex (B = 3.0, SE = 2.84, p = 2.92), the interaction between mothers’ discriminatory experiences and child sex (B = 1.15, SE = 1.55, p = .46) and the interaction between mothers’ educational expectations and child sex (B = -.07, SE = .63, p = .91) were not significantly related to children’s math scores.

Mothers’ Educational Expectations. Around 12% of the variance in mothers’ educational expectations (F(4,2177) = 75.57, R^2 = .12, p < .001) can be accounted for by the variables in our model. Child sex (B = .20, SE = .04, p < .001) was significantly and positively related to mothers’ educational expectations, with mothers holding higher educational expectations for girls in comparison to boys. Family net income (B = .00, SE = .00, p < .001) was significantly related to expectations as well. Mothers’ discriminatory experiences (B = -.06, SE = .07, p = .40) and the interaction between mothers’ discriminatory experiences and child sex (B = -.006, SE = .10, p = .95) were not significantly related to mothers’ educational expectations.
Contradictory to hypothesis 3, child sex was not supported as a moderator for the association between mothers’ racial discrimination experiences and their educational expectations.

**Children’s Educational Expectations.** Around 9% of the variance in children’s educational expectations (F(6,2175) = 37.10, R² = .09, p < .001) can be accounted for by the variables in our model. Mothers’ educational expectations (B = .32, SE = .03, p < .001) and child sex (B = .62, SE = .17, p < .001) were both significantly and positively related to children’s educational expectations. Family net income (B = .00, SE = .00, p < .001) was additionally significantly related to expectations. The conditional effects of mothers’ educational expectations at the values of the child sex revealed that mothers’ educational expectations were significantly and positively related to children’s educational expectations. The effect of mothers’ expectations on children’s expectations was stronger for boys (B = .32, SE = .03, p < .001) than girls (B = .20, SE = .03, p < .001). Mothers’ racial discrimination experiences (B = -.02, SE = .08, p = .79) and the interaction between mothers’ discriminatory experiences and child sex (B = -.11, SE = .12, p = .35) were not significantly related to children’s educational expectations.

**Mediation.** Hypothesis 2 stated that mothers’ and children’s educational expectations would mediate the association between mothers’ racial discrimination experiences and children’s academic achievement. The conditional indirect effects of mothers’ racial discrimination experiences on children’s PIAT math scores revealed that mothers’ and children’s educational expectations did not have a significant indirect effect on this association. The indirect effect of mothers’ and children’s educational expectations was insignificant for boys (95% [-.85, .36]) and girls (95% [-.89, .45]). Therefore, inconsistent with hypothesis 2, mothers’ and children’s educational expectations were not supported as mediators. In addition, our proposed pathway of moderated mediation for children’s PIAT math scores was unsubstantiated.

**Moderated Mediation PIAT Recognition Results**

**Children’s PIAT Recognition Scores.** Figure 3 depicts the proposed moderated mediation model for children’s PIAT recognition scores, along with coefficient and probability values for the direct effects between the study’s variables (as differentiated by child sex). Around 23% of the variance in children’s mean recognition scores (F(8,2177) = 80.87, R² = .23, p < .001) can be accounted for by the variables in our model. In agreement with hypothesis 1, mothers’ racial discrimination experiences (B = -5.08, SE = 1.19, p < .001) were significantly and negatively related to children’s recognition scores. In addition, mothers’ educational expectations (B = 5.26, SE = .49, p < .001), children’s educational expectations (B = 3.37, SE = .44, p < .001) and child sex (B = 9.07, SE = 3.14, p < .01) were significantly and positively related to children’s recognition scores. Girls scored, on average, 9 points higher on the recognition assessment than boys. Lastly, net family income (B = .00, SE = .00, p < .001) was significantly related to children’s recognition scores. There was a significant interaction between children’s educational expectations and child sex (B = -1.46, SE = .63, p < .05). The positive association between child expectations and PIAT recognition scores was stronger for boys (B = 3.37, SE = .44, p < .001) than girls (B = 1.91, SE = .44, p < .001). The interactions between mothers’ discriminatory experiences and child sex (B = -.39, SE = 1.71, p = .82) and mothers’ educational expectations and child sex (B = -.74, SE = .69, p = .29) were insignificant to children’s recognition scores.

**Mothers’ Educational Expectations.** Around 12% of the variance in mothers’ educational expectations (F(4,2181) = 75.28, R² = .12, p < .001,) can be accounted for by the
variables in our model. Child sex (B = .2002, SE = .04, p < .001) was significantly and positively related to mothers’ educational expectations, with mothers holding higher educational expectations for girls in comparison to boys. Family net income (B = .00, SE = .00, p < .001) was significantly related to expectations as well. Mothers’ discriminatory experiences (B = -.06, SE = .07, p = .40) and the interaction between mothers’ discriminatory experiences and child sex (B = -.004, SE = .10, p = .96) were not significantly related to mothers’ educational expectations. In contrast with hypothesis 3, child sex was not supported as a moderator for the association between mothers’ racial discrimination experiences and their educational expectations.

Children’s Educational Expectations. Around 9% of the variance in children’s educational expectations (F(6,2179) = 36.46, R² = .091, p < .001) can be accounted for by the variables in our model. Mothers’ educational expectations (B = .32, SE = .03, p < .001) and child sex (B = .63, SE = .17, p < .001) were significantly and positively related to children’s educational expectations. Family net income (B = .00, SE = .00, p < .001) was additionally significantly related to expectations. The conditional effects of mothers’ educational expectations at the values of the child sex revealed that mothers’ educational expectations were significantly and positively related to children’s educational expectations. The effect of mothers’ expectations on children’s expectations was stronger for boys (B = .32, SE = .03, p < .001) than girls (B = .19, SE = .03, p < .001). Mothers’ racial discrimination experiences (B = -.02, SE = .08, p = .84) and the interaction between mothers’ discriminatory experiences and child sex (B = -.12, SE = .12, p = .32) were not significantly related to children’s educational expectations.

Mediation. The conditional indirect effects of mothers’ racial discrimination experiences on children’s PIAT recognition scores revealed that mothers’ and children’s educational expectations did not have a significant indirect effect on this association. The indirect effect of mothers’ and children’s educational expectations was insignificant for boys (95% [-.25, .11]) and girls (95% [-.09, .04]). Therefore, in contrast with hypothesis 2, mothers’ and children’s educational expectations were not supported as mediators. In addition, our proposed pathway of moderated mediation for children’s PIAT recognition scores was unsupported.

Moderated Mediation PIAT Comprehension Results

Children’s PIAT Comprehension Scores. Figure 3 depicts this proposed moderated mediation model, along with coefficient and probability values for the direct effects between the study’s variables (as differentiated by child sex). Around 20% of the variance in children’s mean comprehension scores (F(8,2159) = 68.11, R² = .20, p < .001) can be accounted for by the variables in our model. Following hypothesis 1, mothers’ racial discrimination experiences (B = -3.98, SE = 1.0, p < .001) were significantly and negatively related to children’s comprehension scores. In addition, mothers’ educational expectations (B = 3.88, SE = .41, p < .001) and children’s educational expectations (B = 2.42, SE = .37, p < .001) were significantly and positively related to children’s comprehension scores. Lastly, net family income (B = .00, SE = .00, p < .001) was significantly related to children’s comprehension scores. Child sex (B = 3.39, SE = 2.66, p = .20), the interactions between mothers’ discriminatory experiences and child sex (B = -.45, SE = 1.44, p = .75), mothers’ educational expectations and child sex (B = -.36, SE = .58, p = .53) and children’s educational expectations and child sex (B = -.56, SE = .53, p = .29) were insignificant to children’s comprehension scores.

Mothers’ Educational Expectations. Around 12% of the variance in mothers’ educational expectations (F(4,2163) = 75.42, R² = .12, p < .001) can be accounted for by the
variables in our model. Child sex (B = .21, SE = .04, p < .001) was significantly and positively related to mothers’ educational expectations, with mothers holding higher educational expectations for girls in comparison to boys. Family net income (B = .00, SE = .00, p < .001) was significantly related to expectations as well. Mothers’ discriminatory experiences (B = -.06, SE = .07, p = .42) and the interaction between mothers’ discriminatory experiences and child sex (B = -.03, SE = .10, p = .80) were not significantly related to mothers’ educational expectations. Therefore, in contradiction with hypothesis 3, child sex was not supported as a moderator to the association between mothers’ racial discrimination experiences and their educational expectations.

**Children’s Educational Expectations.** Around 9% of the variance in children’s educational expectations (F(6,2161) = 35.74, p < .001, R² = .09) can be accounted for by the variables in our model. Mothers’ educational expectations (B = .32, SE = .03, p < .001) and child sex (B = .66, SE = .1, p < .0018) were significantly and positively related to children’s educational expectations. Family net income (B = .00, SE = .00, p < .001) was additionally significantly related to expectations. The conditional effects of mothers’ educational expectations at the values of the child sex revealed that mothers’ educational expectations were significantly and positively related to children’s educational expectations. The effect of mothers’ expectations on children’s expectations was stronger for boys (B = .32, SE = .03, p < .001) than girls (B = .18, SE = .03, p < .001). Mothers’ racial discrimination experiences (B = -.01, SE = .08, p = .87) and the interaction between mothers’ discriminatory experiences and child sex (B = -.11, SE = .12, p = .36) were not significantly related to children’s educational expectations.

**Mediation.** The conditional indirect effects of mothers’ racial discrimination experiences on children’s PIAT comprehension scores revealed that mothers’ and children’s educational expectations did not have a significant indirect effect on this association. The indirect effect of mothers’ and children’s educational expectations was insignificant for boys (95% [-.19, .09]) and girls (95% [-.10, .03]). Therefore, in disagreement with hypothesis 2, mothers’ and children’s educational expectations were not supported as mediators. In addition, our proposed pathway of moderated mediation for children’s PIAT comprehension scores was unfounded.

**Discussion**

Applying Expectancy Value Theory (Eccles & Wigfield, 2002) and the Integrative Model for the Study of Developmental Competencies in Minority Children (Coll et al., 1996), the current study examined whether mothers’ educational expectations and children’s educational expectations mediated the association between mothers’ experiences of racial discrimination and children’s academic achievement. The moderating role of child sex for the conceived association between mothers’ racial discrimination experiences and children’s academic achievement was also investigated. The current study’s findings revealed a significant and negative association between mothers’ experiences of racial discrimination and children’s academic achievement. Specifically, children whose mothers reported previous experiences of racial discrimination held lower academic achievement scores than children whose mothers did not. This, however, was not explained through educational expectations. In addition, the association between mothers’ racial
discrimination experiences and children’s academic achievement did not differ by sex. However, significant sex interactions for educational expectations and achievement were found.

Main Findings

The role of racial discrimination experiences in the model. Prior research has previously demonstrated a link between racially and ethnically discriminatory experiences and children’s academic achievement (Alfaro et al., 2008; Benner & Graham, 2013; Benner et al., 2018; DeGarmo & Martinez, 2006; Alfaro et al., 2009; Stone & Han, 2005). Our findings expand upon this literature by identifying that even parental experiences of racial discrimination can be a detrimentally influential factor on children’s academic achievement. This finding points to the increasingly pervasive influence that discrimination has on the outcomes of Black children.

The role of educational expectations in the model. The association between mothers’ discriminatory experiences and children’s academic achievement remains unexplained by our results. Mothers’ educational expectations, and subsequently children’s educational expectations, were not related to mothers’ racial discrimination experiences. This result was not consistent with previous theory which posited that racial discrimination may impact parents’ beliefs surrounding their children’s achievement (Eccles & Wigfield, 2020). Additionally, our findings did not follow previous research, which revealed that aspects of mothers’ cultural milieu (i.e., fears about racial discrimination) were linked to lower academic expectations (Varner & Mandara, 2013).

These findings may then be explained by alternative factors. Parents who experience racial discrimination may be placed under additional stress, which can negatively impact the quality of their parenting and subsequently influence the general outcomes of their children (Anderson et al., 2015; Varner et al., 2020). In addition, racial discrimination may lead to adaptive beliefs and behaviors surrounding children’s academics (Coll et al., 1996; Varner & Mandara, 2013), which may then impact the direction of their achievement (Eccles & Wigfield, 2002). Mothers’ experiences of racial discrimination may have resulted in informed parental behaviors and beliefs, outside of educational expectations, that contributed to lower levels of academic achievement.

The role of child sex in the model. As our results found no supported association between mothers’ discriminatory experiences and their educational expectations, child sex was not confirmed as a moderator for this association. This finding contradicts previous theory (Coll et al., 1996) and research which suggested that Black boys would be subjected to lower educational expectations due to the presence of racial discrimination in the lives of Black Americans (Varner & Mandara, 2013). Our results revealed that mothers did indeed hold lower educational expectations for Black boys in comparison to Black girls, but this association was not influenced by mothers’ experiences of racial discrimination. This finding may be due to the multiple factors that influence educational expectations. Expectancy Value Theory (Eccles & Wigfield, 2002) states that multiple aspects of socializers’ cultural milieu, children’s stable characteristics, and children’s previous achievement contribute to socializer’s educational
expectations. Parents’ low appraisals for Black boys may need to be investigated from a more multidimensional lens.

Additional Findings

 Mothers’ and children’s educational expectations. In agreement with previous research, our results showed a positive association between parental educational expectations and children’s educational expectations (Kirk et al., 2011; Rutchick et al., 2009; Trusty, 2002; Trusty et al., 2003; Yamamoto & Holloway, 2010). In addition, our results supported previous findings of a positive association between parental educational expectations and children’s academic achievement (Benner & Mistry, 2007; Davis-Kean, 2005; Jeynes, 2005, 2007; Yamamoto & Holloway, 2010). In fact, mother’s educational expectations were more strongly associated with academic achievement than children’s own expectations. This finding supports the notion that parental beliefs are incredibly influential to the beliefs and behaviors of their children (Eccles & Wigfield, 2002). Supporting the concept that it is as equally important to investigate the processes surrounding parents’ achievement related beliefs and behaviors when researching academic achievement processes.

 Child sex. Although child sex was not supported as a moderator for mothers’ discriminatory experiences and their educational expectations, all other areas of the model were moderated by child sex. As seen in previous research (Wood et al., 2007; Wood et al., 2009), our results indicated that mothers hold lower educational expectations for Black boys in comparison to Black girls. Corresponding with previous findings that identified a direct link between parents’ and children’s educational expectations (Kirk et al., 2011; Rutchick et al., 2009; Trusty et al., 2003; Yamamoto & Holloway, 2010), Black boys held lower educational expectations for their future educational attainment in comparison to Black girls. As educational expectations are associated with subsequent academic achievement (Beal & Crockett, 2010; Benner & Mistry, 2007; Domina et al., 2011; Gill & Reynolds, 1999; Halle et al., 1997; Sirin & Rogers-Sirin, 2004), our results revealed that boys scored lower on all three achievement tests in comparison to Black girls.

 In addition, the positive association between mothers’ educational expectations and children’s educational expectations was stronger for boys. Correspondently, the positive association between children’s educational expectations and their academic achievement was also stronger for boys. These findings corroborate a wealth of research that has found that Black boys are subjected to lower educational expectations (Gershenson et al., 2016; Ross & Jackson, 1991; Wood et al., 2007; Wood et al., 2009) and hold lower levels of achievement in comparison to Black girls (Ross et al., 2021). These results, along with previous findings, suggest that Black boys face an increased vulnerability in the academic sphere (Honora, 2002; Skiba et al., 2011; Swanson et al., 2003), in part due to low appraisals of their academic capacity.

 In summary, children whose mothers reported previous experiences of racial discrimination scored lower on all three achievement measures. This association was not explained through mothers’ or children’s educational expectations. Mothers’ racial discrimination experiences were not significantly related to their educational expectations. Mothers’ educational expectations, however, were positively associated with children’s expectations. In addition, mothers’ and children’s educational expectations were positively associated with academic achievement. Lastly, child sex was supported as a moderator for the links between mothers’ educational expectations, children’s educational expectations and
children’s academic achievement. Boys scored lower on all three measures than girls, but there was a stronger link between maternal and child expectations and between child expectations and achievement among boys. These findings suggest that mothers’ racial discrimination experiences hold an enduring link to the outcomes of Black children. An additional suggestion from these results is that Black boys are disproportionally disadvantaged by the interrelated nature of educational expectations and academic achievement.

Theoretical Implications

The finding that parents’ discriminatory experiences are associated with children’s achievement is significant due to the exclusivity of previous motivation and achievement literature. Factors such as racism and discrimination have been highlighted as prevalent influences on the achievement of ethnic minority children, however they have mutually been under researched (Eccles & Wigfield, 2020) Therefore, our findings provide further evidence that experiences of racial discrimination, even previous parental experiences of racial discrimination, have a ubiquitous influence on the future achievement of children. This finding adds weight to Eccles and Wigfield’s statement that further research is needed on the cultural milieu portion of their model (Eccles & Wigfield, 2020).

In further agreement with Expectancy Value Theory, parents’ educational expectations, children’s educational expectations and child achievement were all linked in our findings, with boys experiencing stronger effects for all associations. These findings substantiate the theoretical proposal that observed gender differences in achievement may be influenced by parents’ achievement related beliefs and family demographics such as race and gender (Eccles & Wigfield, 2002). This suggestion was additionally supported by the finding that parents’ educational expectations held a stronger effect on children’s achievement than children’s own expectations. Accordingly, our results imply that Expectancy Value Theory is applicable to the motivation and achievement processes of Black families.

Practical Implications

As parents’ and children’s expectations were more strongly associated with achievement for boys in comparison to girls, our results suggest that Black boys are more vulnerable to negative appraisals of their academic capacity. With recorded trends of teachers (Gershenson et al., 2016; Ross & Jackson, 1991), parents (Varner & Mandara, 2013; Wood et al., 2007), and now children holding lower expectations for Black boys, this phenomenon may be labelled as a risk factor to their achievement. Intervention programs should draw from current research and theory to formulate strategies that target the formation of these expectations and their transference from socializers to children.

Limitations

This study’s numerous findings should be considered with the following limitations. Although an association was found between mothers’ experiences of racial discrimination and children’s academic achievement, this study’s measure for parents’ racial discrimination experiences was relatively weak. As it was an unestablished single item measure, it was impossible to confirm its reliability and validity.

In addition, although recent research has suggested that previous parental experiences of racial discrimination may have lasting consequences for the future outcomes of their children (Ford, Hurd, Jagers, & Sellers, 2013), discrimination experiences were only measured in 1979.
and 1982. These measurements were reported decades before recorded measures of education expectations or academic achievement. Future research should utilize more recent and expanded measurements of parental racial discrimination experiences to fully measure the strength of its influence on child achievement.

Lastly, our research tested for a limited number of covariates due to measurement discrepancies in the longitudinal data. As mothers’ educational attainment has been shown to be significantly influential to their educational beliefs and related behaviors (De Civita et al., 2004; Englund et al., 2004; Pingault et al., 2015), future research should test for mothers’ highest attained educational level as it is significant to any possible associations involving children’s academic achievement.

Future Research

The majority of recent research has focused on the deleterious association between children’s experiences of racial discrimination and their academic achievement (Benner et al., 2018; Chavous et al., 2008). However, based on our finding of a temporally persistent link between parents’ racial discrimination experiences and children’s achievement, I recommend that future research investigate the specific pathways of this relation. We additionally recommend that future research investigate the role of parents’ beliefs surrounding racial discrimination, rather than their experiences, on their educational expectations. This is due to previous theory (Eccles & Wigfield, 2002) and research (Varner & Mandara, 2013) establishing a clear link between parental beliefs surrounding racial discrimination and their educational expectations. Finally, future research should investigate the underlying processes behind the finding that parents’ expectations are more strongly linked to boys’ expectations than girls’ expectations. Examining variables related to this association may lead to a more comprehensive understanding of the specific processes surrounding achievement in Black children.

Conclusion

Despite these limitations, the present study advances current understanding of the specific processes surrounding motivation and achievement in Black families. Whereas previous research has limited investigation to racially inclusive factors (Eccles & Wigfield, 2020), the current findings demonstrate that factors specific to racial minorities, such as racial discrimination, have a significant and lasting impact on child achievement. Our findings additionally supplement previous research that suggest that Black boys face an increased vulnerability in academic spheres (Davis-Kean, 2005; Noguera, 2003; Skiba et al., 2011; Swanson et al., 2003). Additional research that investigates other possible influences on the association between parental experiences of racial discrimination and child academic achievement is necessary to achieve a more complete understanding of achievement-related risk factors specific to Black children.
References


Stone, S., & Han, M. (2005). Perceived school environments, perceived discrimination, and


Appendix A

4. We're trying to find out the main reasons why many young people your age have trouble getting a good job. Have any of the following things ever caused you any problems in getting a good job—(First/Next) READ CATEGORIES A-F AND CODE "YES" OR "NO" FOR EACH.

<table>
<thead>
<tr>
<th>Category</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Lack of transportation? (PROBE IF NECESSARY: Has it caused you any problems in getting a good job?)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>B. Discrimination on the basis of race?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>C. Discrimination on the basis of nationality?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>D. Discrimination on the basis of sex?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E. Discrimination on the basis of age?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>F. A problem with English?</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

TIME AM ENDED PM
Appendix B

BKGN-44

Looking ahead, how far do you think Child First Name will go in school? Will he/she...

(PRESS "DOWN ARROW" TO TURN ON SCREEN AND TO HIGHLIGHT AN ANSWER. THEN PRESS <ENTER> TWICE TO CONTINUE.)

(PRESS <F6> FOR DON'T KNOW AND <F5> FOR DO NOT WISH TO ANSWER.)

1 leave high school before graduation
2 graduate from high school
3 get some college or other training
4 graduate from college
5 take further training after college
6 or something else? (other specify)

Lead In(s): BKGN-43H [Default], BKGN-41 [1:1]
Default Next Question: BKGN-45
Appendix C

28. How far do you think you will go in school? Do you think you will:

*(Circle Only One)*

- Leave high school before graduation ........... 1
- Graduate from high school ..................... 2
- Get some college or other training .............. 3
- Graduate from college .......................... 4
- Get more than 4 years of college ............... 5
- Do something else? *(Please write what) ..... 6

__________________________________________

__________________________________________
Table 1
Descriptive statistics and correlations for study variables

<table>
<thead>
<tr>
<th>Overall sample</th>
<th>1. Mothers’ racial discrimination experiences (X)</th>
<th>2. Mothers’ educational expectations (M₁)</th>
<th>3. Children’s educational expectations (M₂)</th>
<th>4. Children’s PIAT math scores (Y₁)</th>
<th>5. Children’s PIAT recognition scores (Y₂)</th>
<th>6. Children’s PIAT comprehension scores (Y₃)</th>
<th>7. Child Sex (W)</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mothers’ racial discrimination experiences (X)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.02</td>
<td>.30**</td>
<td>.23**</td>
<td>—</td>
<td>94.63</td>
<td>.31</td>
</tr>
<tr>
<td>2. Mothers’ educational expectations (M₁)</td>
<td>—</td>
<td>3.55</td>
<td>.03</td>
<td>.03</td>
<td>—</td>
<td>.03</td>
<td>—</td>
<td>.23**</td>
<td>3.73</td>
</tr>
<tr>
<td>3. Children’s educational expectations (M₂)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.03</td>
<td>.23**</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3.73</td>
</tr>
<tr>
<td>4. Children’s PIAT math scores (Y₁)</td>
<td>.02</td>
<td>.30**</td>
<td>.23**</td>
<td>—</td>
<td>.07**</td>
<td>.32**</td>
<td>.22**</td>
<td>.60**</td>
<td>—</td>
</tr>
<tr>
<td>5. Children’s PIAT recognition scores (Y₂)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.04</td>
<td>.30**</td>
<td>.21**</td>
<td>.55**</td>
<td>.67**</td>
<td>—</td>
</tr>
<tr>
<td>6. Children’s PIAT comprehension scores (Y₃)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.04</td>
<td>.30**</td>
<td>.21**</td>
<td>.55**</td>
<td>.67**</td>
<td>—</td>
</tr>
<tr>
<td>7. Child Sex (W)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.10**</td>
</tr>
</tbody>
</table>

Notes. M = mean; SD = standard deviation.
* p < .05.
** p < .01.
*** p < .001.
Two-tailed.
Table 2
Descriptive statistics and correlations for the study’s variables by child sex

<table>
<thead>
<tr>
<th>Sex breakdown</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mothers’ racial discrimination experiences (X)</td>
<td>—</td>
<td>-.03</td>
<td>.06</td>
<td>.00</td>
<td>-.11**</td>
<td>-.03</td>
</tr>
<tr>
<td>2. Mothers’ educational expectations (M₁)</td>
<td>-.03</td>
<td>—</td>
<td>.14**</td>
<td>.29**</td>
<td>.32**</td>
<td>.27**</td>
</tr>
<tr>
<td>3. Children’s educational expectations (M₂)</td>
<td>.02</td>
<td>.28**</td>
<td>—</td>
<td>.20**</td>
<td>.17**</td>
<td>.14**</td>
</tr>
<tr>
<td>4. Children’s PIAT math scores (Y₁)</td>
<td>.00</td>
<td>.31**</td>
<td>.25**</td>
<td>—</td>
<td>.59**</td>
<td>.55**</td>
</tr>
<tr>
<td>5. Children’s PIAT recognition scores (Y₂)</td>
<td>-.03</td>
<td>.29**</td>
<td>.25**</td>
<td>.61**</td>
<td>—</td>
<td>.62**</td>
</tr>
<tr>
<td>6. Children’s PIAT comprehension scores (Y₃)</td>
<td>-.05</td>
<td>.32**</td>
<td>.27**</td>
<td>.56**</td>
<td>.71**</td>
<td>—</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>Mean (SD)</th>
<th>Mean (SD)</th>
<th>Mean (SD)</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female Children</td>
<td>3.70 (.04)</td>
<td>3.85 (.04)</td>
<td>94.71 (.42)</td>
<td>99.41 (.49)</td>
<td>90.98 (.38)</td>
</tr>
<tr>
<td>Male Children</td>
<td>3.41 (.04)</td>
<td>3.60 (.04)</td>
<td>94.54 (.47)</td>
<td>95.62 (.54)</td>
<td>90.01 (.44)</td>
</tr>
</tbody>
</table>

Notes. Correlations results for female children are above the diagonal and results for male children are below the diagonal. M = mean; SD = standard deviation.

