Perceived Barriers to Higher Education in STEM among High-Achieving Underrepresented High School Students of Color

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Abstract

The underrepresentation of people of color in the fields of Science, Technology, Engineering, and Mathematics (STEM) has become an increasing concern nationwide, with efforts focused on understanding mechanisms causing underrepresentation and implementing policies and interventions to address the problem. Given the structural barriers in educational access and opportunity and the social/psychological barriers facing underrepresented students of color, this study utilizes frameworks of stress, coping, and stigmatization within a sample of 152 high-performing high school students of color to: (a) Examine students' perceptions of internal and external barriers to STEM higher education, (b) Address the intersectionality of race and gender by assessing whether perceptions of barriers vary by race and gender, (c) Explore relationships between perceived barriers and STEM aspirations, and (d) Examine coping mechanisms to overcome perceived barriers to STEM degrees. Results from survey and focus group responses revealed that despite academic ability, students perceived high levels of internal and external barriers to pursuing STEM studies in higher education. While these perceptions did not impact attitudes towards math and science, they were significantly related to a decrease in STEM career aspirations. Male students perceived significantly fewer internal and external barriers than female students, indicating unique challenges faced by female students of color. Despite perceiving internal and external barriers, students demonstrated confidence in overcoming barriers and discussed positive and adaptive coping strategies. This study concludes with implications for improving opportunities for students of color to enter and persist in STEM fields through K-12, higher education, and out-of-school programming, research, and policy.

Introduction

Despite projections that the fastest-growing and highest-paying jobs of the future are in the fields of Science, Technology, Engineering, and Mathematics (STEM; Bureau of Labor Statistics, 2009; U.S. Department of Commerce, 2011), underrepresented students of color continue to comprise only a small percentage of individuals pursuing STEM degrees in higher education and entering the STEM workforce. African Americans and Latinos combined earn only 11% of all science and engineering degrees, and represent just 9% of the entire science and engineering workforce (NSF, 2012). Given the rapidly shifting demographics of the United States (Passel et al., 2012) and the simultaneous demand for a skilled STEM workforce to sustain economic growth and global competitiveness (Stine and Matthews, 2009; President's Council of Advisors on Science and Technology, 2010), the underrepresentation of people of color in STEM fields is increasingly problematic. Amid national efforts to increase the number of underrepresented students completing degrees in STEM, further research is needed to clarify the relationships between structural barriers within schools, psychological responses to inequity, and future STEM aspirations among students of color.

Structural Barriers to Pursuing STEM Degrees

Literature suggests that the underrepresentation of people of color in STEM fields is linked to both structural barriers in educational access and opportunity, and social/psychological barriers and responses to disparities and social stigmatization. Critical Race Theory (CRT) conceptualizes structural barriers and racial disparities in education as a consequence of institutional and structural racism manifested in schools and society (Ladson-Billings and Tate, 1995). Within K-12 STEM education, structural barriers impact low-income students and students of color in the lack of access to equitable school funding, science resources and facilities, high-quality teachers, technology and computer science courses, and advanced coursework (College Board, 2012; Darling-Hammond, 2004; Education Trust-West, 2012; Educational Testing Service, 2008; Goode, 2010; Margolis, 2008; WestEd CFTL, 2011), thus limiting opportunities for success and competitiveness in STEM fields of study. Additionally, within higher education, barriers facing underrepresented students of color include a lack of sufficient high school academic preparation and advanced coursework (AAAS, 2001), lack of mentorship from same-race role models and faculty (Price, 2010), and perceiving a non-welcoming, hostile climate (Chang et al., 2011; Perna et al., 2009; Thiry, et. al, 2011).

As a cumulative effect of these barriers, African American and Latino students demonstrate much lower proficiency rates in science and mathematics than their White and Asian peers (National Center for Education Statistics, 2011, 2012), are less likely to access and achieve success in advanced coursework (College Board, 2012), and demonstrate lower levels of college readiness than their peers (ACT, 2011; SAT, 2011). These K-12 outcomes