*p < .05.

**p < .01.

***p < .001

Two-tailed
Fig. 1. Proposed moderated mediation model.
Fig. 2. Moderated mediation results for children’s PIAT Math scores.
Fig. 3. Moderated mediation results for children’s PIAT Recognition scores.
Fig. 4. Moderated mediation results for children’s PIAT Comprehension scores.

♂ .32***  
♀ .18***

Mother’s Educational Expectations (M₁)  
Children’s Educational Expectations (M₂)

- .06

-3.98***

Mothers’ Racial Discrimination Experiences (X)

Children’s PIAT Comprehension Scores (Y₃)

2.42***
Creativity and Mood Across Cultures: The Relationship Between Mood Disorders and Creativity in North American, South Korean and Indian University Students

Brian Gyamfi
The University of Texas at Austin
Ann Repp, PhD
Eric Youngstrom, PhD
Sabeen Rizvi, PhD

Mood disorders refer to a group of mental health diseases that primarily affect a person’s emotional state. They commonly cause emotions inconsistent with circumstances and diminish mental functionality. The common association between the mood disorder (particularly bipolar disorder) and artistic creativity may provide better understanding of effective mood disorder treatments. Researchers have done studies regarding the association between mood disorders and creativity, but research on this topic is extremely limited to mostly writers in the United States. This article investigated the cultural relevancy of this association, namely whether culture plays a crucial role in that association, based on the cross-cultural surveys of students from Gargi College, University of Delhi, University of North Carolina at Chapel Hill, and Korea University. Our results show that evidence on the correlation between mood disorders and creativity was neutralized by data from all three countries, but both the correlation between mood disorders and creativity and the cultural influence on the correlation were revealed by the correlation map grouped by countries.

Keywords: mood disorders, emotions, creativity, cross-culture

Introduction

“Apophenia means finding patterns or meaning where others don’t. Feelings of revelations and ecstasies usually accompany it. It has some negative connotations in psychological terminology when it implies finding meaning or pattern where none exists; and some positive ones when it implies finding something important,” wrote Peter J. Carroll [1], “useful or beautiful. It thus links creativity and psychosis, genius and madness.”

Many people have longed held onto Carroll’s suspicion that creativity and psychosis are entwined. Presumably, Western history holds countless examples of influential individuals from the creative world who suffered from certain mood disorders. Notably, Vincent Van Gogh who suffered from during much of his short life, prior to committing suicide at the age of 37.

The concept of the “Mad Genius” has had a long history in the West that goes as far back as the ancient times with Dante and Aristotle. This linkage of the Western notion of madness and
artistic temperaments, has been well documented in highly creative persons. However, much of the literature on this subject involves mainly a small population of established writers from the Western world, fails to take into account cultural relevance, relies on anecdotal and biographical sources, or suffers from an inadequate definition of both creativity and mood disorders.

In 1992, psychiatrist Arnold M. Ludwig released an in-depth biographical survey of 1,005 well-known individuals from the artistic world in the 20th century, many of whom had been diagnosed and treated for a mood disorder [4]. He highlighted that the subjects who were successful in the creative world experienced two to three times the rate of psychosis, suicidal thoughts and attempts, mood disorders and the misuse of substances compared those who were successful in the business and scientific world. In his sample, Arnold M. Ludwig noticed that many of the poets were hospitalized for displaying a psychotic episode. These poets also proved to be 18 times more likely to commit suicide compared to the general public.

One of the most eminent contributors to this field of research depicting the correlation between artistic temperament and mood disorders today has been Dr. Kay Redfield Jamison, a former researcher at UCLA and now at the Johns Hopkins Medical Center [5]. Bringing together results from previous studies and her own research, Dr. Jamison concluded that a great number of recognized creatives (artist, writers and performers)—far more than what could be explained away by chance—meet the diagnostic criteria for manic-depression or major depression established in the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). In fact, Dr. Jamison noticed that the mood disorders seemed to, at times, improve or otherwise contribute to creativity in some of her subjects. In another biographical study of 36 famous British poets from the years 1705 to 1805 Dr. Jamison also discovered a similar elevated rate of psychosis and severe psychopathology as Arnold M. Ludwig had discovered in his study. The poets were “30 times more likely to have had manic-depressive illness than were their contemporaries, at least 20 times more likely to have been committed to an asylum and some five times more likely to have taken their own life.

For the present study, we explored the correlation between mood disorders—assessed with the 7up7down inventory “a 14-item measure of manic and depressive tendencies carved from the General Behavior Inventory” [7] and creativity—assessed with the Biographical Inventory of Creative Behaviors [3]—across three cultures, North America, South Korea, and India with the specific goal of understanding wither culture plays a role in the correlation between mood disorders and creativity. The hypothesis for the study is that those who deemed creative in North America will display increased rates of mood disorders compared to those who are deemed creative in South Korea and India. We will then discuss possible reasons as to why culture plays a role when it comes to the correlation between mood disorders and creativity.

2 Method

2.1 Participants

The study was conducted under the guidance of Dr. Ann Repp, Department of Psychology, University of Texas at Austin; Dr. Eric A. Youngstrom, Department of Psychology and Neuroscience, University of North Carolina at Chapel Hill, Dr. Sabeen Rizvi, Department of Psychology, Gargi College, University of Delhi, and was approved by the University of Texas
at Austin’s IRB (Institutional Review Board) for NHSR (Not Human Subjects Research Determination). Prior to the participation in the study, all subjects were obligated to sign a written informed consent. A total of 427 subjects participated in the study. Participants were male and female identifying university students who were enrolled in the University of North Carolina at Chapel Hill, University of Delhi, or Korea University.

2.2 Surveys

The 7up7down inventory is a 14-item measure of manic and depressive tendencies taken from the General Behavior Inventory (GBI) [7]. The Biographical Inventory of Creative Behaviors (BICB) is a 34-item scale that assesses everyday creativity across a broad range of domains [7]. The BICB uses a forced choice yes/no response format to achieve its goal of determining creativity [6]. The Creative Achievement Questionnaire (CAQ) is a self-report measure of creative achievement that assesses achievement across 10 domains of creativity [2]. Sample items include, “My work has been reviewed in national publications” (creative writing) and “I have received a grant to pursue my work in science or medicine” (scientific discovery. It exhibits acceptable validity.

2.3 Procedure

All participants (N = 427) were given detailed (yes/no and scaled) questions to measure their creativity, this was the Biographical Inventory of Creativity Behaviors (BICB). They were also given the Creative Achievement Questionnaire (CAQ) as a way to self-report a measure of their creative achievement. The participants were then given the 7up7down questionnaire to measure their temperament. For the 7up7down questionnaire the participants picked between the numbers 0-3. 0 stood for never or hardly ever, 1 stood for sometimes, 2 stood for often, and 3 stood for very often or almost constantly. These tests were administered through a computer under the supervision of Dr. Eric Youngstrom and Dr. Sabeen Rizivi.

3 Results

To garner results, I will be conducting a correlational analysis, therefore, testing the relationship between creativity and mood. I will conduct a general one that includes all participants, then separate ones for each country to determine whether the specific relationship exists in all countries.
Table 1: Definition and values of considered variables

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Variable Meaning and Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>The gender of the subject (male/female)</td>
</tr>
<tr>
<td>Age</td>
<td>The age of the subject (unit: year, 17-48)</td>
</tr>
<tr>
<td>Race</td>
<td>The racial makeup of the subject (Asian, white, Black, other)</td>
</tr>
<tr>
<td>Class</td>
<td>The year in the undergraduate program (freshman, sophomore, junior, senior)</td>
</tr>
<tr>
<td>Birth Country</td>
<td>The birth country of the subject (Korea, North America, India)</td>
</tr>
<tr>
<td>Gbi7up</td>
<td>The degree of manic based on the General Behavior Inventory (0-1; 0: not manic, 1: manic)</td>
</tr>
<tr>
<td>Gbi7down</td>
<td>The degree of depression based on the General Behavior Inventory (0-1; 0: not depressive, 1: depressive)</td>
</tr>
<tr>
<td>BicbTotal</td>
<td>The total score in the BICB test (0-34)</td>
</tr>
<tr>
<td>BicbTotalPomp</td>
<td>The percent of maximum possible score in the BICB test (0-1)</td>
</tr>
<tr>
<td>Caqpomp</td>
<td>The average (per question) degree of creativity based on the Creativity Achievement Questionnaire</td>
</tr>
<tr>
<td>Gcacpomp</td>
<td>The percent of maximum possible number of checked positive items in the Gough Creative Adjective Checklist</td>
</tr>
<tr>
<td>Gcaapositive</td>
<td>Numbers of checked positive items in the Gough Creative Adjective Checklist (0-18)</td>
</tr>
<tr>
<td>Gcacreverse</td>
<td>Numbers of checked reverse items of the Gough Creative Adjective Checklist (0-12)</td>
</tr>
</tbody>
</table>

Tab. 1 lists the considered variables in the statistical analysis.
Fig. 1. Correlation plot of considered variables about BICB

Fig. 1 shows that the correlation between BICB-indicated creativity and GBI-indicated mood disorders is a very weak positive. The correlation values on the diagonal block of the correlation plot is always 1. On the correlation plot there are two regions, one on the right and the other located on the bottom left. For the top right region the opacity of the circle dictates the absolute value of the correlation. For example, more transparency means the absolute value of the correlation is lower and less transparency means the absolute value of the correlation is higher. The bottom left region is the numerical values of the correlation symmetric to the diagonal line. The large blue circle signifies a positive correlation and because it is the darkest blue it shows the correlation is 1. The bicbpomp is a linear transformation of the bicbtotal.
Fig. 2. Correlation plot of considered variables about GCAC and CAQ

Fig. 2 shows that the correlation between GCAC-indicated creativity and GBI-indicated mood disorders is negligible. The correlation between CAQ-indicated creativity and GBI-indicated mood disorders is a very weak positive as shown in the table below.

The Correlation of CAQpomp and gbi7up, gbi7down

<table>
<thead>
<tr>
<th></th>
<th>caqpomp</th>
<th>gbi7up</th>
</tr>
</thead>
<tbody>
<tr>
<td>caqpomp</td>
<td>1.0000000</td>
<td>0.2712583</td>
</tr>
<tr>
<td>gbi7up</td>
<td>0.2712583</td>
<td>1.0000000</td>
</tr>
<tr>
<td>caqpomp</td>
<td>1.0000000</td>
<td>0.1041824</td>
</tr>
<tr>
<td>gbi7down</td>
<td>0.1041824</td>
<td>1.0000000</td>
</tr>
</tbody>
</table>

Fig. 3 shows that the correlation between BICB-indicated creativity and GBI-indicated mood disorders is weakly positive for India and South Korea while that is weakly negative for North America. This difference may imply some cultural relevancy of the correlation between creativity and mood disorder.

Fig. 4 shows that the correlation between GCAC-indicated creativity and GBI-indicated mood disorders is very weak for India and South Korea, but that is significantly negative for North America. Furthermore, correlation between CAQ-indicated creativity and GBI-indicated mood disorders is weakly positive for all three countries.
Correlation of the BICB of North America, India, and South Korea

**Corr_bicb_South Korea**

**Corr_bicb_North America**

**Corr_bicb_India**
Correlation of the GCAC of North America, India, and South Korea

Corr_gcaec_South Korea

Corr_gcaec_India

Corr_gcaec_North America
Table 2: Statistical summary of considered variables in BICB, GCAC, and CAQ

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Race</th>
<th>BicbTotal</th>
<th>BicbTotalpomp</th>
<th>gbi7up</th>
<th>gbi7down</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Min.</td>
<td>17.0000</td>
<td>Min.</td>
<td>2.0000</td>
<td>Min.</td>
</tr>
<tr>
<td>1st Qu.</td>
<td>1.0000</td>
<td>1st Qu.</td>
<td>17.0000</td>
<td>1st Qu.</td>
<td>2.0000</td>
<td>1st Qu.</td>
</tr>
<tr>
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<td>21.0000</td>
<td>Median</td>
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</tr>
<tr>
<td>Mean</td>
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<td>Mean</td>
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<td>Mean</td>
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<td>Mean</td>
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<tr>
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<td>3rd Qu.</td>
<td>4.0000</td>
<td>3rd Qu.</td>
</tr>
<tr>
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<td>44.60</td>
<td>Max.</td>
<td>5.0000</td>
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</tr>
<tr>
<td>NA's</td>
<td>6</td>
<td>NA's</td>
<td>10</td>
<td>NA's</td>
<td>6</td>
<td>NA's</td>
</tr>
</tbody>
</table>

Fig. 0.1 Correlation Coefficients

<table>
<thead>
<tr>
<th>Age</th>
<th>Race</th>
<th>bicbTotal</th>
<th>bicbTotalpomp</th>
<th>gbi7up</th>
<th>gbi7down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
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<td>-0.04</td>
<td>-0.06</td>
<td>-0.06</td>
<td>-0.10</td>
</tr>
<tr>
<td>Race</td>
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<td>-0.05</td>
<td>-0.05</td>
<td>0.25</td>
</tr>
<tr>
<td>bicbTotal</td>
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<td>1.00</td>
<td>1.00</td>
<td>0.20</td>
</tr>
<tr>
<td>bicbTotalpomp</td>
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<td>-0.05</td>
<td>1.00</td>
<td>1.00</td>
<td>0.20</td>
</tr>
<tr>
<td>gbi7up</td>
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<td>0.25</td>
<td>0.20</td>
<td>0.20</td>
<td>1.00</td>
</tr>
<tr>
<td>gbi7down</td>
<td>-0.03</td>
<td>0.05</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.28</td>
</tr>
</tbody>
</table>

This table illustrates the correlation coefficients and their significance level.

Means of Creativity by Country

<table>
<thead>
<tr>
<th>Country</th>
<th>BicbTotal</th>
<th>BicbTotalpomp</th>
<th>Gbi7up</th>
<th>Gbi7down</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.2507</td>
<td>8.512</td>
<td>0.1727</td>
<td>0.2892</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.2390</td>
<td>8.105</td>
<td>0.2667</td>
<td>0.2704</td>
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<tr>
<td>North America</td>
<td>0.3238</td>
<td>11</td>
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<td>0.3016</td>
</tr>
</tbody>
</table>

This table illustrates the means for the creativity variables by country.

Means of Moods Disorder by Country

<table>
<thead>
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<th>Country</th>
<th>GcacPomp</th>
<th>GcacPositive</th>
<th>GcacReverse</th>
</tr>
</thead>
<tbody>
<tr>
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<td>8.053</td>
<td>0.1727</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.4416</td>
<td>4.862</td>
<td>8.385</td>
</tr>
<tr>
<td>North America</td>
<td>0.5192</td>
<td>6.7692</td>
<td>8.8077</td>
</tr>
</tbody>
</table>

This table illustrates the means for the mood disorder variable by country.
Discussion and Cultural Factors:

From the results we are able to conclude that there is a correlation between creativity and mood disorders. This could be because an expression of creativity is a universal human singularity that is strongly rooted in culture and has its own profound impact on culture itself. We can acknowledge through the results of this experiment that creativity that embraces novelty and originality fits perfectly with the North American belief system, which is based on the ideals of individuality, democracy, and freedom. In opposition, Eastern cultures—such as South Korea and India—firmly grounded in the ideals of interdependence, collectivity, cooperation, and authoritarianism have developed a different perspective on the meaning inherent to novelty and originality [8]. Thus, depending on the part of the world you reside you will view the concept of creativity differently.

Although, culture has a strong influence on the conceptualization of creativity and on creative expression the relationship between cultural factors and creative expression is a very complicated one. Therefore, the intermingling of the forces of culture and creativity is not only shared but also contains societal, historical, and individual factor
References


Gender Differences in Cultural Mistrust and Mental Health in the Black Community

Marlie Harris
The University of Texas at Austin
Kevin Cokley, PhD, Faculty Mentor

This study will examine the relationship between cultural mistrust and the mental health of black men and women (n=408). Given that previous research has shown a correlation between cultural mistrust and help seeking behavior in a variety of cultures, we want to examine how the intersection of race and gender impacts the relationship between mental health and cultural mistrust in Black Americans. Results from our independent sample t-test and correlation analysis indicate significant gender differences in the effects of cultural mistrust and overall mental health in Black Americans. Higher rates of cultural mistrust were significantly correlated with lower mental health averages. Black women from our study had higher rates of cultural mistrust and lower mental health compared to Black men. Implications for our results and the effects of racial trauma on Black women will be further discussed.

Introduction

In the United States, we currently live in a political climate that has brought nationwide awareness to racial strife and injustice. Through news outlets and social media, blatant mistreatment and racial discrimination has become common place in our media consumption. It is not uncommon to open your phone to a notification about the brutal murder or harassment towards a Black person. In response, many people and institutions have expressed a desire to improve the quality of life of Black Americans by implementing diversity training, defunding police, institutional wide changes, or even reparations. However, the damage has already been done. While individuals and corporations revamped their logos with new and improved black versions as a demonstration of solidarity with the Black Lives Matter Movement. Many black people have found themselves looking back at these attempts with healthy skepticism (Vredenburg et al 2020).

The phenomena known as “cultural mistrust” or, wariness towards white people or institutions, is the reason for this doubt and skepticism. Black people have been exposed to regular images of brutality towards people that look like them, and research has shown that witnessing such atrocities can increase an individual’s level of cultural mistrust (Neville et al., 2009). Additionally, cultural mistrust has been shown to be an inhibitor of help seeking behavior in Black Americans (Terrell & Terrell, 1984). During a time of collective trauma with Black Lives Matter protests and Covid 19, it is extremely pressing that people are receiving the mental healthcare that they need during these trying times. However, as more traumatic events become more accessible to witness, we can predict higher levels of cultural mistrust and unattended mental suffering to occur in the Black population (Bryant-Davis et al., 2017) (Miller & Vittrup, 2020).

In response to this, we are interested in exploring the ways cultural mistrust affects Black Americans’ mental health in different ways. Previous research has shown men and women respond to trauma in distinct ways, so we are interested in exploring the relationship between mental health and
cultural mistrust with emphasis on these gendered differences. By bringing awareness to these differences, we hope to expand on the ongoing discussion surrounding cultural mistrust in new ways.

**Cultural Mistrust**

In response to a history of flagrant social, political, and physical racial trauma inflicted upon Black people, cultural mistrust or a wariness towards white people, white institutions, and people that adopt white-centered ideology naturally occurred in African Americans. Considering the brutal history of chattel slavery that connects many African Americans to the African diaspora, distrust of white people would be a natural conclusion for survival. The historical disparity in treatment of African Americans relative to their white counterparts has created a system of oppression that has actively attempted to suppress the Black voice. It would be preferential to avoid situations where you would be vulnerable to inequality, and cultural mistrust is the defense that accounts for this. To put it simply, cultural mistrust is a natural response to racism.

The rationality behind this phenomenon led researchers to vehemently argue against the original coinage of “cultural paranoia” that Grier and Cobbs (1992) denoted as mistrust (Grier & Cobbs, 1992). Grier and Cobbs brought attention to White psychiatrists that over diagnosed paranoa in the Black community because they pathologized normal behavior as irrational (Neville et al., 2009). In response to this, Terrell and Terrell (1992) completed a study on African American, West Indian, and Caribbean college students that found cultural mistrust to be related to perceived discrimination rather than anything to do with clinical paranoia (Terrell & Terrell, 1992) Black scholars rejected this notion and any arguments that described cultural mistrust as some form of mental illness. However, that does not mean that cultural mistrust does not have an impact on mental health. Researchers have found cultural mistrust to be an inhibitor to help seeking behavior, likelihood to stay in therapy, and even a person’s perception of a white counselor’s trustworthiness and effectiveness (Terrell & Terrell, 1984) (Watkins & Terell, 1988) (Wright, 2004).

Also, while cultural mistrust surrounding African Americans will be discussed for the duration of this paper, this is not an occurrence limited to African Americans. Cultural mistrust buffered effects of microaggressions in Asian Americans; It impacted academic achievement in Latinas; and even impacted the cultural identity in Native Americans (Kim et al., 2017) (Cooper & Sanchez, 2016) (Simms, 1995). It is a multifaceted occurrence that affects a multitude of people of color, but it is so endemic within the African American population, scholars have stated it should be considered in the ecological model of all African Americans and an aspect of the Black experience or “Black consciousness” (Neville & Mobley, 2001).

A Black person does not have to experience racism firsthand for this phenomenon to occur, but witnessing the persecution of other African Americans is enough to increase their level of cultural mistrust (Taylor & Brown, 1984). It is not an innate mindset when someone is born to be distrustful towards whites, but an acquired behavior from seeing injustice (Neville et al., 2009). Therefore, in times where videos of African Americans being legally executed by police are widely accessible to anyone with an internet connection, we can anticipate more heightened rates of cultural mistrust now than in previous generations. Then research has mixed results on the way it influences children as they go through school. Some researchers found heightened cultural mistrust led to higher overall achievement, while other studies found students with higher mistrust felt unfairly treated by teachers regardless of their actions. (Irving & Hudley, 2005) (Chase, 2000). As cultural mistrust increased, students felt more unsafe and dissatisfied with campus climate (Chase, 2000).
Cultural Mistrust and Mental Health

Previous research examining the relationship between cultural mistrust and mental health has not shown any indication of cultural mistrust acting as a cause or form of mental illness (Wright, 2004). As a result of this, most of the literature covering the topic is examining cultural mistrust as an inhibitor to help seeking behavior (Neville et al., 2009). Previous studies have indicated a negative relationship between a Black American’s level of cultural mistrust and their likelihood to receive mental health services. (Nickerson et al., 1994; Terrell & Terrell, 1984; Thompson et al., 1994; Watkins & Terrell, 1988; Watkins et al., 1989).

Also, research indicates that higher levels of cultural mistrust in Black men have caused them to doubt the quality of care a white counselor would provide and a stronger aversion towards attending clinics that are predominantly run and employed with white people (Neville et al., 2009). Due to the existing pattern of aversion in the Black community to mental healthcare, a variety of Black researchers have attempted to bring awareness to the necessary considerations a white therapist must take when working with Black clients. They must understand that rather than their identity as a mental health professional, their identity as a white person may be the most pressing issue on a Black client’s mind. If that client does not trust White people in other social situations, then they will be significantly less likely to trust a White therapist (Whaley, 2001). So, it is imperative to take cultural variables into account when working with a client and examining racial differences, because it is easy to overlook cultural differences as nonexistent variables (Whaley, 2001).

Also, as time goes on, cultural mistrust will become an ever more pressing variable, because studies have shown that Black youth have higher levels of cultural mistrust than adults (Whaley, 2001). So as younger generations get older, we can predict cultural mistrust will become more prevalent as a cohort effect.

The Intersection of Race, Gender, and Mental Health

Historically previous research has shown that cultural mistrust has been shown to occur in both Black men and women to varying degrees (Neville et al., 2009). In order to understand cultural mistrust’s gendered psychological impact, it is important to examine the relationship between traditional gender roles and mental health as well as the ways they differ in the Black community.

Traditional ideas of femininity and masculinity have been linked to “innately” different responses to negative stimuli. It is believed that women “internalize” problems that exhibit itself in the form of anxiety or depression. This concept is believed to be the cause of disparate levels of anxiety and depression between men and women (Rosenfield & Mouzon, 2012). Alternatively, men “externalize” their issues through aggression or physicality (Simon, 2014). The reason for these differences has been connected to traditional ideas of femininity and masculinity because studies have shown a negative correlation with masculinity and anxiety, while femininity was positively correlated with anxiety (Wester et. al, 2006). However, many researchers have brought attention to the fact men often hide psychological problems and express reluctance to report symptoms of mental illness out of fear of social stigma (Safford, 2008; Simon, 2014). This has led some researchers to bring up concerns of significant underreporting of depression in men, as well as, measurement bias in diagnostic tools that consider epidemiological influences when screening for depression (Real, 2003; Ubelacker et al., 2008).

These ideas have even been socialized across genders, because when shown a vignette of a man with depression, both men and women were less likely to state the man had depression than a woman exhibiting the same symptoms (Swami, 2012).
Also, traditional ideas of femininity and masculinity completely differ in the Black population. Research has shown that culturally African Americans have more flexible gender conceptualizations when compared to White Americans (Rosenfield & Mouzon, 2012).

Black women have been shown to reject more stereotypically “feminine” traits such as passivity, dependency, and subordination that White women endorse as a part of traditional femininity. When asked to describe womanhood, many Black women described it as being self-determined and prideful and they brought up other key themes they associated with womanhood such as strength, self-sacrifice, care for others, and experiences of oppression (Settles, 2006; Thomas et al., 2011; Abrams et al., 2016; Settles et al., 2008).

Some research even implies Black women and men have higher gender role equality because the traditional economic inequality between Black men and women is lower than that of white men and women. Also due to the higher levels of education Black women have when compared to Black men, Black women often have more power than Black men (Rosenfield & Mouzon, 2012). However, this factor is controlled by socioeconomic status (Cotter et al., 2011). These differences in power run completely contrary to traditional power structures seen in White gender roles where men possess most of the power due to education and income inequality.

However, the differences seen in African American gender roles do not come without their caveats. Higher rates of education and pay have led many African American women to be the primary breadwinner in their household. This may lead to feelings of emasculation and negative health outcomes in men due to socialization of male breadwinner expectations (Springer, 2010). Also, the pressure that comes from an overload of demands such as stressful home environments or an unsupported employer could lead to higher rates of depression and anxiety in women (Rosenfield & Mouzon, 2012). This could then be magnified by the “cost of caring” or the phenomena that shows women are more affected by events that occur to significant others (Kessler et al., 1985).

This is important from a cultural mistrust perspective, because simply seeing the persecution of someone with the same identity as you can lead to higher rates of cultural mistrust (Taylor & Brown, 1984). So, with the consideration towards the “cost of caring”, one can hypothesize that witnessing this trauma this may have a larger effect on women than previously indicated with the easier accessibility to said trauma via social media.

**The Current Study**

After acknowledging the different ways socialization influences gender differences in mental health, this study intends to expand cultural mistrust literature by examining whether cultural mistrust influences mental health in men and women differently. Since both variables have been shown to have gender differences, we want to know if there are actual differences in the relationship of cultural mistrust and mental health. There have not been many studies focusing on gender differences as it relates to cultural mistrust, so we would anticipate our results to support previous gender studies showing higher rates of mental illness in women regardless of cultural mistrust and higher rates of cultural mistrust in women as a reflection of higher societal stressors on Black women. If these differences occur, we attribute it to a cohort effect of ongoing societal changes where Black women have been put in more roles of power and higher education when compared to Black men.
Methods

Sample

Participants were recruited from a nationwide sample of college students via Qualtrics Panel. Inclusion criteria required participants to identify with a Black racial identity and be at least 18 years old. There were 333 participants that identified as women and 75 that identified as male. There were 5 participants that did not identify with male or female and did not meet inclusion criteria due to a lack of enough participants with other gender identities. There was a total of 408 participants that were included in data analysis. There were 126 students that identified as freshman, 132 as sophomores, 85 juniors, and 70 seniors. The average age of the sample was approximately 22 years old.

Procedure

Upon receiving approval from the University of Texas Institutional Review Board, Dr. Kevin Cokley began surveying participants for a study entitled “How college environment impacts sense of belonging, intention to persist, and academic outcomes in African American students” from a national Qualtrics panel that was administered. Participants were compensated for their participation. The original survey measured 16 different variables: Cultural Congruency, retention, University Environment, cultural mistrust, Cognitive Emotional Dependency, Spirituality, Collectivism, Rituals, Mental Health, Devaluing Academic Successes, Racial Centering, Caring, Approachability, Respectfulness, and Perceived Discrimination. Our results for the current study will be based on results from the mental health and cultural mistrust variables.

Measures

For the purpose of this study we will be focusing on survey results from the cultural mistrust index and mental health inventory. We used the abbreviated 7 item, 5 point likert scale, Cultural Mistrust Inventory (Terrell & Terrell, 1981) to measure the four domains of individual cultural mistrust. We used the abbreviated 5 item, 5 point likert scale, Mental Health Inventory (Veit, 1983) to measure an individual's overall mental wellbeing.

Results

The original data set (N=413) was reduced to a sample size of 408 participants (98.8% of the original sample), due to the exclusion of gender variables outside of male and female. We conducted a preliminary review of the data that included examination of means, standard deviations, and internal reliability estimates. To analyze the relationship between the cultural mistrust and mental health variable, we completed a two tailed sample t-test and correlation analysis.
Table 1: Independent Samples T-test of Gender Differences in Cultural Mistrust and Mental Health

<table>
<thead>
<tr>
<th></th>
<th>Levene's Test for Equality of Variances</th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>95% Confidence Interval of the Difference</th>
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<tr>
<td></td>
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<td>Sig.</td>
<td>t</td>
<td>df</td>
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<td>MENTALHEALTH</td>
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<td>.097</td>
<td>3.314</td>
<td>406</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mistrust</td>
<td>4.697</td>
<td>11.515</td>
<td>.001</td>
<td>.47025</td>
</tr>
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<td></td>
<td></td>
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</table>

Table 2: Correlation Analysis of Gender, Cultural Mistrust, and Mental Health

**Correlations**

<table>
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<th>MENTALHEALTH</th>
<th>Mistrust</th>
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</thead>
<tbody>
<tr>
<td>mfsex</td>
<td>Pearson Correlation</td>
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<td>-0.164**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.001</td>
<td>.006</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>408</td>
<td>408</td>
</tr>
</tbody>
</table>

**MENTALHEALTH**

|        | Pearson Correlation | -0.164** | 1       | -0.270** |
|        | Sig. (2-tailed)     | .001     | .000    |          |
|        | N          | 408      | 413     | 413     |

**Mistrust**

|        | Pearson Correlation | 0.136** | -0.270** | 1       |
|        | Sig. (2-tailed)     | .006    | .000    |          |
|        | N          | 408      | 413     | 413     |

**. Correlation is significant at the 0.01 level (2-tailed).**
Statistical Analysis

As seen in Table 1, the two tailed t-test had statistical significance in the mean differences between gender and mental health (p < .01) and the mean of gender and cultural mistrust (P < .001). These results show that Black women have higher levels of cultural mistrust when compared to Black men and lower mental health averages.

Correlations shown in Table 2 suggest that Black participants with higher cultural mistrust towards White people, institutions, and culture were likely to have lower mental wellbeing. Also, results indicate significant gender differences in cultural mistrust and mental wellbeing across male and female participants.

As seen in Table 2, the correlation had statistical significance in the relationship between gender and mental health (r = -.164, p = .001), gender and cultural mistrust (r = .136, p = .006), and the relationship between mental health and cultural mistrust (r =-.270, p = < .001).

Discussion

Our study shows a significant correlation between mental health and cultural mistrust, and that Black women have higher rates of cultural mistrust compared to Black men. While our mental health results support previous literature denoting higher rates of mental illness in women, our cultural mistrust results imply systems of oppression are having more of an impact on Black women and the way they interact with the world than Black men. The reasoning for these differences could be for a multitude of reasons.

The stress from the intersection of race and gender creates a unique perspective that Black women must use to navigate the world. The persisting stereotype of the “strong black woman” places adverse pressure on black women that negatively influences their mental health (Thomas et al., 2004). As time goes on, there has become a larger economic and education gap between Black men and Black women that put Black women in more positions of power and primary Breadwinner positions (Rosenfield & Mouzon, 2012). As a result of this, Black women are placed in a unique position of a “gendered racial identity” that puts them under the unique stress of racial and sexist oppression that
could magnify external stressors (Thomas et al., 2011) (Jones et al., 2018). This factor will become even more apparent as Black women are put in positions of power that puts them at the forefront of racial and gendered hostility.

Since these changes have occurred due to societal shifts over time, we contribute our results to a cohort effect that reflects the increasing stress and pressure that are placed on Black women. These increased pressures could lead to higher rates of cultural mistrust, because the magnitude of trauma is significantly greater on women than men (Kessler et al., 1985). As a natural defense mechanism to these outside stereotypes, it seems natural to adopt cultural mistrust as a coping mechanism to outside pressure. In the current climate of racial trauma, it is unsurprising to see higher rates of cultural mistrust in women than men.

As for the correlation we saw between mental health and cultural mistrust, we believe this is an extension of the effects of collective racial trauma that Black people are currently experiencing (Bryant-Davis et al., 2017). As levels of cultural mistrust increase, we can hypothesize this is an indication of higher exposure to racial trauma, and thus leads to higher rates of mental illness or mental duress.

Limitations and Implications

This is a correlational study, and these are preliminary findings. Also, our data was collected with Qualtrics panel which is not a truly random sample. So, to better support this study, more research needs to be conducted looking at the relationship between cultural mistrust and its impact on mental health. Also, future research should be done looking at the “gendered racial identity” model and how specifically it relates to cultural mistrust.

As for future implications, we could predict higher rates of cultural mistrust as a result of ongoing discussions surrounding Police brutality and Black Lives Matter, so there will be more instances of mental illness due to the racial trauma that comes from it. So, there is a collective responsibility to understand our own mental well-being and practices to protect our own mental health. So, I would implore any reader to take time to reach out for help when they are struggling, be honest with themselves, take time away from negative stimuli, and take time to practice self-care.
References


Modeling of the Production of a Single Top Quark in Association with a Photon with Monte Carlo Generators

Bryce Holloway
The University of Texas at Austin
Peter Onyisi, PhD, Faculty Mentor

The investigation of the modeling of the production of a single top quark in association with a photon using MadGraph5 and Pythia8 generators is discussed. Standard Model $tq\gamma$ events can be produced with MadGraph5+Pythia8 at leading-order (LO) through radiative production and radiative decay. At present MadGraph5 is only capable of producing $tq\gamma$ events through radiative production at next-leading-order (NLO). However, Pythia8 can model radiative decay events through the $tq$ process at NLO. The two NLO samples histograms’ sum displays no significant difference in shape from the LO sample histograms. This implies that the sum of the two NLO samples can be used in the continued search for the $tq\gamma$ process.

Introduction

The top quark is the heaviest known particle within the Standard Model (SM) [1]. Its coupling to the Higgs boson makes it a potential testing ground for beyond Standard Model (BSM) physics [8]. The production of a single top quark in association with a photon ($tq\gamma$) is a rare process predicted by the SM but has not been observed by any experiment yet. Measuring the cross section of this process can test SM predictions about the top quark’s charge and its interactions with the W boson and photon [2].

The CMS experiment conducted a search for the $tq\gamma$ process using partial Run-2 data corresponding to a luminosity of 35.9 fb$^{-1}$. Specifically, the search targeted events in which the top quark decays into a W
boson and b quark, followed by the W boson decaying into a muon and a neutrino. The search resulted in an observed significance of 4.4 sigma indicating the first evidence of events consistent with the tqγ process [3]. The ATLAS collaboration has started a search for this process with full Run-2 data corresponding to a luminosity of 139 fb⁻¹.

The Standard Model predicts three channels in which the tqγ process is produced: s-channel, t-channel, and tW-channel [4]. The t-channel has the largest contribution for this process and will be the focus for this paper.

Based on the source of the photon, tqγ events can be classified into two categories: radiative production and radiative decay. The radiative production category includes events in which a photon is produced along with a top quark. The radiative decay category includes events in which a photon is produced from the decay products of a top quark. Feynman diagrams for events of each category can be seen in Figure 2 [3].

![Feynman diagrams](http://example.com/diagrams.png)

**Figure 2:** (left) Radiative decay event for a general decay and (right) radiative production event

Two approximations are used when modeling the tqγ process: leading-order (LO) and next-to-leading-order (NLO) in quantum chromodynamics. NLO generators include loop diagrams, additional radiation and provide greater accuracy than LO generators. At LO, MadGraph5+Pythia8 can produce events belonging to both radiative production and radiative decay categories. At NLO, MadGraph5_aMC@NLO can only produce radiative production category events. Radiative decay category events cannot be produced with MadGraph5_aMC@NLO because it cannot model the top quark at NLO due to the final state, consisting of five particles, being too large to specify [5]. The NLO contribution of radiative decay events can be approximated by producing the tq process with MadGraph5_aMC@NLO, in which a photon is added to the event by Pythia8 during the showering process [6]. In this report, a comparison of modeling the tqγ process with LO and NLO generators is given.
2 ATLAS Detector

The ATLAS detector [7] is a multipurpose particle physics detector with a forward-backward symmetric cylindrical geometry and has a coverage of nearly $4\pi$. The detector consists of an inner tracking detector (ID) surrounded by a thin superconducting solenoid providing a magnetic field, an electromagnetic (EM) and hadron calorimeter, and a muon spectrometer (MS).

The ID consists of a pixel detector, semiconductor tracker and transition radiation tracker. It is responsible for measuring particle with transverse momentum $p_T > 0.5$ GeV and covers the pseudorapidity range of $|\eta| < 2.5$.

The EM calorimeter consists of a barrel that covers the range of $|\eta| < 1.475$ and two end caps that covers the range of $1.375 < |\eta| < 3.2$. It is responsible for the measurements of electrons and photons. The hadronic calorimeter consists of a tile calorimeter and an end-cap calorimeter that covers the range of $0.8 < |\eta| < 1.7$ and $1.5 < |\eta| < 4.9$ respectively. It is responsible for the measurement and absorption of hadronic showers.

The MS consists of four gas chambers: monitored drift tubes (MDT), cathode strip chambers (CSC), resistive plate chambers (RPC), and thin gap chambers (TGC). It is responsible for measuring the momentum of muons and triggering them. It covers a range of $1.6 < |\eta| < 2.7$.

3 Simulated Events

All events are produced in the 4-flavor scheme meaning protons and jets in MadGraph5 are defined as gluons and four flavors of quarks ($u, d, c, u\sim, d\sim, s\sim, c\sim$).

3.1 LO $tq\gamma$ Process

The exact definition of the tq$\gamma$ process at LO is shown in Figure 3. For event selection for this process, photons at generator level are required to have $e > 10$ GeV and $|\eta| < 5$ and leptons are required to have $|\eta| < 5$. The angular distance between photon and other particles, defined as $\Delta R = \sqrt{\eta^2 + \phi^2}$, is required to be $\Delta R > 0.2$. A total of 100,000 events are generated for this process.
3.2 NLO tqγ Process

The exact definition of the tqγ process at NLO is shown in Figure 4. In this process the top quark is decayed leptonically by MadSpin. The selection requirements are identical to the requirements for the LO tqγ process. A total of 100,000 events are generated for this process.

3.3 NLO tq Process

The exact definition for the tq process at NLO is shown in Figure 5. Similar to NLO tqγ, the top quark is decayed leptonically by MadSpin. Leptons are required to have $|\eta| < 5$. A total of 600,000 events are generated for this process. A higher number of tq events are generated for this process compared to NLO tqγ and LO tqγ events to reduce statistical uncertainty.
4 Results

The experimental cross sections obtained from MadGraph5+Pythia8 for LO tqγ, NLO tqγ and NLO tq are 1.412 pb, 1.1802 pb and 62.41 pb respectively.

A comparison of all three samples is presented after making the following selection cuts: all events where the photon parent is a hadron are excluded; photons are required to have $p_T > 10$ GeV and $|\eta| < 2.5$; and leptons are required to have $p_T > 27$ GeV and $|\eta| < 2.5$. All processes are normalized to their respective cross sections at a luminosity of 139 fb$^{-1}$. Each ratio plot is defined as LO tqγ/(NLO tq + NLO tqγ). These ratio plots would determine if the combination of contributions from NLO tq and NLO tqγ is equivalent to the contributions from LO tqγ.

As expected, the $\Delta R(l, \gamma)$ for NLO tq peaked at a lower value than the other processes due to the produced photons being closer to the leptons in radiative decay events. The value peaked at approximately $\pi$ for LO tqγ and NLO tqγ. This clearly displayed that two separate regions were being observed depending on the process. These results can be seen in Figure 6.

![Figure 6: ΔR (lepton, photon) plot comparing all three processes](image)

The energy and transverse momentum for the produced photons were expected to be larger in radiative production events than in radiative decay events. The processes peak in the same area for the photon energy and $p_T$, but the peaks are noticeably sharper for the NLO tq histogram. These results can be seen in Figure 7. Additionally, lepton and top quark plots are displayed in Figure 8.
Figure 7: (left) Photon energy plot and (right) photon transverse momentum plot comparing all processes

Figure 8: (right) Top quark pT plot and (left) lepton ID plot comparing all three processes

5 Conclusion

In this report a comparison of LO and NLO plots are presented. All photon related plots tend to have LO tqγ lie between NLO tq and NLO tqγ due to containing events from both NLO processes. The ratio plots are relatively flat with the offsets being a result of normalization. This suggests that LO tqγ histograms are essentially the same shape as the sum of the NLO processes histograms implying that there are no significant differences between generators. This allows the use of MadGraph5 _aMC@NLO and Pythia8 to produce NLO tq and NLO tqγ samples to search for the production of a single top quark in association with a photon. These results suggest the tqγ process can continue to be modelled at the higher approximation of NLO during the attempts to observe the process.
References


Popularity in Three-Dimensional Stable Marriage
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The relationship between stability and popularity has been well studied in the context of classical stable marriage and its variants. In these settings, all stable matchings are popular, and all strongly popular matchings are stable. Additionally, there are efficient algorithms for popularity testing and finding strongly popular matchings. This project investigates these properties of popularity in three-dimensional variants of stable marriage. We show that stable matchings need not be popular, and strongly popular matchings need not be stable. We also give graph-theoretic formulations of popularity testing and prove the hardness of deciding whether a popular matching exists in instances of certain variants of three-dimensional stable marriage.

1 Introduction

The interest in matching problems with preferences in computer science began with the Gale and Shapley seminal paper, where they defined the Stable Marriage Problem (SM) [5]. An instance of SM involves sets of \( n \) men and \( n \) women, where each has a strict preference list over the agents in the opposite set. The extension of SM addressed this paper consists of matching three sets of agents instead of two. We refer to these sets as men, women, and dogs, and each agent of a set has preferences over the combinations of the other two sets [11]. For example, each man has a strict ranking over all possible women-dog pairs. This is called Three-Dimensional Stable Marriage (3DSM). Work related to 3DSM has produced largely negative results, as finding a matching, even in many restricted cases, is NP-complete [2, 7, 8, 11].

The popularity criterion has also been investigated in instances of SM. First, Gärdenfors found that all strongly popular matchings are stable, and all stable matchings are popular [6]. More recently, it was shown that there are efficient algorithms for popularity testing and for finding popular matchings in instances of SM [1, 9]. In this paper, we determine which of these results hold in 3DSM and its variants and present results on popularity testing and the problem of deciding the existence of popular matchings in a given instance.

2 Problem Statements and Notation

2.1 Stability

The Stable Marriage Problem With Incomplete Lists (SMI) consists of two disjoint sets \( M = \{m_1, \ldots, m_n\} \) and \( W = \{w_1, \ldots, w_n\} \), referred to as men and women respectively. Let
$E \subseteq \mathcal{M} \times \mathcal{W}$ be the set of acceptable man-woman pairs. Each $m_i$ strictly ranks the women in $E$. This ranking is called a preference list. For women $w_j, w_k$ and man $m_i$, we say that $m_i \text{ prefers } w_j \text{ to } w_k$ if $(m_i, w_j), (m_i, w_k) \in E(m)$ and $w_j$ exceeds $w_k$ on $m_i$'s preference list. The same holds for women with respect to men. A matching is a set $M \subseteq E$ such that each man and woman appear in a pair at most once, and for some agent $a$, we denote $M(a)$ as $a$'s partner in $M$. An acceptable pair $(m, w) \in E \setminus M$ blocks (or is called a blocking pair for) a matching $M$ if:

1. $m$ is unassigned or prefers $w$ to $M(m)$, and
2. $w$ is unassigned or prefers $m$ to $M(w)$.

The matching $M$ is stable if it admits no blocking pair.

The stable marriage problem SM is the special case of SMI where $E = \mathcal{M} \times \mathcal{W}$. Since all man-woman pairs are acceptable, when we define a matching in an instance of SM, it will always be a perfect matching (one where every agent is assigned exactly one partner). We will do the same for all settings that have no further restrictions on the acceptable assignments. Lastly, pairs (and later triples) will be represented with the agents concatenated instead of in a tuple form, so for some $m \in \mathcal{M}$ and $w \in \mathcal{W}$ we write $mw$ to denote $(m, w)$.

### 2.2 Stability in Three Dimensions

An instance of the Three-Dimensional Stable Marriage Problem (3DSM) of size $n$ consists of disjoint sets $\mathcal{M} = \{m_1, \ldots, m_n\}$, $\mathcal{W} = \{w_1, \ldots, w_n\}$, and $\mathcal{D} = \{d_1, \ldots, d_n\}$ of men, women, and dogs respectively. Each man $m_i$ has a strict preference list over the pairs in $\mathcal{W} \times \mathcal{D}$. Similarly, each woman has preferences over $\mathcal{M} \times \mathcal{D}$, and each dog has preferences over $\mathcal{M} \times \mathcal{W}$. We define the $\prec$ relation for preferences such that $m_i \text{ prefers } w_j d_k \text{ to } w_k d_\ell$ if only if $w_k d_\ell \prec_{m_i} w_j d_k$. A matching $M$ is a set of $n$ disjoint triples. As in SM, we define a blocking triple as an element $t \in \mathcal{M} \times \mathcal{W} \times \mathcal{D}$ such that each agent $a$ of $t$ prefers their assignment in $t$ to their assignment in $M$. A matching is stable if it admits no blocking triple.

In one special case of 3DSM, every man is primarily interested in the women, every woman is primarily interested in the men, and there are no restrictions on the preferences of dogs. For example, if some man $m_i$ prefers $w_j d_k$ to $w_l d_m$, then for any $p, q \in [n]$ the man $m_i$ prefers $w_j d_p$ to $w_l d_q$. We say that an instance of 3DSM with these restrictions has lexicographic preferences. Interestingly, instances of 3DSM with lexicographic preferences always admit a stable matching, and there is an algorithm to find one in polynomial time.

We define a variant of 3DSM where ties are allowed in the agents' preference lists. Instead of agents ranking elements of combinations of the other two sets, they now rank disjoint subsets of those combinations. For example, some $m_i$ could have the preference list

$$m_i \mid \{w_1d_1\} \{w_2d_2, w_3d_3, \ldots, w_{n-1}d_{n-1}\} \{w_nd_n\},$$

where $w_1d_1$ is his first choice, all of $w_2d_2, \ldots, w_{n-1}d_{n-1}$ is his second choice, and $w_nd_n$ is his last choice. Naturally, he is indifferent between every element of his second choice set. We call
this setting \emph{Three-Dimensional Stable Marriage with Ties (3DSMT)}. When the preferences of an agent in instances of 3DSMT have a set with only one element, we will present the element without brackets on the preference list. For example, \(m_i\)'s preference list may be written as

\[
m_i \mid w_1 d_1 \{w_2 d_2, w_3 d_3, \ldots, w_{n-1} d_{n-1}\} \ w_n d_n.
\]

In another variant of 3DSM, every agent has \textit{consistent} preferences. In 3DSM, it is possible for some man \(m_i\) to rank \(w_j d_k\) higher than \(w_i d_k\) yet also rank \(w_i d_p\) higher than \(w_j d_p\). An instance where some agent's preference lists has this property is called \textit{inconsistent}. To enforce consistency, Huang constructed a new kind of preference structure, where each agent has two \textit{simple lists} that rank agents from the other two sets \[7\]. For example, each man \(m_i\) would have a simple list with strict preferences over \(W\) and another over \(D\). Then, these simple lists are combined to make a \textit{preference poset} as shown in the following example. For man \(m_i\) and pairs \(w_j d_k\) and \(w_i d_p\), we have that \(w_j d_k\) precedes \(w_i d_p\) on \(m_i\)'s preference poset only if \(w_j\) ranks at least as high as \(w_i\) and \(d_k\) at least as high as \(d_p\) in the simple lists. Otherwise, they are incomparable.

A broader example of such a scheme is the \textit{Precedence by Ordinal Number} (PON) scheme \[7\]. In PON, each agent strictly ranks the agents of a single set for each simple list. The preference poset is simply constructed by summing the ranks of the simple lists of the elements in each pair. For some man \(m_i\) and woman \(w_j\), we define \(\text{rank}(m_i, w_j)\) to be the position of \(w_j\) on \(m_i\)'s simple list, where the most preferable pair is rank \(n\) and the least preferable is rank \(1\). Similarly, for a dog \(d_k\), \(\text{rank}(m_i, d_k)\) is the rank of \(d_k\) on \(m_i\)'s preference list. This is defined analogously for the women and dogs. We define the partial order on the preference poset such that for any \(i, j, k, \ell, p \in [n]\),

\[
(w_j, d_k) \preceq_{m_i} (w_{\ell}, d_p)
\]

is equivalent to

\[
\text{rank}(m_i, w_j) + \text{rank}(m_i, d_k) \leq \text{rank}(m_i, w_{\ell}) + \text{rank}(m_i, d_p).
\]

This can be generalized to a setting where agents give \textit{ratings} instead of rankings, where a higher rating is more preferable \[7\]. This means that agents are able to provide the same rating (causing a tie) to two or more agents on their simple list. We call this setting \textit{Precedence by Ordinal Number with Rankings (PON-RATE)}. In this paper, we allow ratings of any positive integer value.

In these settings, agents can be indifferent between two different pairs of partners, which allows for a variety of “strengths” of stability. For a triple \(t\) and agent \(a\), let \(t(a)\) be the pair that \(a\) is partnered with in \(t\). Given an instance of PON and a triple \(t\), we define different levels of stability based on their corresponding blocking triples.

\begin{itemize}
  \item \textit{Weakly Stable}: triple \(t\) is a blocking triple if for each \(a \in t\), we have \(M(a) \prec_a t(a)\) (this is equivalent to a blocking triple in 3DSM).
  \item \textit{Strongly Stable Matching}: triple \(t\) is a blocking triple if there are distinct \(a, b \in t\) such that \(M(a) \prec_a t(a)\) and \(M(b) \prec_b t(b)\), while for the final \(c \in t\), \(M(c) \preceq_c t(c)\).
\end{itemize}
• Super-Stable Matching: triple \( t \) is a blocking triple if for some \( a \in t \) \( M(a) \prec_a t(a) \), while for the remaining \( b, c \in t \), \( M(b) \preceq_b t(b) \) and \( M(c) \preceq_c t(c) \).

• Ultra-Stable Matching: triple \( t \notin M \) is a blocking triple if for each \( a \in t \), \( t(a) \preceq_a M(a) \).

The Three Dimensional Matching Problem (3DM) is an NP-complete decision problem that was used to show that the problem of deciding whether a given instance of 3DSM admits a stable matching is NP-complete [11]. A three-dimensional matching is defined as follows. Let \( A, B \), and \( D \) be finite, disjoint sets and \( T \subseteq A \times B \times D \). A set \( M \subseteq T \) is a matching if all triples in \( M \) are disjoint. 3DM is the decision problem where the input is an integer \( k \) and \( T \subseteq A \times B \times D \), and the problem is to determine whether there exists a matching \( M \subseteq T \) such that \(|M| \geq k \). This problem is still NP-complete when \( k = |A| = |B| = |D| \) [10]. When we refer to 3DM, we will refer to this restriction.

### 2.3 Popularity in Stable Marriage

For an instance of 3DSMT and two matchings \( M \) and \( M' \), we define \( P(M, M') \) to be the set of agents who strictly prefer \( M \) to \( M' \). Matching \( M \) is more popular than \( M' \) if more agents prefer \( M \) to \( M' \) than prefer \( M' \) to \( M \), meaning \(|P(M, M')| > |P(M', M)|\). Recall that if ties are allowed, then agents can be assigned different partners in \( M \) and \( M' \) while still being indifferent between them (meaning that they are in neither \( P(M', M) \) nor \( P(M, M') \)). Matching \( M \) is popular if there is no matching \( M' \) that is more popular than \( M \), and \( M \) is strongly popular if it is more popular than every matching \( M' \neq M \). We define

\[
\Delta(M, M') = |P(M, M')| - |P(M', M)|,
\]

so \( M \) is popular if only if for all matchings \( M' \) we have that \( \Delta(M, M') \geq 0 \), and \( M \) is strongly popular if and only if for all matchings \( M' \neq M \) we have that \( \Delta(M, M') > 0 \). These definitions are applied in exactly the same way to SM, 3DSM, PON, and PON-RATE, based on the construction of the preferences for the agents.


**Theorem 1.** For instances of SM, all stable matchings are popular, and all strongly popular matchings are stable.

Next, Biró, Irving, and Manlove [1] present the following algorithmic result.

**Theorem 2.** There exists a polynomial-time algorithm to test whether a matching \( M \) in an instance of SM is popular.

Since stable matchings can be found in polynomial time and always exist in instances of SM, from Theorem 1 we find that popular matchings can also be found in polynomial time [5]. However, this reasoning cannot be applied to strongly popular matchings, which led Biró, Irving, and Manlove [1] to leave the complexity of finding a strongly popular matching as an open problem, which was addressed by Huang and Kavitha [9], leading to the following result.

**Theorem 3.** There exists a polynomial-time algorithm to find a strongly popular matching in an instance of SM or determine that no such matching exist.
2.4 Our Contributions

First, we determine whether Theorem 1 generalizes to 3DSM and its variants. We found that, except in some cases with few agents, there are instances that admit stable matchings that are not popular and instances that admit strongly popular matchings that are not stable. We prove that this is the case in 3DSM even with the restriction to lexicographic preferences. Furthermore, we show that this is the case in PON and PON-RATE, even with different levels of stability.

To address Theorem 2, we define \textsc{pop-test-3dsm} to be the decision problem “given matching \( M \) in an instance of 3DSM, is \( M \) popular?” We give two graph-theoretic formulations for popularity testing in 3DSM in order to aid in determining its complexity. Since Theorem 1 does not always hold in instances of 3DSM, we define \textsc{pop-3dsm} to be the decision problem “given an instance \( I \) of 3DSM, does there exist a popular matching in \( I \)?” The decision problems \textsc{pop-3dsmt} and \textsc{pop-pon-rate} are defined analogously. Finally, we give a reduction from 3DM to \textsc{pop-3dsmt} to prove that it is NP-hard, further implying that \textsc{pop-pon-rate} is NP-hard.

3 Structural Results

This section details the extent that stable matchings are popular and strongly popular matchings are stable in variants and restrictions of 3DSM. We show that for most conceivable settings it is not the case that all stable matchings are popular and all strongly popular matchings are stable.

3.1 Three-Dimensional Stable Marriage

Proposition 1. For an instance of 3DSM with size \( n = 2 \). If the instance admits a strongly popular matching \( M^* \), then \( M^* \) is stable.

Proof. We prove the contrapositive. Since there are two agents per set, for an agent \( a_i \in M \cup W \cup D \) let \( \bar{a}_i \) be the other agent of the same set, so \( \bar{m}_1 = m_2 \). Let \( M \) be a matching that is not stable. Let \( m_iw jd_k \) be a blocking triple for \( M \). Then \( M = \{m_iwjd_k, \bar{m}_i\bar{w}jd_k\} \) is at least as popular as \( M \). This is because, by the definition of a blocking triple, \( w_jd_k \) prefer the blocking triple to \( M \). Even if the rest (\( \bar{m}_i, \bar{w}_j \), and \( d_k \)) of the agents prefer \( M \), there is an equal number of agents who prefer \( M \) to \( M' \) and who prefer \( M' \) to \( M \). Thus \( M \) is not strongly popular, meaning that for instances where \( n = 2 \), all strongly popular matchings are stable. \( \Box \)

However, Proposition 1 does not extend past two agents per group. In fact, even under the restriction of lexicographic preferences, we can find such an example.

Lemma 1. Let \( I \) be the instance described in Figure 1, then

\[ M = \{m_2w_1d_3, m_1w_3d_2, m_3w_2d_1\} \]

is strongly popular but not stable.
agents that prefer

First we will show that

Proof. First we will show that $M$ is strongly popular in $I$. Suppose for the sake of contradiction that there exists $M'$ such that $M$ is not more popular than $M'$. Let $A$ be the set of agents that prefer $M'$ to $M$.

Case 1: Suppose $M \cap M = \emptyset$, then we must show that $|A| < 5$. We know that no agent who is matched with their first choice in $M$ is in $A$, so $A \subseteq \{m_1, m_2, w_1, w_3, d_1, d_2\}$.

- If $m_2 \in A$, then either $m_2 w_1 d_2 \in M'$ or $m_2 w_1 d_1 \in M'$. If $m_2 w_1 d_2 \in M'$ then $w_1, d_2 \notin A$, so $m_2 \notin A$.

- Now we have that $A \subseteq \{m_1, w_1, w_3, d_1, d_2\}$. If $d_2 \in A$ then $m_3 w_2 d_2 \in M'$, so $w_1 \notin A$, meaning that $M$ is more popular than $M'$. By our assumption $d_2 \notin A$.

Thus, $|A| \leq 4$, so if the matchings are disjoint then $M$ is more popular than $M'$.

Case 2: Suppose $M \cap M' = \{t\}$. We must show that $|A| \leq 2$.

- If $t = m_2 w_1 d_3$ then $A \subseteq \{m_1, w_3, d_1, d_2\}$. Then if $d_2 \in A$ we have $m_3 w_1 d_1 \in M'$, which is a contradiction, so $d_2 \notin A$. Now, if $m_1 \in A$, then $m_1$ must be paired with $w_3$, but they cannot be paired and prefer $M'$.

- If $t = m_1 w_3 d_2$, then $A \subseteq \{m_2, w_1, d_1\}$, but $m_2$ cannot be paired with $w_1$ or $w_3$ and still prefer $M'$ to $M$.

- If $t = m_3 w_2 d_1$, then $A \subseteq \{m_1, m_2, w_1, w_3, d_2\}$.
  - If $m_2 \in A$ then $m_2 w_1 d_2 \in M'$. Then if $m_1 w_3 d_3 \in M'$ we have $M = M'$, so $A \subseteq \{m_1, w_1, w_3, d_2\}$.
  - $w_3 \in A$ then $w_3$ is paired with $m_3$, so $w_3 \notin A$.
  - We have $A \subseteq \{m_1, w_1, d_2\}$. If $d_2 \in A$ then $m_3 w_1 d_2 \in M'$, which is false by the construction of $t$.

Thus $M$ is strongly popular.

The matching $M$ is not stable because $m_1 w_1 d_1$ is a blocking triple. \qed

Figure 1: An instance of 3DSM restricted to lexicographic preferences with a strongly popular matching that is not stable.
Likewise, we give an example of an instance with lexicographic preferences that admits a stable matching that is not popular.

**Lemma 2.** For the instance of 3dsm described in Figure 2 and matching $M = \{m_1w_1d_1, m_2w_2d_2\}$, the matching $M$ is stable but not popular.

**Proof.** Let $M' = \{m_2w_1d_2, m_1w_2d_1\}$. Because in $M$ each man $m$ is paired with their first choice woman $w$ and dog $d$, there cannot be a blocking triple, since that requires $m$ to prefer another pair. Thus $M$ is stable. Similarly, in $M'$ every woman $w'$ is paired with their first choice couple of $m'$ and $d'$, so there cannot be a blocking triple, meaning that $M'$ is stable.

In $M$, each man is paired with his first choice, and each woman are paired with her last choice. Similarly, in $M'$ each woman is paired with her first choice, while each man is paired with his last choice. Thus, when considering only the men and women, there are an equal number of agents who prefer the other matching. However, $d_1$ and $d_2$ both prefer $M'$, since the couple they are paired with is their first choice in $M'$ while it is not for $M$. Thus $P(M', M) = \{w_1, w_2, d_1, d_2\}$ while $P(M, M') = \{m_1, m_2\}$, so $M$ is not popular. \qed

From Lemmas 1 and 2 we obtain the following result.

**Theorem 4.** There are instances of 3dsm, even under the restriction lexicographic preferences, where the properties mentioned in Theorem 1 do not hold. Namely, there are instances that admit strongly popular matchings that are not stable, and there are instances that admit stable matchings that are not popular.

### 3.2 Precedence by Ordinal Number

Because PON introduces stronger versions of stability, it is natural to investigate the relationship between popularity and these different notions of stability.

**Lemma 3.** Let $I$ be the instance of PON described in Figure 3, the matching $M = \{m_2w_1d_2, m_1w_2d_1\}$ is ultra stable but not popular.
Figure 3: An instance of PON that admits an ultra-stable matching that is not popular.

Proof. The men $m_1$ and $m_2$ are paired to their first-choice partners in $M$ (of which there is only one combination of women and dogs), so for any $t = (m, w, d) \in (M \times W \times D) \setminus M$, man $m$ strictly prefers $M(m)$ to $t(m)$. Thus, $M$ is ultra stable.

Consider $M' = \{m_2w_1d_1, m_1w_2d_2\}$. We have $P(M, M') = \{m_1, m_2\}$ while

$$P(M', M) = \{w_1, d_2, w_2\},$$

so $M$ is not popular.

Since we have shown there exists an ultra stable matching that is not popular, the same follows for weakly stable, strongly stable, and super-stable matchings.

**Lemma 4.** For the instance of PON described in Figure 4. The matching

$$M = \{m_1w_1d_1, m_2w_2d_2, m_3w_3d_3\}$$

is strongly popular but not weakly stable.

Proof. Let $M'$ be a matching that is not $M$. Suppose $M$ and $M'$ are disjoint. Then

$$\{m_1, m_3, w_1, w_2, d_2, d_3\} \subseteq P(M, M'),$$

since those are the agents that are matched with their first choice partners in $M$. Thus, $M$ is more popular than $M'$.

If $M$ and $M'$ have one triple in common, then $|P(M, M')| \geq 4$ since four agents not in the triple are paired with their first choice. Then $|P(M', M)| \leq 2$, so $M$ is more popular than $M'$. Thus, $M$ is strongly popular.

The matching $M$ is not even weakly stable since $m_2w_3d_1$ is a blocking triple.

We have shown that there is an instance of PON that admits a strongly popular matching that is not weakly stable, so we know that Lemma 4 holds for strongly stable, super-stable, and ultra-stable matchings as well.
Figure 4: An instance of PON that admits a strongly popular matching that is not weakly stable.

**Theorem 5.** There exists instances of PON where the properties mentioned in Theorem 1 do not hold, even when replacing traditional (weak) stability with strong, super, or ultra stability. That is, for each definition of stability, there are instances that admit strongly popular matchings that are not stable, and there are instances that admit stable matchings that are not popular.

4 Algorithmic Results

The primary algorithmic problem we aim to solve is determining the hardness of POP-3DSM. For this reason, we also study the problem of popularity testing, called POP-TEST-3DSM, since if POP-TEST-3DSM is in P, then POP-3DSM is in NP. This is because a popular matching serves as a certificate for popularity, and the popularity test could be an efficient verifier. We show the equivalence of POP-TEST-3DSM to two graph-theoretic problems, and prove the hardness of POP-3DSMT, the generalized version of POP-3DSM that allows ties in preference lists.

4.1 Popularity Testing

Let $M$ be a matching in an instance of 3DSM. Define $H_M = (V, E)$ to be a hypergraph such $V = M \cup W \cup D$ and $E = M \times W \times D$. For $e \in E$, let $wt(e)$ denote the weight of $e$. For
For any perfect matchings $M_1$ and $M_2$, we have $\Delta(M_1, M_2) = |\Delta(P(M_1, M_2) - |\Delta(P(M_2, M_1))|$ and $\Delta(M_1, M_2) > 0$ if and only if $M_1$ is more popular than $M_2$. Let $M'$ be a perfect matching.
in $H_M$. We have

$$
wt(M') = wt(M' \setminus M) + wt(M' \cap M) \\
= wt(M' \setminus M) \\
= \sum_{a \in M \cup W \cup D} vote_M(a, M'(a)) \\
= |P(M', M)| - |P(M, M')| \\
= \Delta(M', M),
$$

so if $wt(M') > 0$, then $M$ is not popular. On the other hand, if $M$ is not popular, then there exists a perfect matching $M^*$ such that $\Delta(M^*, M) > 0$, meaning that $M$ is not a maximum-weight perfect matching. Thus, $M$ is popular if and only if $M$ is a maximum-weight perfect matching of $H_M$.

It is unknown whether this problem is polynomial-time solvable, so we give another formulation for pop-test-3dsm on graphs.

Define $G_M = (V, E)$ such that $V = M \times W \times D$ and $E = \{\{u, v\} : u \cap v \neq \emptyset, \forall u, v \in V\}$. For $v \in V$, let $wt(v) = \sum_{a \in v} vote(a, M(a))$ and for $M' \subseteq V$ let $wt(M') = \sum_{t \in M'} wt(t)$. Equivalently, $V$ represents the edge set of $H_M$, and $E$ connects non-disjoint triples.

**Theorem 7.** A matching $M$ in an instance of 3dsm is a maximum weight $n$-independent set of $G_M$ if and only if $M$ is popular.

**Proof.** By the definition of a 3dsm matching, $|M| = n$ and $M$ is an independent set in $G_M$. Let $M'$ be an independent set of size $n$ of $G_M$. The set $M'$ is a matching because it assigns all agents exactly once. By the argument with $H_M$, we know that $wt(M') = \Delta(M', M)$, so $wt(M') > 0$ implies that $M'$ is more popular than $M$. Then there is a matching $M^*$ such that $\Delta(M^*, M) > 0$. Thus, in $G_M$ we have that $wt(M^*) > 0$, so $M$ is not a maximum-weight independent set of size $n$.

As an example to explain the intuition behind the formulation, Figure 5 shows $G_M$ for the instance of 3dsm in Figure 2 where

$$
M = \{m_1w_2d_1, m_2w_1d_2\}
$$

and

$$
M' = \{m_1w_2d_1, m_1w_2d_1\}.
$$

We can tell that $M$ is not popular because $M'$ is an independent set with weight greater than the weight of $M$ in $G_M$.

### 4.2 NP-Hardness in the Case With Ties

We prove that pop-3dsmt is NP-hard by providing a polynomial reduction from 3dm. First, we discuss a motivating example that we use as a gadget. This instance has the interesting property that it admits no popular matching, which we use in our reduction.

**Lemma 5.** The instance of 3dsmt described in Figure 6 does not admit a popular matching.
Figure 6: An instance of 3DSMT with no popular matching.

\[
\begin{array}{c|cccc}
m_1 & w_1d_1 & w_1d_2 & w_2d_1 & w_2d_2 \\
m_2 & w_1d_1 & w_1d_2 & w_2d_1 & w_2d_2 \\
w_1 & m_1d_1 & m_1d_2 & m_2d_1 & m_2d_2 \\
w_2 & m_2d_1 & m_1d_2 & m_1d_1 & m_2d_2 \\
d_1 & m_2w_1 & m_1w_2 & m_1w_1 & m_2w_2 \\
d_2 & m_2w_1 & m_2w_2 & m_1w_1 & m_1w_2 \\
\end{array}
\]

\[\text{Figure 6: An instance of 3DSMT with no popular matching.}\]

Proof. Let

\[
M_1 = \{m_1w_1d_1, m_2w_2d_2\} \\
M_2 = \{m_1w_1d_2, m_2w_2d_1\} \\
M_3 = \{m_1w_2d_1, m_2w_1d_2\} \\
M_4 = \{m_1w_2d_2, m_2w_1d_1\}
\]

We have

- \(M_3\) is more popular than \(M_1\) since \(P(M_3, M_1) = \{m_2, w_2, d_1, d_2\}\),
- \(M_1\) is more popular than \(M_2\) since \(P(M_1, M_2) = \{m_1, w_1, d_1, d_2\}\),
- \(M_4\) is more popular than \(M_3\) since \(P(M_4, M_3) = \{m_2, w_1, w_1, d_1, d_2\}\), and
- \(M_2\) is more popular than \(M_4\) since \(P(M_2, M_4) = \{m_1, w_1, w_2, d_1, d_2\}\).

Since for every matching \(M\) there is an \(M'\) that is more popular than \(M\), there is no popular matching.

\[
\begin{array}{c|cccc}
\vdots & \vdots & \vdots & \vdots & \vdots \\
a_i & T(a_i) & (B \times D) \setminus T(a_i) & B \times \{\delta\} & \{\beta\} \times D & \beta\delta \ldots \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
b_i & T(b_i) & (A \times D) \setminus T(b_i) & A \times \{\delta\} & \{\alpha\} \times D & \alpha\delta \ldots \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
d_i & T(d_i) & \{\alpha\} \times B & A \times \{\beta\} & (A \times B) \setminus T(d_i) & \alpha\beta \ldots \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
\alpha & B \times D & B \times \{\delta\} & \{\beta\} \times D & \beta\delta \ldots \\
\beta & \{\alpha\} \times D & A \times \{\delta\} & A \times D & \alpha\delta \ldots \\
\delta & \{\alpha\} \times B & \alpha\beta & A \times B & A \times \{\beta\} \ldots \\
\end{array}
\]

\[\text{Figure 7: The mapping from instances of 3DM to instances of 3DSMT.}\]
In order to understand how this example functions in our reduction, we first give the mapping between the two problems. To simplify notation, we briefly abandon using $M$, $W$, and $D$ for the men, women, and dogs. For an instance $I = (A, B, D, T)$ of 3DM, we define $I'$ to be an instance of POP-3DSMT with sets $A' = A \cup \{\alpha\}$, $B' = B \cup \{\beta\}$, and $D' = D \cup \{\delta\}$. As a result of our simplified notation, we make no distinction between elements of $A', B'$, and $D'$ and their corresponding elements in $I$. Finally for any $e \in A \cup B \cup D$, we let $T(e)$ be the set of partners of $e$ in $T$, and “...” in the preference lists refers to a fixed but arbitrary preference of the remaining pairs.

**Lemma 6.** For an instance $I = (A, B, D, T)$ of 3DM, let $I'$ be the result of the mapping described in Figure 7 with corresponding sets $A', B'$, and $D'$. If $I$ admits a perfect matching $M$, then $M' = M \cup \{\alpha\beta\delta\}$ is a popular matching for $I'$.

**Proof.** If $M$ is perfect, then all of $A$, $B$, and $D$ are matched to their first choice pair in $I'$. Suppose some matching $M^*$ of $I'$ does not match elements of $A, B$, and $D$ corresponding to a perfect matching with respect to $T$. Then there exists $a \in A$, $b \in B$, and $c \in C$ that are matched to triples not in $T$, so $a$, $b$, and $c$ prefer $M'$ to $M^*$. Then, the only agents that could be better off in $M^*$ are $\alpha$, $\beta$, and $\delta$. Thus, $\Delta(M', M^*) \geq 0$, meaning that $M'$ is at least as popular as any matching that does not correspond to a perfect matching of $M$.

Suppose $M^*$ does correspond to a perfect matching of $I$, meaning that all of $A$, $B$, and $D$ are matched in the triples of $T$. Then all elements of $A$, $B$, and $D$ are indifferent between $M^*$ and $M'$ since they are matched to their first choice in both. Also, $\alpha$, $\beta$, and $\delta$ have the same partners in $M^*$ as they do in $M'$, so $\Delta(M', M^*) = 0$. \qed

**Lemma 7.** For an instance $I$ of 3DM and its corresponding 3DSMT instance $I'$, if there is no perfect matching in $T$, then there is no popular matching in $I'$.

**Proof.** We show that for each matching $M^*$ that matches $k$ triples in $T$ for $0 \leq k \leq n - 1$, there exists a matching $M'$ that is more popular than $M^*$. Let $M$ be a matching of size $k$ of $T$ and let $\overline{M}$ be an arbitrary matching of the elements of $A'$, $B'$, and $D'$ that are not accounted for in $M$. Let $M^* = M \cup \overline{M}$. Then, following the motivating example:

1. If $\alpha\beta\delta \in M^*$, then for any $a_i b_j d_\ell \in (A \times B \times D) \setminus T$ we have $M' = (M^* \setminus \{\alpha\beta\delta, a_i b_j d_\ell\}) \cup \{a_i b_j d_\ell, \alpha\beta\delta\}$ is more popular than $M^*$.

2. If there are $i, j, \ell \in [n]$ such that $\alpha\beta d_\ell, a_i b_j \delta \in M^*$ then $M' = (M^* \setminus \{\alpha\beta d_\ell, a_i b_j \delta, a_i b_j \delta\}) \cup \{a_i b_j d_\ell, \alpha\beta d_\ell, \alpha\beta \delta\}$ is more popular than $M^*$.

3. If there are $i, j, \ell \in [n]$ such that $a_i \beta d_\ell, a_i b_j \delta \in M^*$ then $M' = (M^* \setminus \{a_i \beta d_\ell, a_i b_j \delta\}) \cup \{a_i \beta d_\ell, a_i \beta d_\ell, \alpha\beta \delta\}$ is more popular than $M^*$.

4. If there are $i, j, \ell \in [n]$ such that $a_i \beta \delta, a_i b_j d_\ell \in M^*$ then $M' = (M^* \setminus \{a_i \beta \delta, a_i b_j d_\ell\}) \cup \{a_i b_j \delta, a_i \beta \delta, a_i \beta d_\ell\}$ is more popular than $M^*$.

Therefore, a matching that contains $k$ triples from $T$ is not popular. If $I$ does not admit a perfect matching, then $M$ cannot match $n$ elements of $T$, so every matching in $I'$ is accounted for. \qed
Theorem 8. The decision problem \textsc{pop-3dsmt} is NP-hard

\begin{proof}
For any instance $I$ of 3DM and the corresponding $I'$ of 3DSMT, if there exists a perfect matching of $T$, then there is a popular matching in $I'$. Namely, for a perfect matching $M \subseteq T$, the matching $M' = M \cup \{\alpha\beta\delta\}$ is popular. Finally, we showed that if there is no perfect matching in $I$, then there is no popular matching in $I'$. Thus $I$ admits a perfect matching if and only if $I'$ admits a popular matching, so \textsc{pop-3dsmt} is NP-hard. \hfill \square
\end{proof}

5 Concluding Remarks

We have shown that in 3DSM and its variants, certain properties of popularity from two-sided stable marriage do not hold. We have also given graph-theoretic formulations for popularity testing and have proven that \textsc{pop-3dsmt} is NP-hard. We intend to further investigate this formulation to better understand the complexity of both \textsc{pop-test-3dsm} and \textsc{pop-3dsm}. It is important to answer the question of whether there is a polynomial-time algorithm for popularity testing, since the existence of such an algorithm would mean that \textsc{pop-3dsm} is in NP. If popularity testing is NP-hard, then \textsc{pop-3dsm} may be NP-complete or strictly NP-hard.

References


Emotion Perception in Emergency Service Jobs: ‘Ungendering’ the Strong Black Woman

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Author Note
I would like to show my gratitude to Dr. Marci Gleason, my advisor, for being supportive and encouraging throughout this entire process.

Black women are said to go through a process of “ungendering” and are expected to adhere to the Strong Black Woman (SBW) stereotype which reflects an expectation to be emotionally strong. Gender and emotion stereotypes, which tell us display rules for certain emotions, typically center around men’s crying and women’s anger. I infer that ‘ungendering’ and masculinization in racial stereotypes keep Black women from being held to the same standards of emotional expression as their white counterparts. The present study investigates how women’s crying behaviors in a gender-stereotyped context may be perceived differently depending on target race. I used measures for perceived target emotional appropriateness, emotional strength, and workplace status. I hypothesized that (1) participants would perceive crying firefighters who are Black women to be more emotionally appropriate/emotionally strong than those who are nurses and (2) that participants would perceive Black women to be less emotionally appropriate/strong than white women, for both occupations, because of biases regarding the stereotypes attributed to Black women. Participants (N = 551) read a vignette about a Black woman or a white woman crying in either a stereotypically feminine (nursing) or stereotypically masculine (firefighting) context, then rated the target on the dependent measures. Findings were not consistent across all variables. Black firefighters were rated as emotionally stronger than nurses and as having a higher workplace status unless race was implicit. In addition, white women were rated as emotionally weaker than Black women. These findings highlight the masculinization of Black women in racial stereotypes.

Keywords: emotion perception, identity, crying, gender, race

Emotion Perception in Emergency Service Jobs: ‘Ungendering’ the Strong Black Woman

Much work has been done in emotion research on the differences between men and women in emotional behaviors. These studies focus on gender stereotypes related to the subjective feeling states, or feelings that result from the mental processing of physiological reactions to a stimulus (Dolan, 2002), experienced by individuals and the expectations of others in terms of what emotions an individual feels, and how they express said emotions. What these findings show us is that emotional expressions are gendered, and these gender stereotypes breed expectations for subjective feeling states (Plant et al., 2000). Crying and sadness are perceived as signs of weakness because they are associated with times when one is powerlessness in their situation (Vingerhoets et al., 2001). These behaviors have thus been characterized as “feminine” and young boys are often socialized to refrain from expressing feminine emotions (Oransky and Marecek, 2009).
Although women are perceived as being more emotional, such that they are more expressive of their emotions (Fabes and Martin, 1991; Fischer, 1993), it has also been shown that there are particular contexts in which men’s crying is deemed appropriate or is even lauded by spectators (MacArthur, 2019). Athletes, in particular, seem to be afforded more leeway in expressing their emotions than non-athletes (MacArthur and Shields, 2015). In addition, expression of emotion is essential for performing masculinity, especially when it is passionate and controlled such as in the instance of losing a sports competition. The ability of men to control their emotions, even as they are affected by situations around them, shows that they have the mental toughness associated with idealized masculinity.

Group and individual characteristics other than gender also influence observers’ judgements of the meaning and appropriateness of emotional behavior. In particular, Black people in the United States and elsewhere are ascribed “stereotypes” and/or “archetypes” that are gendered and racialized in ways that differ from their white counterparts (Donovan, 2011). For Black women, these stereotypes include the Jezebel (a hypersexual being), Sapphire (tough, domineering, and loud), and the Mammy (loyal servant) as well as traits like dominant and aggressive. The Strong Black Woman (SBW) archetype presents the societal expectation that Black women are emotionally strong, resilient, independent, and nurturing even to their own detriment (Baker, Buchanan, Mingo, Roker, and Brown, 2014). Although each of these stereotypes is attributed to Black women, the traits tend to be contradicting. While the Sapphire is described as a working-class woman who is tough and loud, she is also said to be lacking in care and sensitivity (Donovan, 2011). “Strong” and “dominant” are characteristics that The SBW and the Sapphire have in common, but, unlike the Sapphire, the SBW is also extremely nurturing.

These contradicting stereotypes show that society expects that Black women have both masculine and feminine traits. Black people are also subject to the process of ‘ungendering’, a concept coined and developed by Hortense Spillers in 1987 to explain the relationship between Black people and gender during and post-captivity. Spillers describes how Black people were commodified during the period of enslavement for the capitalistic gain of their enslavers. She makes a distinction between the “body” and the “flesh”. “Flesh” comes before the body as it is the captive subject. Black people are of the flesh; violently captured and displaced and forced into labor for their captors. The “flesh” lacks will and power. The “body”, on the other hand, is the liberated subject, with will, power, and access to due process by law. Although slavery has been abolished in the United States of America, except for people who are incarcerated (U.S. Constitution, 13th amendment), Black people have not actually been liberated or achieved liberation and, therefore, do not and cannot conform to colonialist notions of gender. This, in part, explains why many of the stereotypes ascribed to Black women are typically deemed male attributes.

In the present study, I investigate how this ‘ungendering’ and/or masculinization of Black women may manifest in the context of emergency occupations: firefighting, a typically masculinized profession, and nursing, a typically feminized profession historical disassociation of Black women with femininity (Cole and Zucker, 2007; Liben and Bigler, 2002; O’Connor, 2015). Given that firefighting itself is considered masculine, men who engage in feminine behaviors, such as crying, are ‘protected’ from being seen as feminine whereas men in feminine jobs reinforce their lack of masculinity by engaging in feminine behaviors on the job (MacArthur, 2019). The historical disassociation of Black women with femininity (Cole and Zucker, 2007) combined with the masculine traits associated with stereotypes perpetuated against Black women led me to hypothesize that Black women will be judged similarly to men when they engage in a feminine behavior in a masculine job (i.e. crying as a firefighter) as compared to feminine behavior in a feminine job (i.e. crying as a nurse). Specifically, crying Black women firefighters will be rated more favorably than crying Black women nurses on —three outcomes
associated with observers’ judgements of emotional displays in a workplace setting: emotional appropriateness, emotional strength, and workplace status.

In this study, I also wanted to investigate the potential differences between how Black women’s crying is judged compared to white women’s crying in both masculine and feminine gender-stereotyped contexts. I test the hypothesis that participants will perceive Black women, regardless of occupation, as more emotionally appropriate, emotionally strong, and as having a higher workplace status, than white women. The stereotypes attributed to Black women often have masculine characteristics, so Black women may be rated similarly to men.

Race and gender can intersect in stereotypes about how men and women are expected to express emotions (e.g., Donovan, 2011; Salerno et al., 2019), therefore half of the vignettes in the current study included an explicit statement of the target’s race as either Black or white. The other four vignettes relied on the name of the target, either Amber (the white target) or Aaliyah (the Black target), to observe how participants may rate the target based on their implicit biases, or lack thereof.

Method

Design

To determine how emotion is perceived when expressed by Black and white women in different occupational contexts, I conducted a 2 [occupation: masculine (firefighting)/feminine (nursing)] × 2 (target race: Black/white) × 2 (Explicitness of race) between-subjects experiment.

Procedure

After receiving IRB approval for the project, participants were first recruited from the social media profiles of the lab members (n = 61). Then, I used Amazon’s open-source Mechanical Turk (MTurk) system to recruit the remaining participants (n = 559; N = 620). Given that the meaning of emotions and emotion-related words may vary across cultures and languages (e.g., Becht and Vingerhoets, 2002), recruitment was limited to United States citizens who were fluent in English as well as being over 18 years old. Mturkers received $0.50 as compensation for their participation. Responses from all participants were anonymous.

Participants were directed to an online survey on the Qualtrics system. Participants were told that they would participate in a study investigating people’s reactions to emergency service situations. They then provided their informed consent. They were randomly assigned to one of eight vignettes, adapted from MacArthur (2019). After reading the vignette, participants completed measures assessing their reaction to the vignette (described below), an attention check, completed a survey assessing level of stereotypical gender beliefs (not used in current study), and finally answered three demographic questions.

Participants

A total of 620 individuals participated in the study. However, 11 participants were dropped from the MTurk sample due to indications that they did not meet survey requirements. Thirty-five participants were excluded from the sample for failing to pass the basic attention check. The basic attention check consisted of three true/false/I don’t know questions regarding the vignettes; participants had to answer at least two correctly to remain in the study. An additional 22 participants failed to correctly identify the race of the target in the vignette by either claiming they did not know her race when they were explicitly told her race or by incorrectly identifying her race.
The final sample consisted of 551 (302 male, 235 female, 2 transgender, 4 genderqueer, 4 preferred not to answer, and 4 who selected other), who identified primarily as white (n = 402; 73%), followed by Asian (n = 46; 8.3%), Black or African American (n = 41; 7.4%), Latinx (n = 40; 7.3%), multiracial (n = 13; 2.4%), other (n = 6; 1.1%), and Native American or Alaska Native (n = 3; 0.5%). The average age of the participants was between 35-44 years (SD = 1.91) and ranged from 18 to 74.

Vignettes

The vignettes described a female firefighter or a nurse who began to cry over an injured child while on the job (see Appendix A for full wording). The race of the target in the vignette was either Black or white. In half the vignettes, race was indicated through the names of the target that were chosen due to their high association with either Black women or white women. Specifically, I conducted a pilot study (N=11) of 20 names to determine whether certain names were particularly associated with either Black or white women. The name ‘Amber’ was identified as a white name by 10 pilot participants and never as a Black name and 9 pilot participants identified ‘Aaliyah’ as a Black name, 1 as an Asian name, 1 as ‘other’ with no specification, and never as a white name. In the implicit race condition, the only indicator of the target’s race was the use of the name ‘Amber’ or the name ‘Aaliyah’. In the explicit race condition, the race of the target, as well as their name, was included. The number of participants assigned to each condition can be found in Table 1.

<table>
<thead>
<tr>
<th>Explicit Race</th>
<th>Target</th>
<th>N</th>
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</thead>
<tbody>
<tr>
<td>Explicit Black</td>
<td>127</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>Implicit Black</td>
<td>139</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>143</td>
<td></td>
</tr>
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</table>

Note: N = 551.

Emotional Appropriateness (app)

Perceptions of the appropriateness of the target’s emotion (e.g., “Amber’s expression of emotion was appropriate in this situation”) were measured using four items from the perceived appropriateness subscale of Wong et al.’s (2011) Evaluations of Emotional Behaviors Questionnaire (EEBQ). Items were measured on a 7-point Likert scale ranging from Strongly disagree to Strongly agree. All items were summed and averaged to create a single emotional appropriateness variable (α =.83), in which higher scores represented greater perceived emotional appropriateness (M = 5.81, SD = 1.11). See Table 2 for descriptive statistics by condition.

Emotional Strength (emo)

This measure consisted of three items that assess how mentally and emotionally strong a target is perceived to be. These were, “How strong is Amber/Aaliyah, mentally and emotionally?”; “How tough is Amber/Aaliyah, mentally and emotionally?”; and “How weak is Amber/Aaliyah, mentally and emotionally?” (reverse scored). All items were measured on a 5-point Likert scale ranging from Not at
all to Extremely. Items were summed and averaged to create a single emotional strength variable (α = 0.75), in which higher scores represented greater perceived emotional strength (M = 3.60, SD = 0.84).

Workplace Status (status)

Workplace status was a three-item measure that assessed how good the target was perceived to be at their job, and how much status they believed the target had in the eyes of their coworkers. The three items included: “How good do you think Amber/Aaliyah is at her job?”; “In general, how respected do you think Amber/Aaliyah is within her job?”; and “How much authority and status do you think Amber/Aaliyah has in the eyes of her coworkers?.” All items were measured on a 5-point Likert scale ranging from Not at all/none to Extremely. Items were summed and averaged to create a single workplace status variable (α = 0.83), in which higher scores represented greater perceived workplace status (M= 3.84, SD = 0.77).

Table 2
Descriptive Statistics by Condition

<table>
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<tr>
<th>Explicit</th>
<th>Race</th>
<th>Target</th>
<th>Job</th>
<th>Variable</th>
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<th>M</th>
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Results

Table 3 presents the means and standard deviations of all three dependent variables: emotional strength, emotional appropriateness, and workplace status across each of the possible eight study groups.

Hypothesis 1: Black firefighters will be perceived as more emotionally appropriate, emotionally stronger, and to have higher workplace status than Black nurses.

In order to investigate this hypothesis, I first selected out only those participants who had been given vignettes that described Black women (explicitly or implicitly). This resulted in a sample of 266 participants. Given that those assigned to the implicit race condition might not have imagined the women in the vignette as a Black woman, I conducted a series of multiple regressions for each outcome. First, I conducted a multiple regression analysis that allowed me to examine the effect of job, then I added explicitness of race as a control variable, and finally added the interaction between job and the explicitness of race.

Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
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<tr>
<td>Emotional Appropriateness (app)</td>
<td>5.81</td>
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<td>Emotional Strength (emo)</td>
<td>3.60</td>
<td>0.84</td>
</tr>
<tr>
<td>Workplace Status (status)</td>
<td>3.84</td>
<td>0.77</td>
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</table>

Note: N = 551. emo = emotional strength; app = emotional appropriateness; status = workplace status
The results were not consistent across outcomes. All three regression models examining participant's judgments of the appropriateness of the target's emotional response failed to reach significance (model with only job entered: F(1, 264)=.732; p = .39).

However, there was some evidence that Black firefighters were judged as being emotionally stronger than Black nurses (b = .19, SE = .10; t = 1.94; p = .053), but only when explicitness of race was adjusted for as a main effect (b = .26, SE = .10; t=2.603; p = .01) (overall regression model F(2, 263) = 4.98, p = .008; r² = .04). If the interaction term is included, the overall regression remains significant, but the individual coefficients are no longer significant. The findings suggest that participants generally judged firefighters as more emotionally strong and thought both nurses and firefighters were emotionally stronger when they were explicitly described as Black women.

The status of each job was judged differently when the target was explicitly stated to be Black versus when she was not (F(3, 262)=2.76, p = .043). Although the main effects of job (b=-.20, SE = .14, p = .14) and explicitness (b=-.04, SE=.14, p = .79) were not significant, their interaction was (b=.41, SE =.19, p = .031). When race was explicit, firefighters were judged to be higher in status (M = 4.02) than nurses (M = 3.81), however when race was implicit, nurses were judged to be higher in status (M = 3.8) than firefighters (M = 3.65).

Hypothesis 2: Regardless of the type of job, Black women will be perceived as being more emotionally appropriate, more emotionally strong, and as having higher workplace status than white women.

In order to investigate this hypothesis, I used the full sample (N=551) and, again, conducted a series of multiple regression analyses. Again, given that those assigned to the implicit race condition could have imagined the target to be of any race, I conducted a series of multiple regressions for each outcome. First, I conducted a multiple regression analysis that allowed me to examine the effect of target race, then I added explicitness of race as a control variable, and finally added the interaction between job and the explicitness of race.

Again, the results were not consistent across outcomes. All three regression models examining participant's judgments of the appropriateness of the target's emotional response failed to reach significance (model with only target of race entered: F(1, 549)=.009; p = .93). The same was true of workplace status, none of the models reached significance (model with only target of race entered: F(1, 549) = .148; p = .70).

As I hypothesized, white women were judged as emotionally weaker than Black women (b = -.16, SE = .07, p = .028) (overall model: F(1,549) = 4.86, p = .03, r² = .01). However, when explicitness of race is fully accounted for, the main effect of target race is no longer significant (b = -.004, SE = .10, p = .97). There is a main effect of explicitness (b = .25, SE = .20, p = .02) which is modified by a significant interaction between race of target and explicitness (b = -.30, SE = .14, p = .04) (overall model: F(3, 547) = 3.65, p = .013, r² = .02). As can be seen in Figure 1, when the target is explicitly described as being Black, she is judged as being emotionally stronger.

**Figure 1**

*Emotional Strength Means*
**Discussion**

The present study examined how stereotypes commonly held about Black women may influence how Black women’s emotional displays are judged compared to white women’s when engaging in male versus female identified occupations. MacArthur (2019) found that male firefighter targets were judged to be more emotionally appropriate, emotionally strong, and to have a higher workplace status than male nurse targets. This finding was not replicated for female targets, there was not a difference between the ratings of female nurse targets and female firefighter targets. I wanted to assess the possibility that Black women would be judged differently than their white counterparts and more similarly to white men based on these findings. Our results suggest that crying Black women in masculine-stereotyped contexts are generally judged as emotionally stronger. It did not seem that job was a consistent predictor for how favorably the target would be rated on the three dependent variables, but some evidence suggests that Black firefighters are perceived as more emotionally strong and as having a higher workplace status than Black nurses, particularly when it is explicitly stated that the target is a Black woman. This is consistent with the stereotypes around Black women that masculinize them, such as the Sapphire or the Strong Black Woman (e.g., Baker et al., 2014; Donovan, 2011). When the Black female target is performing the masculinized job of firefighting, she is, to some extent, judged more favorably. Notably, nurses were judged as having a higher status when race was implicit. This suggests that for women who are perhaps not identified by the reader as being from a certain racial or ethnic group, the more feminine job of nursing is deemed to be higher status.

In line with my hypotheses, when comparing the judgment of white targets to the judgment of Black targets, in the present study, white women were judged as emotionally weaker than Black targets. This supports the theory that suggests that the stereotypes attributed to Black women serve to masculinize them. As previous studies suggest, there is less negative feedback for men who cry in masculine-stereotyped settings such as competitive sports (MacArthur and Shields, 2015; MacArthur, 2019). In the present study, we see a similar theme for Black women in a masculine setting. Notably,
though, when comparing across the white and Black race conditions, the results are less clear than when we analyzed the results for just the Black target conditions.

There are some possible explanations for this ambiguity. The first is that participants felt the need to correct themselves and be more positive towards “Aaliyah” when they knew she was Black because they did not want to engage in negative stereotyping. The behavior of self-correcting to give an answer believed to be socially acceptable is called social desirability bias (Bergen and Labonté, 2020). The second possibility is that there was a methodological issue where, although I pilot tested the target names to investigate which name is more likely to be automatically coded as either Black or white, the participants of this pilot study were made of my network—people more likely to be Black or around Black people. People who are around Black people more often may be more likely to readily identify “Aaliyah” as a Black name than people who are not often around Black people. Non-Black people, especially white people, may not readily identify “Aaliyah” as a Black name. The Mturk sample of the present study comprised of primarily self-identified white people. Although they may not identify “Aaliyah” as a Black name, they may not identify it as a white American name, thus making conclusions drawn from the implicit conditions difficult to interpret.

Limitations

Although this study had a large sample size that resulted in adequate power, there were limitations to this study. The random assignment did result in certain conditions having more power than other conditions. It may have been more beneficial for me to recruit at least 80 individuals per condition rather than seeking a total N above 500 accounting for unusable entries. In addition, the majority of our sample was recruited through Amazon’s Mechanical Turk Service, Mturk. Although Mturk is useful and reliable, provided the investigator uses strict criteria for “workers” who take the surveys (Chmielewski and Kucker, 2020), there are limitations to using the service. The first was that majority of our participant population was white. It would have been beneficial for a more even racial mixture to be present in the participant population so that we could gain a better understanding of attitudes about race and gender for each racial group and make comparisons. Also, there were participants from the Mturk sample who completed the survey relatively quickly, especially when compared to the sample of participants recruited through social networking. Although these participants still passed the attention check, it is a possibility that these people may not have been giving much thought to the survey. It may have been more beneficial to have a population of participants who were more engaged with the material.

Conclusion

The present research investigated people's perceptions of Black and white women’s crying in masculine- and feminine-stereotyped occupations. I found that Black women’s crying was generally rated more favorably, especially in stereotypically masculine contexts and when her race was explicit. These findings highlight the masculinization of Black women through stereotypes and archetypes attributed to them in the context of the United States. In the future, it may be useful to evaluate people’s adherence to both gendered and racial stereotypes to investigate the potential correlation between these attitudes and people’s judgement of others. To address the possibility that participants do not imagine the target the way it is intended in the implicit condition, it may be valuable to conduct a study where participants are given a visual representation of the target.
References


influential when they express anger during group decision making. Group Processes & Intergroup 
Relations, 22(1), 57–79. https://doi.org/10.1177/1368430217702967


https://doi.org/10.4324/9780203717493

https://doi.org/10.1037/a0020576
Appendix A

Aaliyah works as a nurse in the emergency room of a major city in the U.S. One day when Aaliyah is on duty, she is told that there’s been a car accident on a road near the hospital, and that a family involved in the accident has arrived at the ER. Aaliyah meets the ambulance and is the first to attend to a child who is badly injured. Aaliyah works hard to stabilize the child, who is still breathing and has a heartbeat when she hands him off to the surgical team at the hospital. As she walks back to her nursing station, Aaliyah feels sad and begins to tear up. Visibly crying, she tells the other nurses, “He’s just a kid.”

Aaliyah is a 26-year-old Black nurse who works in the emergency room of a major city in the U.S. One day when Aaliyah is on duty, she is told that there’s been a car accident on a road near the hospital, and that a family involved in the accident has arrived at the ER. Aaliyah meets the ambulance and is the first to attend to a child who is badly injured. Aaliyah works hard to stabilize the child, who is still breathing and has a heartbeat when she hands him off to the surgical team at the hospital. As she walks back to her nursing station, Aaliyah feels sad and begins to tear up. Visibly crying, she tells the other nurses, “He’s just a kid.”

Amber works as a nurse in the emergency room of a major city in the U.S. One day when Amber is on duty, she is told that there’s been a car accident on a road near the hospital, and that a family involved in the accident has arrived at the ER. Amber meets the ambulance and is the first to attend to a child who is badly injured. Amber works hard to stabilize the child, who is still breathing and has a heartbeat when she hands him off to the surgical team at the hospital. As she walks back to her nursing station, Amber feels sad and begins to tear up. Visibly crying, she tells the other nurses, “He’s just a kid.”

Amber is a 26-year-old white nurse who works in the emergency room of a major city in the U.S. One day when Amber is on duty, she is told that there’s been a car accident on a road near the hospital, and that a family involved in the accident has arrived at the ER. Amber meets the ambulance and is the first to attend to a child who is badly injured. Amber works hard to stabilize the child, who is still breathing and has a heartbeat when she hands him off to the surgical team at the hospital. As she walks back to her nursing station, Amber feels sad and begins to tear up. Visibly crying, she tells the other nurses, “He’s just a kid.”

Aaliyah works in the fire department of a major city in the U.S. One day when Aaliyah’s team is on duty, a call comes through the radio that there’s been a car accident on a road near the fire station. Aaliyah’s team is first on the scene, and Aaliyah sees that a child in the back seat of one of the cars involved in the accident is badly injured. Aaliyah works hard to stabilize the child, who is still breathing and has a heartbeat when she hands him off to the paramedics who have arrived on the scene. As she walks back to the firetruck, Aaliyah feels sad and begins to tear up. Visibly crying, she tells the other firefighters, “He’s just a kid.”

Aaliyah is a 26-year-old Black firefighter who works in the fire department of a major city in the U.S. One day when Aaliyah’s team is on duty, a call comes through the radio that there’s been a car accident on a road near the fire station. Aaliyah’s team is first on the scene, and Aaliyah sees that a child in the back seat of one of the cars involved in the accident is badly injured. Aaliyah works hard to stabilize the child, who is still breathing and has a heartbeat when she hands him off to the paramedics who have arrived on the scene. As she walks back to the firetruck, Aaliyah feels sad and begins to tear up. Visibly crying, she tells the other firefighters, “He’s just a kid.”

Amber works in the fire department of a major city in the U.S. One day when Amber’s team is on duty, a call comes through the radio that there’s been a car accident on a road near the fire station.
Amber’s team is first on the scene, and Amber sees that a child in the back seat of one of the cars involved in the accident is badly injured. Amber works hard to stabilize the child, who is still breathing and has a heartbeat when she hands him off to the paramedics who have arrived on the scene. As she walks back to the firetruck, Amber feels sad and begins to tear up. Visibly crying, she tells the other firefighters, “He’s just a kid.”

Amber is a 26-year-old white firefighter who works in the fire department of a major city in the U.S. One day when Amber’s team is on duty, a call comes through the radio that there’s been a car accident on a road near the fire station. Amber’s team is first on the scene, and Amber sees that a child in the back seat of one of the cars involved in the accident is badly injured. Amber works hard to stabilize the child, who is still breathing and has a heartbeat when she hands him off to the paramedics who have arrived on the scene. As she walks back to the firetruck, Amber feels sad and begins to tear up. Visibly crying, she tells the other firefighters, “He’s just a kid.”
Visual Forms of Transformation and Resistance: A Close Reading of East Austin’s Murals

Aracely Lara
The University of Texas at Austin

Introduction: Mexican Muralism’s Influence in East Austin

“‘In the community, people were mobilizing in the most creative ways in spite of those who would discredit our work, and in the wake of the recent police violence, at City Hall, we were battling Pepsi-Cola and defending the Juarez-Lincoln Institute and attempting to save the powerful mural ‘Los Elementos’ by Raúl Valdez.’” -From Memoir de un Ser Humano: The Life and Times de raúlrsalinas

In Memoir de un Ser Humano, raúlrsalinas describes the mobilization and creative ways the working-class Mexican American residents of East Austin created to assert themselves in the City of Austin. Raúlrsalinas explains that their demonstration was lead to defend the Juarez-Lincoln institute. From the 1940s to the present the majority of African-American and Mexican American working-class population resides east of I-35. The rapid development in EastAustin is pushing working-class African Americans and Mexican Americans out of the historical-cultural centers they created. In his website, "Murals, Música y Más: It’s impossible tobe proud when you don’t know who you are,” Raul Valdez claims that “This mural’s prime location on the corner of Cesar Chavez St. (then East First Street) and IH-35 garnered much attention and much commentary. On the final day that Juarez-Lincoln stood, the East Austin community surrounded the building and protested against the developers. The mural “Los Elementos” by Raul Valdez is an example of mural use to assert beliefs and cultural knowledge. Murals cure environments from the trauma of the people and that space have endured.

In “Cleansing Rites of Curanderismo”, Erika Buenaflor argues that “spaces have the potential in their own right to aid in healing, purification, and renewal. Spaces, especially livingspaces, are not simply inanimate objects; they have a soul essence and can take care of us in many ways (Buenaflor 153).” Curandera Buenaflor’s argument on the healing potential of spacerelies on the ritual and circumstances that are used to cleanse or activate a space. While curandera Buenaflor discusses sacred rituals, such as the use of fire, herbs, or water to cleanse oractivate a space. This study focuses on murals and their ability to transform space. I claim that East Austin's murals such as "Liberación" by Raul Valdez, "Our Lady of Guadalupe" by Juan Ruiz, and "Loteria" by Johnny Martinez and its restoration by Arte Texas are huellas or footprints of transformation for working-class Mexican American communities in East Austin.

Art as Laura Perez argues in Chicana Art: The Politics of Spiritual and Aesthetic Altarities offers a lens to observe the everyday interaction with the spiritual world. It is in those interactions between art, spirituality, and community where this research finds the transformationof working-class Mexican American communities in East Austin into sacred spaces for communal healing. Murals are wall paintings. The recontextualization of murals from wall paintings to material manifestation of belief is needed to compare murals’ transformative qualities through spirituality to other forms of art. The comparison is necessary because the healing ability of murals is from their ability to ignite belief. Murals are a powerful ritual residents use to assert their agency. To further explore spiritual art, the
function of murals will be compared to the use and effect of altares on space.

According to Kay Turner in “Voces de Fe,” the altar is the meeting place of the sacred and the mundane. An altar at home creates accessibility of the power to transform. Meaning that anyone can use this form of art to directly connect to the deities, spirits, and recast their own space. This research uses the same lens as Laura Perez and Kay Turner to portray altares as servers of art whose function is to interrupt the hierarchical systems of knowledge, I compare home altares function to murals as they possess the same transformative qualities, but one (mural) is for the public sector while the other (home altar) is for the private.

Altars/Altares are raised surfaces used to communicate with Gods, spirits (family members, ancestors), angles. They function as a bridge between a spiritual and material world, turning the space that they reside on as sacred. This is because of the interaction and exchange of power that is occurring in the space/place/room between the altar maker and the spirit the altar maker is connecting to. Kitchens, living rooms, trailers, or places that are usually not deemed as important become hallowed. Kay Turner argues that “altarcitos are richly significant in the way they visually and artistically model an ideal of good, productive relationships between various distinct domains (secular/sacred; material/spiritual; earth/heaven)” (Turner 183). Altares materially represent the visions of hope of the altar creator. The altar maker’s creation of meaning allows them in the crowd to recast what is deemed sacred, a power no longer reserved for dominant cultural structures.

To reiterate the power to transform is in the agency to recast or redefine the functionality of something. For example, a cigarette box is painted over with the image of a loved one and placed on an altar. The changing function of the cigarette box is that it is no longer meant to carry cigarettes. Now the function of the cigarette box is to honor the picture of someone that is loved. The cigarette box is deemed sacred by the altar maker. The potential and as Perez argues in Chicana art, “the great responsibility and sacredness of the very real and consequential ‘transformative power’ yielded by image-makers” (Perez 31), shapes and transforms what we imagine, can perceive and can give material embodiment. Altares can change the function of intimate or private space in the home, while murals have this ability to transform at a larger scale. To assert that murals serve as healing agents that communities use to resurface barrios, this research reviews texts that discuss the Mexican Muralism Movement that began in Post-Revolutionary Mexico.

Muralism (the Mural Movement) began in Post-Revolution Mexico from 1920 to late 1970 as an attempt to unify the nation. In “Muralism and the State in Post-Revolution Mexico, 1920-1970,” Robin Adèle Greeley argues that the Mexican state used muralism and muralists to advance their political and economic agenda. The mural movement helps the analysis of murals as rituals to transform space by giving historical use of murals as a movement and their national impact. Greeley claims that in Post-Revolution Mexico President “Obrégon turned to muralism to resolve the monumental problem of the rebellious peasantry (Greeley 18).” According to Greeley, all the presidencies between Post-Revolutionary Mexico to the 1970s used artists in two ways: to pursue the agenda of creating a relationship with the united states and to change perceptions of Mexico as primitive. Later when Mexico hoped to attract support from the United States “Muralism was again called on to present Mexico internally as defiantly nationalist, yet externally as open to foreign interest… particularly in Rivera’s hands, muralism began to serve as a cultural liaison to American industrialists and bankers (Greeley 22).” Greeley’s explanation over the interests that the government had in controlling the image of the nation not only the image that its citizens had, but also hoped to control the image that other nations had of the Mexican Government. In “Muralism and the State in Post-Revolution Mexico, 1920-1970,” explains the historic use of muralism and its potential to shape
the beliefs of the people around the mural. Mexican murals helped Mexican residents feel heard, like the community murals in East Austin, alter the energy in a space.

Greeley explains that “Rivera painted Zapata standing to one side of his horse, holding a farmer’s sickle (rather than on horseback, gun in hand-the traditional warrior pose that Zapata readily adopted for photographers), placing the agrarian leader just above the viewer’s eye level(Greeley 25).” The position Zapata is in is crucial for the viewer’s interpretation of the image. Because the image of Zapata is at eye level they can imagine a camaraderie linked to “Zapata’s heroic struggle, eliding any cultural differences or class antagonisms. In front of the mural, we are all Zapatistas (Greeley 25).” Lastly Greeley acknowledges the space that the mural resides on. She observes, “in the space, viewers automatically do what the state commands; they stand passive, whatever their class position, before the mural that asserts the triumph of Zapata’s landreform, which the caretaker state has purportedly implemented in the absence of Zapata himself(Greeley 25).” The study of mural placement in Greeley’s essay will aid this research’s close reading of murals, as the position and the intent of the space of the mural change the symbolic use of imagery. Greeley’s essay “Muralism and the State in Post-Revolution Mexico, 1920-1970,” examines the four eras after the Revolution of 1910 and the process that muralism activated space for the period, for the government, but later explained by Bruce Campbell in his essay, “An Unauthorized History of Post-Mexican School Muralism”, in which he examines the legacy of muralism and how the Mexican government’s exploitation of the arts allowed for muralism to publicly serve working-class communities later on from the 1970s to present. But for a better understanding of the impact and legacy of muralism in working-class communities, It’s crucial to discuss the use of space, ideologies, representation, and the function of muralism.

In "José Clemente Orozco’s use of Architecture in the Dartmouth Mural” Leonard Folgarait argues that Orozco’s drawings, paintings, and murals are aware of the space or structure they are part of. Dr. Folgarait analyzes multiple artworks, the drawing vs the final piece on the walls of the buildings. Folgarait asserts his argument by explaining that Orozco wanted to “demonstrate how the buildings remain fully functional, how the murals neither compromise nor change the buildings’ efficiency. … he casts them (murals) as innocuous, decorative elements, almost worthy of being ignored (Folgarait 94-95).” Orozco used the architecture to produce the meaning of certain images, making “it clear that he trusted buildings to establish space and presence in his images (Folgarait 95).” To further explain his argument, Folgarait explains that Orozco had a pattern in which architecture served as an agent to express the content of his murals, by acknowledging the space the mural is in impacts its reception and message a reciprocal relationship is established between space and mural. Both hold the power to change each other and enable communities to strategically and purposely transform. Folgarait explains that “A comparison of adjustments Orozco made from drawings to finish the paintings… demonstrates how he recast architecture from background to active agent in the narrative (Folgarait 95).” To support his argument Folgarait close reads murals and drawings created by Orozco. One of Folgarait’s examples is, Hispano-America. In Hispano-America José Clemente uses the architecture of where he places the mural and uses architecture in the imagery in the mural to carry out his message.

Folgarait explains the “comparison of adjustments Orozco made from drawings to finish the paintings... demonstrates how he recast architecture from background to active agent in the narrative (Folgarait 98).” Folgarait describes the buildings of Hispano-America as inhabitable or habitable “either bearing down on the human figures in front of them with real destructive force, as on the left, or with more subtle implications, as the factory has forced masked capitalism on the streets (Folgarait
In the mural, a man resembling Pancho Villa, one of the leaders from the Revolution of 1910, stands at the center of the mural as the ruins of architecture move towards the viewer. Folgarait asserts that the ruins in Hispano-America flow while asserting a dichotomy between a ruined system that begins to affect another, expressing the economic interest of the state and the unfulfilled promises of the Revolution infect the following system.

On the mural, the architecture gives the imagery the space to move, in turn, the message of domino effect and disappointment in the result of the Revolution of 1910 can become emphasized. Unlike the drawing as Folgarait observes that “Its wooden composition, which resists dramatic narrative, presented problems, which Orozco solved in the final painting by rethinking the historical meanings of architecture and exploiting its formal properties into agents of movement through space and narrative (Folgarait 99).” The ruins in the mural push the background into the foreground causing the lines of the image to project through the picture plane, supported by the dimensionality of the architecture. This reading reinforces the ending sentiment in Greeley’s essay “Muralism and the State in Post-Revolution Mexico” that the mural Zapata by Diego Rivera shows that despite the revolutionary symbolism, the mural depends on the space for intention. Space where the mural rests impacts the mural’s message as much as the symbolism reveals about the place the mural is in. In East Austin, the community murals are deemed as ‘low art’ because of their accessibility, but notions of art such as those ignore the rigorous work and planning that goes behind those murals. To further analyze the symbolism, composition, and location of murals, the ideologies that incited and inspired the muralists to create.

In the essays “Murales Estridentes: Tensions and Affinities between Estridentismo and Early Muralism” by Tatiana Flores and “Nietzsche Contra Marx in Mexico: The Contemporáneos, Muralism, and Debates over ‘Revolutionary’ Art in 1930s Mexico” by Robin Adèle Greeley both explain avant-garde ideologies that existed around muralism. Flores’s essay “Murales Estridentes: Tensions and Affinities between Estridentismo and Early Muralism” focuses on the first avant-garde movement in Mexico, while explaining the developing ideologies of muralists and their growing concerns and critiques of avant-garde’s encouragement in notions of technology. While Greeley’s essay “Murales Estridentes: Tensions and Affinities between Estridentismo and Early Muralism”, focuses on the ideological tension between the generation that is too young to have participated in the Revolution and first-generation muralists.

In “Murales Estridentes: Tensions and Affinities between Estridentismo and Early Muralism” Flores explains that “Estridentismo (Stridentism), Mexico’s first self-acknowledged avant-garde movement, erupted in Mexico City in December 1921 with the publication and dissemination of the manifesto Actual No. 1 by the poet Manuel Maples Arce (1900-1981) (Flores 108).” Stridentism called for the renovation of the arts, for the artist to modernize and to look for inspiration in technology, and to look at the present for new methods of approaching art. Flores asserts that “muralists shared the belief that artists could bring about social change and that the post-Revolutionary moment called for radical re-conception of art, though they did not necessarily accept Maples Arce’s faith in Technology (Flores 109).” In her essay, Flores observes the evolving works of Fernando Leal (1896-1964), Jean Charlot (1898-1979), and Fermin Revueltas (1903-35). Flores argues that the historical consciousness muralists gained as a result of their experience as muralists “led them to question estridentismo’s relevance to post-Revolutionary Mexico (Flores 110).” Flores argues that the theory of the avant-garde of art’s content and its function caused “mural painters… to create relevant social content and to demystify art to bring it closer to the lives of the Mexican people (Flores 111).” Flores explain that the
difficulty in reconciling avant-garde to muralism is due to patronage.

Muralism was a government-sponsored activity tasked to create national art, it was not an autonomous practice. Muralism at the time was a “project that became an effort to impose order by controlling the territory of the nation and thus to prevent further social upheaval. In that process, the effort threatened to eradicate Mexico’s regional differences. The government, however, promised great social improvements, such as redistributing lands to peasant communities and making education accessible to all (Flores 112).” The muralists were aware of the contradictions as artists muralized. A couple of examples Flores uses to demonstrate the evolving ideologies of the muralists are Leal’s “The Feast of the Lord of Chalma” and Revuelta’s “In Andamios exteriores”. In “The Feast of the Lord of Chalma” a conflicted view of race and class of Mexico is presented. The painting portrays a group of indigenous people conducting a ritual, dancing tribute to the Black Christ of the Church of Chalma. There are little girls with long braids, women holding rebozos, and men hanging sombreros on their backs. Leal’s mural invokes Mexico’s indigenous cultures and places them in the present, a criticism that Leal has of the anthropologist is their persistent and systematic tendency to place them in a time other than the present. Leal’s mural addresses the cultural and diverse population of Mexico, he critiques the state covertly. His critique is of the task to paint something ‘Mexican’, Leal questions the government as to what it necessarily means to be Mexican and unite under a nation.

Flores’s close reading of Revualta’s “In Andamios exteriores” demonstrates the muralist’s criticism of Avant-garde’s depoliticization and encouragement of developments made from the state after it failed to redistribute land back to Campesinos and recognize the African and Indigenous populations in Mexico. Flores states that “In Andamios exteriores”, “Telegraph poles and wires overshadow the men, who are further diminishing by being shown from the back, their faces are hidden from view (Flores 121).” Revuelta acknowledges the creativity and artistry of campesinos he positions the campesinos “facing the wall like muralists at work (Flores 122).” Flores quotes Jean Charlot, a major muralist that challenged avant-garde theory, stating that “Only bad muralists may remain immune to the … social responsibilities involved in speaking with painting on public walls. Working elbow to elbow with masons stresses the fact that art is also a manual exertion, that wall painting, and house painting are twins (Flores 122).” The muralist Leal, Charlot, and Revueltas implicitly and explicitly identify with the struggle of the working class and question Avant-garde theory in its complicit to the state.

But in “Nietzsche Contra Marx in Mexico: The Contemporáneos, Muralism, and Debates over ‘Revolutionary’ Art in 1930s Mexico” Greeley challenges the revolutionary position of murals. Greeley explains that Contemporáneos is a journal to call out muralism and their militant approach to art. The journal was composed of young artists too young to have participated in the Revolution, but old enough to witness the slow corruption of former revolutionaries. The Contemporáneos intended to resist what they perceived as increasing political, religious, and especially artistic inflexibility on a national level. Contemporáneos “argued, moreover, that muralism’s interpretations of indigenous culture were propagandistic and had little to do with the reality of rural existence (Greeley 149).” According to Greeley, Contemporáneos were against the militant and masculinized national culture the majority of the muralists had developed. They were exclusively critical of Diego Rivera and his depiction of indigenous people, “Contemporáneos argued that national culture should serve as a means of entry into the world community (Greeley 152).” Greeley asserts that “the Contemporáneos also criticized the politics of class hidden in the aesthetics of ‘revolutionary nationalism’. The country’s elite, they argued, deployed the concepts of nationalism and anti-imperialism to obscure power inequalities in Mexico. Gorostiza criticized social realist art for hiding class conflict under a veneer of national unity, and the urban elite’s enthusiasm for it as narcissistic charity to relieve bourgeois guilt.
over the despicable conditions of the poor (Greeley 152).” Jorge Cuesta, a Contemporáneo, recognized art as in and of itself, political. Political in the sense that it allows people to foster the power of hope. The tense ideologies of the avant-garde and muralists were flawed. But if it were not for the mistakes of the past, the legacy of muralism would be difficult to picture, after all, it was Post-Revolutionary Mexico’s environment that allowed for the study of the ritual of muraling.

In “An Unauthorized History of Post-Mexican School Muralism” Bruce Campbell explains the changing practice of muralism, from state-commissioned murals to their decline and disappearance. Campbell asserts that “art historians sometimes err in isolating the mural from themuralism that produced it. Adequate recognition of late-twentieth-century Mexican muralism requires that we see latter-day muralism as the visual record of cultural practice and its rich, ongoing public engagements (Campbell 263).” Because community murals are not perceived as important due to artists not receiving formal training, and community murals adopt the hopes and struggles of their communities, murals are hardly recognized by formal spaces such as museums. Campbell argues that murals “with the privatization of land murals began disappearing (Campbell 267), he explains that during the 1960s Mexico peaked foreign companies’ interests by providing cheap labor in maquiladoras. The murals commissioned by the Post-Revolutionary Mexico, that “revolutionary workers and campesinos famously were depicted in Mexican School Murals were no longer politically convenient images for a government that weakened organized labor and lowered real wages to attract foreign investors (Campbell 265).” The murals that allowed the Post-Revolution state to unfulfilled the promises made to the popular mass were nowposing a threat as the murals incited students to rebel. Campbell supports this assertion by explaining the conflict that occurred in 2000 Mexico, “when student activists were jailed for the ‘destruction of the artistic patrimony of the nation,’ after they altered a detail of Siqueiros mural at the National University, adjusting an open-ended revolutionary date inscribed in the image “19??” To read “1999.” The students wanted to link the Siqueiros mural to the students' protest in 1999 against tuition hikes and privatization measures that would make a University education less accessible to most Mexicans. - mural “/the Right to Culture (1956) depicts students as agents of Mexican history Cortez and Mexica 1521 revolution of 1910 to an unknown historical moment (Campbell 265).” Los Tres Grandes had passed away before the student demonstration.

Throughout their muralist careers, Orozco and Siqueiros subtly expressed their disappointment with the outcome of the Revolution of 1910 in Mexico. But the students' willingness to connect the struggle of the present to the past, just as Siqueiros attempts to reachthem from the past to their present, as Campbell explains, created “new and innovative mural production to the public arenas of working class-communities. Murals did not disappear - but many of them become less visible to art historians Mural practice produced images and public discourse for local public arenas, and the muralists experimented with materials, visual aesthetics, thematics, and modalities of production suited to the popular venues, a mass culturalmovement- connecting to mural work to the multiple fronts of political and cultural struggle from the past to the present (Campbell 268).” With rapid urbanization, space has become politicized with local housing and community economic interests engaged in the struggles against commercial designs and/or government schemes. Campbell asserts near the end of his essay that a “broader sociographic attention to mural practice is needed (Campbell 277),” because muralism outside government institutions and the formal art world is largely undocumented.

This research documents three murals that reflect the stories, hopes, historical and present struggles of the East Austin Mexican American community. This documentation of East Austin’s murals looks to analyze the transformative and healing power in muraling. By using the previous work
on the historical, ideological, space, and legacy use of murals. In Post-Revolutionary Mexico, the state’s goal of modernizing Mexico and unifying the nation through murals backfired because the government refused to acknowledge and address the struggles of its people. Later the murals helped activate the power in the working-class population through historical, symbolic, and communal properties in the murals. Those are the properties in murals that create a spiritual transformation in space.

Despite all murals having these properties, this research will separate the chapters by the mural and the property most prevalent in the mural. The first chapter is “La Lotería”: Healing Through Cultural Symbols”, The first chapter looks into the cultural symbols used by the artist of the “La Lotería” mural located in 1619 E. Cesar Chavez & Chalmas, followed by a close reading of the “Loteria” mural. The final chapter looks deeper into the Mexican American community in East Austin. The second chapter observes the historical implications of space. In this chapter, I claim that an understanding of historical movements in the location of the mural is needed to observe the spiritual transformation. “La Virgen de Guadalupe”: Historical Context Through Art describes the struggles of the residents in Holly street, followed by a close reading of “Our Lady of Guadalupe” by John Ruiz on the side of the Kleen Wash Laundry at Holly St. and Robert T. Martinez. Following “La Virgen de Guadalupe”: Historical Context Through Art is “La Lotería”: Healing Through Cultural Symbols” where the symbols of East Austin are explored. Then the last chapter “Liberación: Liberation Through Art” is focused on the final mural by Raul Valdez, “Liberacion”, located in the Pan American Theater. The three murals mark transformation and agency for the community, in asserting the hopes and struggles of East Austin’s working-class Mexican Community.
Chapter 1. “La Loteria”: Healing Through Cultural Symbols

“Platicas for the Mexica could release the wrongdoings, emotional or mental woes, and illnesses, and typically involved invoking supernatural aid. These wrongdoings, or straying from one’s truth, were believed to dislocate the heart from its proper place, which could then cause disease, community disdain, or bad fortune.” - from “The Platica Rites of The Mexica” in Cleansing Rites of Curanderismo by Erika Buenaflo

Curandera Buenaflo asserts that platicas are used as forms of healing an individual through the community. Through platicas or authentic conversations, individual healing becomes communal through platicas because to speak your truth, or wrongdoing one must have at least another person with them for the conversation. For this section, rather than observing a conversation between a group of people, will observe a platica between an environment and a group of people. The cultural and communal symbols in the mural, “La Loteria” evoke healing to the Mexican American working-class community that resides in East Austin. The symbols represent individual and community history and experiences. Loteria is a 54 card game, with a 4 x 4 board with 16 pictures on it typically played in Mexican and Latinx identifying families. The cards have tiny numbers on the corners of the pictures.

The names of the pictures are not called out, rather an announcer will recite a traditional riddle associated with the image on the card, and the players have to figure out what which image the riddle represents. It tests Spanish language skills and cultural knowledge. The first player to fill their board
calls out Loteria! And wins a prize (Villegas 2019). Loteria has now evolved to a pastime that anyone can enjoy, but Loteria is mainly recognized as a family pastime amongst Mexican and Mexican American families. Teresa Villegas’ artist website, an artist inspired to learn about Loteria, explains that “the most recognized version of Loteria is the “Don Clemente Gallo” rendition introduced into Mexico in 1887. Loteria is a game of chance, children playing with their families or amongst other children, this game allows them to play on an even field for a chance for recognition. The importance of this game is in its ability to allow individuals to bond over the imagery, over the riddles, and cleverness of each other. To fill the 4x4 cards families use beans, quarters, rice, or buttons to cover the images that one resonates the riddle to. Loteria is a game that allows individuals, whether strangers or familiars, to form a connection. The foundation of platicas is about forming a connection, the connection creates a bridge for individuals to build a community with one another while undrowning their woes. The creation of community in the mural is facilitated by the symbols that are embodied.

“La Loteria” is an homage to the game, the wall is decorated with a couple of original symbols from the game while other symbols are reinterpretations and replacement of other symbols. The East Austin Mexican American community initiates a platica with their environment by asserting themselves by using community and broader cultural symbols conveyed in “La Loteria”.

“La Loteria” was painted around 1989. According to the Statesman writer James Barragan, “nine young local artists put up a mural on a wall at 1619 E. Cesar Chavez St. that became a source of pride for the neighborhood’s largely Latino community (Barragan 2018).” “La Loteria”, recently restored in 2016 after the South by Southwest painted over the community mural. The Loteria mural marks cultural agency, a place where children walking home from school can point and relate to a rapidly changing environment. The mural is on the side of Cycleast bike shop, now with a couple of new symbols to convey their anger towards displacement. The mural’s aesthetics, the use of bright colors demand attention.

“La Loteria” mural is three giant game cards, some spaces in the cards are traditional Loteria images, such as la corona, la Estrella, la Muerte, el Perrico, el Soldado, la Rana, el Pescado, la Garza, la Sirena, el Corazon, la luna, and some symbols are altered from their original imagery, or the artist has added special significance to a primary image. The depictions of traditional symbols on the murals are symbols reflect the Mexican American community in East Austin documenting the struggle with gentrification, displacement, personal struggles, accomplishments. Other symbols that address cultural symbols shared by Latines, such as Selena y el Chavo del Ocho.

With the use of community and border cultural symbols, the people in Cesar Chavez st initiate a platica of struggle, hope, and celebration. The platica helps the community rearrange their dislocated community heart. After experiencing the loss of the mural people were angered and saddened but because of the experiences and connections, they build through the use of symbols, they were able to bring the mural back. The transformative quality of symbols in space, I will look at the symbols from the traditional Loteria, additions, and modifications of the representation of the game Loteria in the mural “Loteria”. This research focuses on the particular spots from the mural: 14 La Muerte, 13 The Bulldozer, 29 La Piñata, El Nopal, El Corazon, 15 La Quinceañera, and finally the two giant hands holding a bean. The original symbols from the game loteria that are represented on the mural are: 14 La muerte, La Rana, 23 La Luna, La Calavera, El Pescado, El Soldado, El Nopal, La Estrella y El Corazón. To understand the images and their reinterpretations, or their recontextualization in a crucial location for Mexican Americans in East Austin, the close reading of the mural and symbols will be guided by the blog “Loteria Interpretations”.

The blog lists the symbols of Loteria, with the riddles that accompany the images, and the
interpretations of the images as tarot readings. La Muerte according to Rafael Castro’s Dictionary of Chicano Folklore is usually “personified as a woman dressed in white clothing...Death is sometimes feared but it is also accepted as the transition to another stage of the life cycle (Castro 175).” In “Loteria” by Felipe Garza and the other eight artists, death is unclothed, genderless, and clutching a scythe. The riddle that accompanies the image in the traditional Loteria game, is “La Muerte sirqui siaca. La Muerte tilica y flaca. (Death: Skinny death. The sycachi death, The tilica, and skinny death.) (Loteria Interpretations 2021)”. The blog explains that if an individual were to pull this card from a deck, the interpretation for an individual and their situation means that they are dying themselves of something, a dissatisfaction, or an ending has occurred. In “Loteria” the symbolism of death, resonates with the sentiment of marginalized communities in East Austin, James Barragan from the Statesman in, “Beloved ‘La Lotería’ mural restored in East Austin” explains that despite the restrictive city policies, the working-class Mexican American and African American communities in East Austin created thriving communities through an embracement of colorful aesthetics, represented by murals, and community programs. Like “Los Elementos” by Raul Valdez, Mentioned in the introduction of this paper, the first mural of “Loteria” was painted over by a large commercial festival known as South by Southwest. The festival painted over the mural with the intention of according to the Austin Chronicle writer Tony Cantu in “La Loteria Returns”, bringing “local and international artists together ‘to transform ordinary walls throughout the downtown area into large public works of art for the Austin community.’ To that end, Australian graphic artist Rone painted an image of a girl's face on top of the Loteria mural outside the Cycleast store at 1619 E. Cesar Chavez (Cantú 2015).” The mural was restored after the community efforts to bring the mural back. The symbol of La Muerte on the restored mural signifies an ungendered eventual end, signifying a life cycle for murals.

Murals are public, and that makes them vulnerable to vandalism, their temporality also is dependent on the owner of the wall and the commitment of the artist and the future generation to maintain it. “El Nopal” in the mural signifies the presence of a source that can aid (Loteria Interpretations 2021). The riddle that accompanies this image in the game of Loteria is, “El Nopal: al que todos van a ver cuando tiene que comer, (The Cactus: To which all go to see when they have to eat) (Loteria Interpretations 2021). Nopal speaks of seeing something because it is a last resort. Nopal’s riddle speaks to the appropriation of aesthetics that is happening in Austin, as buildings and owners change, and the lack of comprehension of symbols leads to the erasure of cultural healing spaces the communities have built in those locations. But when the murals and bright colors are adopted into new businesses such as “La Virgen de Guadalupe” on the Launderette in Chapter two, Where her image attracts customers, but she is no longer a sign of hope for the residents of Holly Street, because those residents are being pushed out by higher-income citizens who do not identify with the same struggles the working-class residents of Holly street fought. Same for the residents in Cesar Chavez St. in the “Loteria Mural”, in boxes 13 bulldozer, 29 La Piñata. In the mural image 13, a bulldozer crosses over its designated spot in the Loteria game card to demolish the piñata. Those images reference the ongoing rapid gentrification of the city of Austin. Mexican Americans and African Americans have been pushed eastward, removing them from places they have transformed environmentally.

The next images from the mural “Loteria” are El Corazón and La Quinceañera. The riddle for El Corazon is “No me extrañes corazón que regreso en el camion (The Heart: Don't miss me, heart, because I will return in a truck.)”, El Corazon represents hope and even a nickname for endearment in Spanish. The image is meant to encourage someone to not give up, while comforting the viewer, it promises that at the end of a lucha, there will be a reward. One of the artists Raymond Robledo who painted the black cat, vase, and the heart, shares that he is most connected to the heart in the mural. He explains that it is because if up close to the mural, the name of his son, Raymond Robledo Jr., is
etched. His son died at a young age from cancer (Barragan 2018). The last image is La Quinceañera. She is image fifteen. She sits in a wheelchair, she is a young girl that was going to volunteer in the restoration of the “Loteria” mural, who had to pull out last minute. El Corazon and La Quinceañera are some of the few images that reflect the people, their struggles, and celebrations.

In the conclusion of Quinceañera Style: Social Belonging and Latinx Consumer Identities Rachel Valentina González claims that “Representation in the form of self-documentation founded in the present lays the groundwork for a persistent social narrative; these representations influence over time and thus help foment a sense of collective remembering in the form of Latinx commemoration (González 175).” While Dr. Gonzalez’s discussion is intended for quinceañera’s ability to demonstrate and document personal and social transformations, I claim that murals like La Quinceañera preserve communal memories. “La Loteria” depicting mourning the loss of community members and honors them, as demonstrated by El Corazon with artist Raymundo Robledo, and the death of his son, and from the struggle to keep the community history from benign erased, as it did by South by Southwest. In “Hybrid Spiritualities and Chicana Altar-Based Art: The Work of Amalia Mesa-Bains” Laura E. Perez argues that Chicana feminist artists from the post-sixties emphasize the use of art to express spiritual and political consciousness. Altare are used to indicate agency in social justice issues, as well as murals like “La Loteria” and its symbolism of communal struggles, gentrification, and hope to influence the outcome of their environment. By the interaction between environment and community as demonstrated in “La Loteria” where residents take control of symbols that represent their narratives. The resident’s ability to control their living situations purifies the environment of Cesar Chavez st from the attempts of the commercial art of the city to paint over Mexican American working-class presence in East Austin.

The healing transformation that takes place in Cesar Chavez st is due to the symbolic use of images to narrate the story of the people that reside in the area. People create a conversation with themselves about the environment they live in, and with the city that they are fighting against. The conversation is only effective because of the bond and willingness to listen to one another through “La Loteria”. The platica between space and people is then used to influence the historical contextualization of a location. Like “La Virgen de Guadalupe”, whose Mexican and African American working-class history is becoming displaced and people dance on the symbols left behind by their presence.
Chapter 2. “La Virgen de Guadalupe”: Historical Context Through Art

“¡O! ¡Siempre sea así! Siempre lleven tus ojos la primera alegría a todas partes, siempre lleventus labios la aurora del consuelo a los que sufren, y siempre las bondades de tu alma sean auroras no solo para el mundo de las risas, sino auroras que alejen con sus rayos misteriosos las noches de dolor.”

[Oh! May it be so always! May your eyes always take that first happiness everywhere; may your lips always carry the dawn of comfort of those who suffer, and may the goodness of your soul always dawns not only for the world of laughter but also dawns whose mysterious rays dispel the nights of pain.] -Sara Estela Ramírez, ‘Aurora,’ Demócrata Fronterizo, 6 de Junio de 1908.

Translation by Iné Hernandez-Ávila.

Sara Estela Ramírez writes this mantra of protection, in hopes of La Virgen to give hope that to anyone feeling at a loss, as well to those who are in the celebration can feel comforted. An eternal figure for comfort for disenfranchised communities, La Virgen de Guadalupe also known as Nuestra Señora de Guadalupe, Lupita, Morenita, Madrecita, Madre de Dios, is a powerful cultural symbol of Mexico. To understand the effects of cultural symbols such as La Virgen de Guadalupe, this section discusses the history of the symbol in Holly st. The mural “La Virgen de Guadalupe”. The mural reflects the hope that residents in Holly st exerted on the cultural symbol. By discussing the historical
contextualization of the location of murals hope is tangibly demonstrated through the beautification of barrios, the hope the residents exert “La Virgen de Guadalupe” radiates. Historical contextualization of murals provides a passage to understanding the effect and meaning of the mural.

La Virgen de Guadalupe in East Austin was painted in 1992, on a launderette. La Virgen de Guadalupe, located on Holly street, near the Holly Power plant, is a mural that evokes hope. The relationship between the mural and the community in Holly street embodies the reciprocal relationship between Our Lady of Guadalupe and Juan Diego. In the story of the apparition of Our Lady of Guadalupe, she appears to Juan Diego, asking him to tell the colonial Catholic bishops to build a temple for her on the hill at Tepeyac. Our Lady of Guadalupe and Juan Diego’s’s relationship is reciprocal-as you see her in this image with her hands in offering style, asking for Juan Diego to present Castilian Roses to the bishops as prove of her existence- and she reciprocates by giving Juan Diego an Indigenous man a safe place to worship Tonantzin, the Mexica fertility Goddess.

The Holy Power plant caused severe health issues for the residents in the Holly Street neighborhood east of Highway 35 in Austin. The Our Lady of Guadalupe mural was created to manifest hope for the community while residents were petitioning to close down the power plant. Holly street residents were fighting for the plant’s closing since the 1960s, and it was finally closed down in 2007. The residents, in turn, activated the old launderette as a marker for their commitment to their environment. The closing of the plant increased property taxes and displaced the residents of Holly street. Still, the mural resides on the wall of The Launderette, now an American restaurant. Holly St., where La Virgen de Guadalupe painted by Juan Ruiz in 1992 is located, There is the Holy Power plant a street away from the mural. The Black and Mexican communities pushed for the closing of the Holy Power Plant because it was causing health and environmental issues- it took years for the city of Austin to close down the plant.

The location of the Our Lady of Guadalupe mural by Juan Ruiz was a launderette, while Holly street residents fought to close the plant. The Holly Power Plant after years of the residents suffering from health issues, being ignored by the city, the power plant was closed and the property taxes became higher so the Black and Mexican communities in Holly st were and are in the process of being displaced, For Example, the launderette went from a family-owned washer to an expensive American restaurant. As the plant was closed those communities that fought hard better their community was displaced.

The importance of this mural lies in the icon painted- Our Lady of Guadalupe and her apparition to Juan Diego. Her symbol has been used secularly and the religiously-her image was used to establish hope during the Mexican War of Independence from Spain in 1810. Her image was used again 100 years later to create unity and hope at the onset of the Mexican Revolution of1910 by famed freedom fighter, Emiliano Zapata. In “The Virgen de Guadalupe: A Mexican National Symbol,” Eric Wolf connects our lady of Guadalupe to Tonantzin the fertility Goddess under these connections wolf interprets the image in two ways through the Mexican Catholic family lens and an indigenous family lens. Indigenous Catholic lens family lens focuses on reciprocity the image Tonantzin/Our Lady of Guadalupe has her hands positioned in offering style. But is asking for a favor from Juan Diego, an indigenous man who was asked to tell bishops about the existence of Our Lady of Guadalupe. This favor brings Juan Diego and indigenous people a safe space to worship Tonantzin during colonial Mexico. Wolf offers two possible readings of the image of Our Lady of Guadalupe, and opens up possible comparisons between the function of a mural of Our Lady of Guadalupe and an altar, as they can bring hope into space. A hope much needed for marginalized communities around the murals to assert themselves in a space in a city that continues to disregard their needs. The mural “Our Lady of
“Guadalupe” is becoming estranged from the community she was meant to empower as the gentrification of Holly street intensifies. Her community placement differs from “Liberacion” by Raúl Valdez, whose mural is in constant communication with its intended community audience.

While conducting fieldwork for this mural project, I waited in the Launderette to photograph the “La Virgen de Guadalupe.” A group of white sorority girls was posing with the mural, grinding on La Virgen de Guadalupe and drinking in front of the mural, demonstrating disdain for La Virgen de Guadalupe. The interaction embodied the displacement of meaning, culture, and manifested reality that working-class Mexican American residents of Holly st created. Holly Street is now surrounded by a park, with beautiful murals, quiet, and expensive. Holly street transformed twice, once by the presence of working-class residents and secondly by the displacement of those residents who enacted change. The sorority girls now get to enjoy the transformation of Holly street, as they dance around and disrespect cultural symbols left behind by the people their presence displaced, because to them those sacred spaces created by the working-class residents before their displacement in Holly street are sacred to the sorority girls.

The residents of Holly st asserted their presence and hope for the beautification of their environment with murals such as “La Virgen de Guadalupe”. The residents shut down the Holly Power Plant and petitioned for the old power plant to become a park. This change in the environment although enacted by working-class citizens they did not get the pleasure to reap the benefits of their manifestation. Leaving behind inactive murals, as the new residents of Holly st don’t have to think or worry about their environment. While “La Virgen de Guadalupe” is no longer in the middle of the residents it was meant for, “Liberación” by Raúl Valdez is in constant interaction with the community it was meant to empower.
Chapter 3. “Liberación”: Liberation Through Art

“We, the seeds of resistance, activated across Great Turtle Island to continue los movimientos, struggles, and challenges of our disparate and distinctive neighborhoods, barrios, communities, y pueblos to empower, heal, grow, and liberate.”- Lilia Rosas in “Afterward on Resistencia, Liberación y tapón: en memoria de raúlrsalinas y tod@/XS en resistencia”, Memoir of un Ser Humano

Dr. Lilia Rosas writes in “Afterward on Resistencia, Liberación y tapón: en memoria de raúlrsalinas y tod@/XS en resistencia” from Memoir of un Ser Humano, about the work of individuals that act as a catalyst for change and healing in communities of marginalized identities. Dr. Rosas’s afterward is dedicated to raúlrsalinas, a poet, artist, community activist, and founder of Red Salmon Arts (grassroots cultural arts organization). Red Salmon Arts host creative programs for working-class Chicana/o/x/Latina/o/x/ and Native communities in Austin to nourish their creative pursuits and commitment to social justice. Dr. Rosas’s homage to creative work that enables healing and change in barrios, facilitates this section’s focus on transformation. The creative work of individuals in collaboration with their community to transform and assert themselves in an environment demonstrates the ability of a community mural to manifest liberation.

Mural art in barrios transforms the community through empowering and amplifying the voice
and vision of a community. I first became acquainted with “Liberación” when I first stepped out of the University of Texas at Austin’s campus as I pursued a teaching certification. The certification required aspiring teachers to assist a classroom, I was assigned Zavala Elementry which was a thirty-five-minute bus ride from campus. Those days I grew homesick, for the colors of the neighborhood trailers I grew up in, for the smell of enfrijoladas as I walkthrough the old trailer park, I yearned for closeness to home.

At Zavala Elementary, behind the school is the Pan American Neighborhood Park. As the children and I marched outside, they gravitated towards the amphitheater. The amphitheater was swallowed by bright red, yellows, vivid imagery of the Conquista, low riders, brown children sitting behind a car, dancers, war, a giant luna placed inside. I would observe the children chase each other around the amphitheater, chasing the colors and tracing the images. As I turned with the kids I experienced “Liberación”. The mural was painted and designed by Raúl Valdez and the community around Zavala Elementry. “Liberación” sternly stands on the back wall of the amphitheater, painted on an environment that is meant to spotlight. But “Liberación” is not at the center of the amphitheater it is behind the space in which recognition and platforming take place. The position, the negotiation of space and vision is where the power to transform environments into cultural healing places takes action.

The aesthetic use of art and culture to resurface Austin is the community and artist creating a pathway to manifest a vision and revision of reality. The arrangement of the symbolic process of using art to manifest is discussed in Chapter 4 “The Chicana/o Mural Environment Indigenists Aesthetics and Urban Spaces” by Guisela Latorre in Walls of Empowerment. Latorre argues that community mural painting is a ritual that requires intricate mediation by the city, the artist, and the community that interacts with the wall on which the mural is (Latorre 140). The public nature of murals creates the need for pacification between different groups, the negotiation becomes a collaboration when all parties benefit and input towards the community mural. People around the mural activate a specific space through their daily rituals, such as grocery shopping, walking, sitting at a corner, working, and observing.

A community mural will not function properly without negotiation between the community, artist, and wall owner. Without the property owner, the mural grows more temporary, without the people there is no message therefore no activation of space, and without the artist, the vision can not become tangible therefore there isn’t transformation. But the mediation of ideas is difficult when the communication and beliefs of collaborators clash. Space, according to Latorre, is inherently political because of the “history of marginalization, dislocation, displacement, and forced migration suffered by Chicana/o and Mexican populations in the United States (Latorre 143).” Because of the history of disregard for Mexican, Black, and Native populations in the United States, as asserted by Latorre, murals become perfect sites to critique and revise history.

For example, during the early seventies, muralists transformed spaces that were deemed as awful places into places to nourish barrio-life can in working-class Mexican neighborhoods. Barrios were deemed as negative places to live because of the food deserts and working-class association. Their reputation, as explained by Latorre, was described “as dangerous and undesirable places to live these beliefs are challenged by the creation of murals in these environments (Latorre 144).” Chicana/o artists redecorated environments by expressing the purpose to transform barrio spaces and the negative attitudes about the spaces in which Mexican Americans occupy. The process of barrio transformation by murals is conveyed in “Liberación” by Raúl Valdez and his centering of the
Raúl Valdez is a Texas artist and community muralist. He discusses in “Raúl Valdez: Texas Mural Artist (1984)” a video interview by the Austin History Center, about muralism and the tradition that proceeds community murals. Mural painting tradition, Valdez asserts that people use it to document their own culture, their own lives, their activities. Valdez’s explanation of mural use asserts the view that through mural paintings people have control of their reality. Community murals transform a space physically by serving as a source to educate people about historical events or cultural traditions. Valdez elaborates in “Raúl Valdez: Texas Mural Artist (1984)” that he is sure to engage with the people around the mural that is being created. Stating that thirty people will work on the mural, and then later more people usually join. To ensure that people of all ages work on the mural, Valdez uses acrylics or paint that is safe for children to interact with.

Tools for Valdez are crucial to ponder to make mural making accessible to the community. Valdez explains that people ask for history, so he decided to depict the Mexican Revolution for one of the murals around the amphitheater. Valdez has painted with over a hundred people, of all ages. In the interview, Valdez reminisces reading a prompt from an elder in the community. The elder was proud of being close and knowing her cultural roots. Valdez thought he voice to be significant for the time, as in the prompt to she discussed to be excited about the present, she explained that she had a daughter who was in college who didn’t know about her history. So the elder decided to teach her despite her daughter having a college education. Valdez thought her story crucial and compared it to what the murals hope to do, which is to teach cultural history. The theme of murals being to help the community connect to cultural heritage, at the time there is a lack of ethnic studies.

“Liberación” by Raúl Valdez, was created in 1978. The amphitheater is part of the A.B. Cantu Pan/American Recreation Center built in 1942. The perseverance of Raul’s mural on the Amphitheater is rooted in its intent-- it was painted for the community. Valdez emphasizes that this mural is a reflection of what the people surrounding the park wanted to see. “Liberación” by Raúl Valdez honors the voices of the community, giving a sense of cultural heritage. Painted to portray indigenous Civilizations the blue background becomes one with the sky and it gives the illusion that the picture is sustaining itself as a counternarrative to the histories that claim to civilize indigenous cultures, on the side the people that the city of Austin ignores and pushes to the side. On the bottom, the green of the earth connects to the green of the grass, the similar shades of green make it seem like the mural not only sustains itself but that is rooted in the ground, the mural seems to grow like a wise tree. The mural seems vast, as one stands under it, it gives the feeling of being part of something bigger. Mother earth unchains from dominant cultures that make it tradition to keep voices stifled and demands to be heard. The mural introduces the people from el barrio, with a raised platform, almost altar like for the people by the people.

Valdez’s mural “Liberacion,” Transformation of space relies on communal vision but as well on its execution. Valdez explains that he works especially on the composition of the images to alter the perspective of the environment. He discusses his process of changing the composition of the image giving the optical illusion that the lines in the mural are straight. This sculpts down the corners of the walls or edges, this, in turn, brings together fragments and sections of the amphitheater into a giant panoramic mural.

The community murals like the altars are reciprocal relationships, they both exchange services to each other, the mural materializes visions and amplifies voices, while the people, in turn, retouch the paint and maintain the mural. But as working-class communities continue to be displaced, as is
seen in Holly street. The community that activated the space around “Our Lady of Guadalupe” has been displaced, Liberation's audience and community are still around the panAmerican amphitheater are located right behind Zavala elementary predominantly Black and Latino school.

In the conclusion of Quinceañera Style: Social Belonging and Latinx Consumer Identities, “Rights/Rites and Representation: Reading Latinx Social Performance,” Dr. Rachel Gonzalez asserts that self-documentation is a powerful acknowledgment of collective motivation to be recognized, “even if not completely understood, rememberer-resides at the heart of contemporary folklore studies and as a central point of relevance to communities of color whose lives are continuously rendered ‘outsider’ within mainstream notions of accepted normatively (González 175).” Community murals in East Austin such as “Liberación” look to beautify a community that had been rendered negatively by American history. “Liberacion” acknowledges the struggles of displacement and environmental racism in Austin, for this community muralism, is a crucial ritual to activating transformation in space to induce cultural healing.

Conclusion: When Transformation Meets Gentrification

“How to deal with hatred, in a healing way. How to speak of prejudice, yet stereotype neither oppressor nor victim. How to expose the ugliness, respect the beauty, open the wound, reveal the pous, but not exacerbate the injury.” -Carmen Tafolla, “Healing A Cultura, AD 2000.” Entre Guadalupe y Malinche: Tejanas in Literature

In “Healing A Cultura, AD 2000,” Carmen Tafolla discusses the pain that comes with a process of healing, and the dangers that come with aggravating a wound. Healing and cleansing rituals are used to help lure the soul back into place. As Tafolla explains in “Healing A Cultura, AD 2000,” to heal one must expose the ‘ugliness’ and acknowledge the ‘beauty. Murals in East Austin balance this notion of cleansing by conveying the injustices and celebrations of the working-class Mexican Americans in East Austin. To bridge healing and murals this research continues with curandera Buenaflor’s idea of space or environments having a soul essence. This soul essence is what allows people to relate to their environment and activating space as a healing agent.

By acknowledging the soul essence or the energy of environments, then the possibility of losing the soul essence of a place to susto is possible as well, explaining the dis-activation of murals like “La Virgen de Guadalupe” in Holly Street when marginalized communities are displaced. Susto or shock means a deep fright, a serious deep shock that causes the inability to sleep, restlessness, depression, weakness, chills, lack of appetite, and lack of interest in their own body. When susto occurs, the soul has left the body causing the symptoms described above. Susto is usually described in terms that relate to the illness of a person But when an environment is robbed of what curandera Buenaflor calls the soul essence of a space, the transformation of an environment is not undone. As healing rituals for susto call back the soul to the body, murals call back the soul essence to the environment or the space activated by working-class Mexican Americans in East Austin.

The transformation embodied by “La Loteria”, “La Virgen de Guadalupe”, and “Liberación” is sustained. The transformation of environments is initiated by the usage of cultural symbols that reflect working-class Mexican American experience in East Austin as demonstrated by “La Loteria”. Then change is conducted through a reciprocal relationship between the environment and the residents as contextualized by the history of Holly st and the usage of “La Virgen de Guadalupe” to radiate hope to the residents as they worked through healing themselves and their space. Then “Liberación” conveys the effects of transformation for when residents are allowed to benefit from their manifestations to enact community pride. The murals visually channel the dreams and reality of the people, creating a
portal to advocating for social justice and communal healing. The murals document the history and culture of a population overshadowed by Austin’s student and commercial art culture.
Bibliography


making-a-fashion-statement/.


Marginalized communities often face a unique set of obstacles when navigating higher education. Professor mindset beliefs have the possibility of providing insight into how the higher education environment can influence the representation of women, underrepresented minority, and first-generation undergraduates, as well as women and underrepresented minority graduate students and faculty. Results from this study suggest that women, people of Black/Hispanic/Native American descent, and first-generation students are most underrepresented in departments where professors report stronger unproductive mindsets about student learning—that is, more fixed beliefs about ability, more negative beliefs about failure, effort, and difficulty, and the belief that only naturally talented students can succeed in their field.

Introduction

A large amount of literature has found that students’ mindset beliefs about their own intellectual abilities affect student motivation and academic success (Dweck and Yeager, 2019). Growth and fixed mindsets are on a spectrum, with a full growth mindset meaning the belief that abilities can improve an unlimited extent with effort, while a full fixed mindset is the belief that abilities are innate and cannot be changed. According to Dweck and colleagues (e.g., Dweck and Yeager, 2019), people’s mindset beliefs about intelligence or intellectual abilities may create a “meanings system” that includes other kinds of beliefs, including those about failure, effort, and difficulty. If people endorse stronger growth mindset beliefs, they are likely to believe that failure, effort, and difficulty can be helpful for growth, whereas if they endorse stronger fixed mindset beliefs, they are likely to believe that failure, effort, and difficulty are signals of low ability.

Those with fixed mindsets may see failure as debilitating, meaning that failure is viewed as negative experience that inhibits learning and growth (Haimovitz and Dweck, 2016). Difficulty as importance is the belief that difficulty is an enhancing step in the learning process. Difficulty as impossibility is the belief that difficulty is a negative barrier that can make desirable outcomes impossible (Oyserman et al., 2018). A recent study by Leslie et al. (2015) examined a similar belief which they called “field ability beliefs”, which is the belief that success in a specific field requires a certain innate aptitude or talent. The extent to these beliefs varies by academic field, and they found that most fields with a greater emphasis on a need for natural giftedness in turn had less representation of women and African Americans Ph.D. students within that field. These phenomena may be explained by women and minoritized ethnicities being negatively stereotyped when it comes to these
natural brilliance beliefs. This suggests that one’s intersectional identity (race, gender, etc.) may affect the extent to which one is influenced by field ability beliefs.

According to identity threat theory (Murphy, et al., 2007), students are attuned to cues in the environment about whether their identity is valued or not. Students from historically marginalized or negatively stereotyped groups—such as women in certain STEM fields, underrepresented minority (URM) students, and first-generation college students—may be particularly attuned to these cues in the college environment (e.g., Canning et al., 2019; LaCosse et al., 2020). Professors’ beliefs can be one such cue. Students’ interactions with their professors can be an integral part of student success and experience in college. Previous research suggests that student identity affects the extent of students’ relationships with their professors (Kim and Sax, 2009). Particularly, professors’ mindsets about student learning—their beliefs about ability, failure, effort, difficulty, and who can succeed in their field—may signal to students whether they belong (e.g., Muenks et al., 2020; LaCosse et al., 2020). This may especially be the case for women, URM, and first-generation students (e.g., Canning et al., 2019; LaCosse et al., 2020). When professors communicate more unproductive mindsets about student learning—that abilities are fixed, that effort, failure, and difficulty are signs of low abilities, and that only the most talented students can succeed—this may lead to stronger representation of people who are historically overrepresented and/or positively stereotyped in their fields (e.g., men, White/Asian people, and continuing generation students), and weaker representation of people who are historically underrepresented and/or negatively stereotyped (e.g., women, Black/Hispanic/Native American people, and first-generation students; Leslie et al., 2015).

The purpose of this study is to examine whether we see underrepresentation of women, URM, and first-generation students and faculty in departments where professors have stronger unproductive mindsets. If significant, this would suggest that professor beliefs about failure, effort, and difficulty may affect student and faculty sense of belonging, leading to more people dropping out of fields or departments in which faculty report unproductive mindsets. Our research questions are as follows:

RQ 1: How do department-level faculty unproductive mindsets relate to percent of women-identifying undergraduate students, graduate students, and faculty?

Hypothesis: Department-level faculty unproductive mindsets will be related to less representation of women-identifying undergraduate students, graduate students, and faculty in those departments.

RQ 2: How do department-level faculty unproductive mindsets relate to percent of URM undergraduate students, graduate students, and faculty?

Hypothesis: Department-level faculty unproductive mindsets will be related to less representation of URM undergraduate students, graduate students, and faculty in those departments.

RQ 3: How do department-level faculty unproductive mindsets relate to percent of first-generation undergraduate students?
**Hypothesis:** Department-level faculty unproductive mindsets will be related to less representation of first-generation undergraduate students in those departments.

**Methods**

**Participants**

Participants were 1104 instructors/faculty at a large, public southwestern university who came from 137 academic departments. The participant demographics for gender identity were 45.8% men, 42.8% women, 0.7% non-binary, 0.1% agender, 0.2% Do not know, 2.2% choose not to answer, 8.2% missing. The demographics for race were 2.3% Black, 3.7% East Asian, 5.4% Hispanic, 2.8% Indian, 0.6% Middle Eastern, 0.2% Native American, 0.4% Southeast Asian, 68.4% White, 3.1% Multiracial, 13.1% missing. The average age was 50.42 years (SD = 12.93).

**Measures**

For each survey item, responses from faculty were averaged to form an average departmental score on that item. Some of the survey item categories were made into a composite variable prior to running for Pearson's correlation coefficient. To ensure internal consistency, each composite (using the mean of items) was checked with Cronbach's alpha reliability analysis. See Table 1 for complete list of survey items.

**Table 1**

<table>
<thead>
<tr>
<th>Theme</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed mindset beliefs</td>
<td>My intelligence is something about me that I can’t change very much.</td>
</tr>
<tr>
<td>Fixed mindset beliefs</td>
<td>I can learn new things, but I can’t really change my basic intelligence</td>
</tr>
<tr>
<td>Fixed mindset beliefs</td>
<td>To be honest, students have a certain amount of intelligence, and they really can’t do much to change it.</td>
</tr>
<tr>
<td>Fixed mindset beliefs</td>
<td>To be honest, students can’t really change how intelligent they are.</td>
</tr>
<tr>
<td>Growth mindset beliefs</td>
<td>I can change even my basic intelligence level considerably.</td>
</tr>
<tr>
<td>Growth mindset beliefs</td>
<td>No matter how much intelligence students have, they can always change it quite a bit.</td>
</tr>
<tr>
<td>Faculty failure beliefs</td>
<td>Experiencing failure inhibits students’ learning and growth.</td>
</tr>
<tr>
<td>Faculty failure beliefs</td>
<td>Experiencing failure debilitates students’ performance and productivity.</td>
</tr>
<tr>
<td>Faculty effort beliefs</td>
<td>It doesn't matter how hard students work - if they're not smart, they won't do well.</td>
</tr>
<tr>
<td>Faculty effort beliefs</td>
<td>If students are not good at a subject, working hard won’t make them good at it.</td>
</tr>
<tr>
<td>Difficulty as impossibility</td>
<td>My gut tells me that material that feels difficult for students is probably impossible for them.</td>
</tr>
<tr>
<td>Difficulty as impossibility</td>
<td>When a concept is difficult for students to grasp, the course may not be for them.</td>
</tr>
<tr>
<td>Difficulty as importance</td>
<td>When a concept is difficult for students to grasp, it likely means that it is important for them to learn.</td>
</tr>
<tr>
<td>Difficulty as importance</td>
<td>If students find something difficult to learn, it often signals that it is important for them.</td>
</tr>
</tbody>
</table>
Field ability beliefs | Being a top student in my class requires a special aptitude that just can’t be taught.
---|---
Field ability beliefs | If you want to succeed in my class, hard work alone just won’t cut it; you need to have an innate gift or talent.

**Fixed mindset beliefs.** Four items (Dweck 1999) assessed fixed mindset beliefs (e.g., “I can learn new things, but I can’t really change my basic intelligence.”) Faculty were instructed to rate each item on a scale of 1 (strongly disagree) to 6 (strongly agree). Internal consistency was high with a Cronbach’s alpha value of 0.910.

**Growth mindset beliefs.** Two items (Dweck 1999) assessed growth mindset beliefs (e.g., “I can change even my basic intelligence level considerably.”) Faculty were instructed to rate each item on a scale of 1 (strongly disagree) to 6 (strongly agree). Internal consistency was high with a Cronbach’s alpha value of 0.874.

**Faculty failure (as debilitating) beliefs about students.** Sourced from Haimovitz and Dweck (2016), two items assessed faculty failure beliefs about students (e.g., “Experiencing failure debilitates students’ performance and productivity.”) Faculty were instructed to rate each item on a scale of 1 (strongly disagree) to 6 (strongly agree). Internal consistency was high with a Cronbach’s alpha value of 0.821.

**Faculty effort beliefs about students.** Adapted from Blackwell, Trześniewski, and Dweck (2017), two items assessed faculty effort beliefs about their students (e.g., “It doesn't matter how hard students work - if they're not smart, they won't do well.”) Faculty were instructed to rate each item on a scale of 1 (strongly disagree) to 6 (strongly agree). Internal consistency was marginal, with a Cronbach's alpha value of 0.636.

**Difficulty as impossibility beliefs.** Two items assessed difficulty as impossibility belief (e.g., “When a concept is difficult for students to grasp, the course may not be for them.”) The items were not made into a composite due to lack of internal consistency, yielding a Cronbach’s alpha value of 0.494. Therefore, we report results from each item separately.

**Difficulty as Importance.** Two items assessed difficulty as importance belief (e.g., “When a concept is difficult for students to grasp, it likely means that it is important for them to learn.”) Internal consistency was high with a Cronbach’s alpha value of 0.802.

**Field ability beliefs.** Sourced from Leslie, Cimpian, Meyer, and Freeland (2015), two items assessed field ability beliefs (e.g., “If you want to succeed in my class, hard work alone just won’t cut it; you need to have an innate gift or talent.”) Internal consistency was high with a Cronbach's alpha value of 0.821.

**Procedure**
All instructors at a large, public, southwestern university were sent a link for a 5-minutes online survey that they completed voluntarily in the Fall of 2019. In the survey, participants responded to items measuring their beliefs about ability, failure, difficulty, effort, and field ability, and their demographics (gender identity, racial/ethnic identity, age, years teaching). This data was compiled with undergraduate, graduate, and faculty demographics from the
same university. The demographic data was reported by the Institutional Reporting, Research, and Information Systems department of the university. For each department in the undergraduate category, the report (2020) indicated the percentage of first-generation, underrepresented minority, and women identifying students in each individual department. For the graduate category, the report (2020) indicated the percentage of underrepresented minorities and women identifying students in each individual department. The faculty category reported (2019) percentage of underrepresented minorities and women-identifying faculty.

For undergraduate and graduate students, underrepresented minority was defined as the following categories: American Indian (Indigenous)*, Multiracial including Black (excluding Hispanic), Black, Hispanic (any combo), and Pacific Islander. The categories combined were divided by the total demographic population to determine percentages. The categories “unknown” and “Foreign” were omitted from the data collection as they are not descriptive enough to include in analysis. The total included the following categories: American Indian (Indigenous)*, Multiracial including Black (excluding Hispanic), Black, Hispanic (any combo), and Pacific Islander, Asian, White, 2 or more excluding Hispanic and Black. These percentages were calculated for each individual department. For analysis purposes, some departments had to be combined into one category, such as Spanish and Portuguese (See Supplemental Materials for more details on what adjustments were made.)

Results

To test our research questions and hypothesis, we examined the relations between faculty departmental unproductive mindsets and representation of student and faculty populations within their department. Composites (besides difficulty as impossibility items which were kept separate) were ran with departmental %women undergraduate, %URM, %1st generation undergraduate, % women graduate, %URM graduate, %women faculty, and %URM faculty to determine correlations and statistical significance via Pearson’s correlation coefficient (continuous variables, 2 tailed test of significance).

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* We recognize that some communities prefer the term “indigenous,” the term “American Indian” was a predetermined racial category designated by the university.
Table 2
Pearson Correlation for survey items

<table>
<thead>
<tr>
<th></th>
<th>% women undergrad</th>
<th>% URM undergrad</th>
<th>% first-generation undergrad</th>
<th>% women graduate</th>
<th>% URM graduate</th>
<th>% women faculty</th>
<th>% URM faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed mindset</td>
<td>-.42**</td>
<td>-.10</td>
<td>-.26*</td>
<td>-.19</td>
<td>-.06</td>
<td>-.17</td>
<td>.08</td>
</tr>
<tr>
<td>Growth mindset</td>
<td>.29*</td>
<td>.05</td>
<td>.24*</td>
<td>.06</td>
<td>.11</td>
<td>.01</td>
<td>.06</td>
</tr>
<tr>
<td>Effort</td>
<td>-.22</td>
<td>-.03</td>
<td>-.13</td>
<td>-.04</td>
<td>-.06</td>
<td>-.08</td>
<td>-.08</td>
</tr>
<tr>
<td>Difficulty as impossibility item 1</td>
<td>-.20</td>
<td>-.19</td>
<td>-.13</td>
<td>-.26*</td>
<td>-.26*</td>
<td>-.24*</td>
<td>-.15</td>
</tr>
<tr>
<td>Difficulty as impossibility item 2</td>
<td>-.10</td>
<td>-.15</td>
<td>-.30**</td>
<td>-.05</td>
<td>-.23</td>
<td>.05</td>
<td>-.16</td>
</tr>
<tr>
<td>Field ability</td>
<td>-.38**</td>
<td>-.33**</td>
<td>-.36**</td>
<td>-.38**</td>
<td>-.29*</td>
<td>-.36**</td>
<td>-.33**</td>
</tr>
</tbody>
</table>

Note. ** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed). N values range from 67 to 72.

RQ 1: How do department-level faculty unproductive mindsets relate to percent of women-identifying undergraduate students, graduate students, and faculty?

In departments where faculty have stronger fixed mindsets ($r = -.42**$) and field ability beliefs ($r = -.38**$), there are fewer undergraduate women. In contrast, in departments where faculty have stronger growth mindset beliefs ($r = .29*$), there are more undergraduate women.

In departments where faculty have stronger difficulty as impossibility beliefs (item 1; $r = -.26*$) and field ability beliefs ($r = -.38**$), there are fewer graduate women.

Finally, in departments where faculty have stronger field ability beliefs, there are fewer women faculty ($r = -.36**$).

RQ 2: How do department-level faculty unproductive mindsets relate to percent of URM undergraduate students, graduate students, and faculty?

In departments where faculty have stronger field ability beliefs, there are fewer URM undergraduates ($r = -.33**$).

In departments where faculty have stronger failure as debilitating beliefs, there are more URM graduate students ($r = .27*$).

In contrast, in departments where faculty have stronger difficulty as impossibility beliefs (item 1; $r = -.26*$) and field ability beliefs ($r = -.29*$), there are fewer URM graduate students.
Finally, in departments with stronger failure as debilitating beliefs, there are more URM faculty ($r = .31^{**}$). In contrast, departments with stronger field ability beliefs have fewer URM faculty ($r = -.33^{**}$).

**RQ 3: How do department-level faculty unproductive mindsets relate to percent of first-generation undergraduate students?**

In departments where faculty have stronger fixed mindsets ($r = -.26^{*}$), difficulty as impossibility beliefs ($r = -.30^{**}$), and field ability beliefs ($r = -.36^{**}$), there are fewer first-generation undergraduates.

In contrast, departments with stronger growth mindsets ($r = .24^{*}$) and difficulty as importance beliefs ($r = .26^{*}$), have more first-generation undergraduate students.

**Discussion**

This research found that department-level professor beliefs about ability, failure, effort, and difficulty—what we refer to as unproductive mindsets—are related to student and faculty representation in terms of gender, race/ethnicity, and first-generation status. We found that representation of first-generation and women undergraduates was most strongly related to professor beliefs, while representation of underrepresented minority undergraduates was the least strongly related to professor beliefs. The most significant professor belief in predicting student demographic representation was field ability beliefs. Strong field ability beliefs were significantly correlated with lower percentages of all demographic categories (women/URM undergraduate, graduate, and faculty, as well as first-generation undergraduate students). This suggests that representation within fields is related closely to professors’ beliefs on field ability, that is the belief that success in a specific field requires a certain innate aptitude or talent (Leslie, et al., 2015). Our findings are consistent with the work done by Leslie et al. (2015), which found that racial and gender representation of Ph.D. students was related to field ability beliefs. Our findings extend on their work by including undergraduate and faculty demographics.

Growth and fixed mindset beliefs were related to representation of women and first-generation undergraduates, suggesting that professor fixed mindsets may be associated with these populations choosing to leave certain departments. Women and first-generation students may already be experiencing negative stereotype threat (e.g., Canning et al., 2019; LaCosse et al., 2020). With many factors at play for these two demographics, their student experience could possibly be improved by additional support in their undergraduate careers. Work done by Limeri et al. (2020) suggests that student undergraduate mindset changes throughout their first year, which means their mindset shifts could possibly be influenced by their professor mindset beliefs.

Difficulty as impossibility beliefs were related to less representation of first-generation undergraduates, women and URM graduate students, and women faculty. This suggests that the belief that difficulty is a negative barrier that can make desirable outcomes impossible (Oyserman et al., 2018); may be influencing these groups to stay away from departments where professors hold these beliefs. In contrast, departments with stronger difficulty as importance beliefs were shown to have more first-generation undergraduate students.
Unexpectedly, stronger failure as debilitating beliefs were found to be related to higher representation of URM graduate students and faculty. This could possibly suggest that failure as debilitating beliefs operate differently in post-undergraduate populations than they do in undergraduate populations. Or perhaps that underrepresented minority graduate students and faculty use these negative beliefs as motivation. Many factors could be at play regarding how failure beliefs influence student’s faculty, requiring further research on the topic.

These findings suggest that ones’ intersectional identity relate to how they may be influenced by professor beliefs. Professor beliefs operate differentially, as some were shown to be more influential than other. In addition, populations are influenced differently in relation to professor beliefs. The way professor beliefs and demographic representation operates is complex and requires additional research to investigate further how gendered and racial gaps in departments can begin to be mended.

There are several limitations to the current study. Given that this is a correlational study, we cannot say with certainty that professor mindset is causing certain students to leave fields. Because of this, a longitudinal study that follows students into college and tracks their decision making and feelings would be useful to gain insight to this issue.

Another limitation of this study is how the university categorizes race, as some students were categorized under broad categories such as foreign and unknown, and thus had to be omitted from analysis. In addition, department names change within field from undergraduate to graduate courses, making matching departments difficult (See Supplemental Materials for more details on what adjustments were made). An additional limitation is what other factors may be at play to influence one’s decisions to enter a field. Factors such as upbringing, familial life, and conditioning may also be implicated in field representation.

Conclusion

Do department-level professor unproductive mindsets relate to student and faculty representation in terms of gender, race/ethnicity, and first-generation status? We found that there were significant correlations between professors’ unproductive mindsets and student and faculty representation, however, there is a need for additional future research. Understanding how professor mindset relates to student outcome can provide information to push for change in professor training and classroom environment, ultimately opening possibility for more equitable learning experiences.
References


Supplemental Materials

Log of Adjustments

Averaged all BIO departments in undergraduate data to fit the faculty survey. All biology faculty responses (across sub-departments) are in “BIO.”

- BIOLOGY INSTRUCTIONAL OFFICE, DEPT OF INTEGRATED BIOLOGY, DEPT OF MOLECULAR BIOSCIENCES

Undergraduate data category “DEPT OF CIVIL, ARCH, & ENVIRN ENGNR,” combined data was used for ARE (architectural engineering), C E (civil engineering) on faculty survey.

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Graduate category “DEPT OF CIVIL, ARCH, & ENVIRN ENGNR” combined data was used for both ARE (architectural engineering), C E (civil engineering) on faculty survey.

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Faculty demographic data “DEPT OF CIVIL, ARCH, & ENVIRN ENGNR” as used for both ARE (architectural engineering), C E (civil engineering) on faculty survey.

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Autoencoders for Dimension Reduction in Single Cell Data

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Deep neural networks have been proposed as a better approach for gene expression profiling of single-cell RNA sequencing. Autoencoders are a specific type of deep learning architecture that compress the data input into a lower-dimensional code and then reconstruct the output from this representation. The objective of this research is to provide a comprehensive summary of Autoencoders by using multiple articles from the literature and test the neural network learning architectures for gene expression profiling of single-cell mRNA sequencing.

Introduction

The interest in single-cell RNA sequencing research has increased ever since it was first published as “mRNA-Seq Whole-Transcriptome Analysis of a Single Cell” in 2009. (Tang et al., 2009). Multiple methods have been developed to analyze the feature that the single-cell data has to offer but often fail to capture all of them due to their zero inflated nature. This phenomenon is better known as the dropout effect. Single-cell RNA sequencing provides the expression profiles for thousands of individual cells which allow researchers to analyze data at the single-cell level. Researchers can examine cell state, phenotypes, cell expression, quantities, and much more from single-cell RNA sequences. Further research in single-cell RNA sequencing is needed to preserve the integrity of Single-cell data.

Commonly used dimensionality reduction methods such as Principal Component Analysis and t-Distributed Stochastic Neighbor Embedding enable easy visualization of the data but do not explicitly allow for the existence of dropout values. (Zhang, 2020) Multiple methods for gene expression profiling of single-cell RNA sequence hypothesize a linear relationship between latent space and the model parameters. This strong assumption often leads to increased residuals and results in a general underestimation of counts during dimensionality reduction of single-cell RNA sequences. An underestimation of the counts presents a major problem for single-cell analysis pipelines that rely on the mRNA counts. (Trong, 2019)

Principal Component Analysis (PCA) is a linear dimensional reduction method that is often compared to Autoencoders. Testing single-cell RNA sequencing with principal component analysis has proven to be slightly effective but lacks true representation since it considers the single-cell data to be linear. Generalized principal component analysis is a PCA-like method that is suitable for raw counts, avoiding the pitfall of normalization. (Townes, 2019) Unlike Principal Component Analysis, Autoencoders can handle
non-linear dimensionality reduction and thus might prove to be more effective for dimension reduction in single-cell data.
My research focuses on the potential use of autoencoders for dimension reduction in single-cell data. If the neural network architecture can accurately display a minimal loss of data count or accuracy in reproducing the mRNA sequence, we can propose autoencoders as an effective method for dimension reduction in single-cell data.

An autoencoder is a type of artificial neural network that uses unsupervised machine learning algorithms to reproduce its input to its output by backpropagation. They are typically used for application in feature extraction, data compression, learning generative models of data, and dimensionality reduction. Autoencoders consist of three parts: encoder, code, decoder. (Goodfellow, 2016) The encoder compresses the input into a latent space representation that will become the code that the decoder uses to reconstruct the original input.

An encoder is a feedforward neural network that encodes the input data as a reduced dimension representation. The code of an autoencoder usually refers to the reduced dimension product of the encoder. Although the decoder is also a feedforward neural network and its structure is similar to that of an encoder, its primary function is to reconstruct the code to the original dimension that was fed into the autoencoder.

![Diagram of an autoencoder](image)

**FIG 1.** A simple encoder representation created using Lucid and Drawboard software.

Autoencoders are data-specific neural networks. This means that the learning architecture is only able to efficiently compress data that is similar to the training data that was used to create the autoencoder. The nodes within the encoder and decoder side of the neural network are created by assigning weight to given features also known as activation functions. The hidden layer where all the data is stored as a latent space representation is built with one or more hidden layers. Since the primary purpose of an autoencoder is to reduce and recreate the data the number of nodes closer to the code decreases. Creating the bottleneck effect that gives autoencoders their unique architectur
The four hyper-parameters needed to determine before training the autoencoder: the code size, the number of layers in the neural network, the loss function, and the number of nodes per layer. The code size determines the degree that the latent space representation will be compressed while the loss function is set to measure the loss of data in the autoencoders’ hidden layers. The loss function is the total sum of the reconstruction loss and the call back labeler divergence between the encoder distribution also known as the regularizer.

There are multiple functions that can be assigned to the loss function but the use of each depends on the data and model that is being created.

The most common types of autoencoder are Sparse, Undercomplete, Convolutional, and Variational. All autoencoders consist of the same bottleneck architecture; the only variance is determined by the structures of their encoder and decoder. There is still current research at works for developing different models of autoencoders.

**Materials and Methods**

The conceptual modeling and implementation of the autoencoder algorithm were fully implemented in a GCP jupyter notebook for environment control. The code was run on a GCP notebook instance with a 8 vCPUs, 30 GB RAM, and a TensorFlow 2.4 environment.

TensorFlow is an open-source software library that particularly focuses on training and inference of deep neural networks. The TensorFlow library allows users to build and train models with Keras’ APIs library. It provides a simple and easy to use structure to build high-level machine learning models. TensorFlow is also a free open-source software, making it accessible for anyone to use. This software provides all of the tools necessary to create a beginner-friendly Autoencoder.

The single-cell mRNA sequence data used in this research project was provided by Giovanni Rebaudo. The single-cell data is a binary matrix representation of the cells and genes expressed in the mRNA sequence. Although there are multiple types of autoencoders, due to a time constraint and lack of resources we will focus on implementing a single hidden layer autoencoder also referred to as a Vanilla Autoencoder. (Chollet, 2016) A single hidden layer autoencoder consists of a dense encoder layer as well as one dense decoding layer. Since the data we are working with is
a binary representation of the single-cell mRNA sequence all model layers were created with rectified linear units as the activation function for non-linearity.

The given single-cell data was a data frame of 33694 genes and 5826 cells. We first filtered the single-cell data by deleting genes with a count less than 10, reducing our gene count to 16415. The single-cell data frame was transformed into a 2-dimensional matrix and split into a train and test subset. The train mRNA data was created by using 80% of the original data and the other 20% was used to test the efficiency of the autoencoder. The autoencoder encoding dimension was created with an approximate 15% of data reduction. This means that the code would be a 2626 by 5826 reduced representation of the original data.

The autoencoder was compiled with an Adam optimizer and a binary cross-entropy loss function. An Adam optimization is a stochastic gradient descent method that is based on adaptive estimation of first-order and second-order moments. The autoencoder was then trained with batch size of 5 and an epoch of 10. The batch size is the number of samples from the training set processed before the model is updated while the epoch determines how many times this process is applied. In detail, the 13131 values from the training data will then be processed in batches of 5. After every batch, the autoencoders model structure will be updated to better fit the data.

**Results**

After running the single-cell mRNA trained and test data through the fitted autoencoder the following loss and accuracy values were calculated.

![Training and validation accuracy](image)

**FIG 2.** Loss and accuracy values obtained from the autoencoder for 10 epochs. The validation data represents the test data results after being fed through the autoencoder.
In FIG 2 we can see that the accuracy for the training and testing data of the autoencoder is never really able to reach a 30% accuracy. The graph suggests that the autoencoder had drastic updates after every peak in order to increase the accuracy. It is important to note that the autoencoder does seem to have a local max for the training and testing data at the same epochs. This suggests that the autoencoder is able to preserve the main data features for both the validation and training data.

![Training and validation loss](image)

**FIG 3.** Loss and accuracy values obtained from the autoencoder for 10 epochs. Like the previous table, the validation data represents the test data results after being fed through the autoencoder.

The training and validation data display the same number of averaged elements lost through every epoch and batch. This consistency leads me to believe that the autoencoder does show some efficiency at preserving the data after dimensional reduction. Although the structure of the autoencoder seemed to provide low accuracy of the data predicted it displayed consistency in its loss values.

The loss and accuracy data obtained from the autoencoder shows that the autoencoder was able to conserve consistency for the training and testing data. The low accuracy and loss can be attributed to the simple design of our autoencoder. Since our simple autoencoder forces a 20% dimensional data reduction in one layer, it is justified why the amount of data lost is high.

In order to better understand the autoencoder model, a heatmap was needed in order to show how the data was being modified. FIG 4 is better able to show the drastic change that the autoencoder had on the single cell sequence mRNA data. The original heatmap of the test data shows the variance of 1’s that are within the data while in the after picture
we can see that a lot of these numbers are lost. From the second graph we can see that the autoencoder preserved the same cell value for every gene within the testing data.
FIG 4. These graphs are heatmaps of the before and after test mRNA data for our autoencoder. The value 1 is represented in white while the value 0 is represented in black.

Fitting the autoencoder with 5 samples of the mRNA trained data for a total of 10 times took an estimate of 2hrs to complete. Although it was attempted to train the autoencoder 50 times for better data variation, it was never able to fully process due to length of time and GCP unstable connectivity.
Discussion

After examining the graphs produced by the autoencoder loss and accuracy values obtained we can assume that autoencoders are complicated neural networks that are inadequate for single-cell mRNA dimension reduction with a simple model. I believe that further research is needed in order to confirm that this is the case for different types of autoencoder. For future projects it would be interesting to apply a more complex autoencoder with multiple hidden layers as well as some of the other well known autoencoders mentioned before.

It is also important to consider that when working with a huge dataset the type of computing machine impacts the computation performance. Running the mRNA data through the autoencoder was expensive to process since there is a lack of computational power for heavy complex data. I would also propose to further clean the data to preserve the unique features of the mRNA sequence. Autoencoders are also sensitive neural networks that take time to train with any given dataset and therefore should be processed through a CPU with a higher RAM capability.

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Computer Code

Below is all of the code developed for the purpose of this research. The Autoencoder model code was developed with reference to the code on *Build the right Autoencoder* by Chitta Ranjan and *Building Autoencoders in Keras* by Francois Chollet.

```
# Build Model
epoch = 10
batch_size = 5
input_dim = train_mRNA.shape[1]
encoding_dim = 5391
learning_rate = 1e-3

# Simple Layers
encoder = keras.layers.Dense(encoding_dim, activation='relu', input_shape=(input_dim,), use_bias=True)
decoder = keras.layers.Dense(input_dim, activation='relu', use_bias=True)

autoencoder = keras.Sequential()
autoencoder.add(encoder)
autoencoder.add(decoder)

autoencoder.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])

autoencoder.summary()

# Fit and Test Model
batch_size = 5
autoencoder = autoencoder.fit(train_mRNA, train_mRNA, epochs=epoch,
batch_size=batch_size, shuffle=True, validation_data=(test_mRNA, test_mRNA))

# Plot the accuracy and loss plots between training and validation data
accuracy = AE_history.history['accuracy']
val_accuracy = AE_history.history['val_accuracy']
loss = AE_history.history['loss']
val_loss = AE_history.history['val_loss']
epochs = range(len(accuracy))

plt.plot(epochs, accuracy, 'bo', label='Training accuracy')
plt.plot(epochs, val_accuracy, 'b', label='Validation accuracy')
plt.title('Training and validation accuracy')
```
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend() plt.figure()
plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')

**Github:**
https://github.com/ivonnem3/scRNAseq_Autoencoders/blob/main/Autoencoders_for_sc-mRNA_code.ipynb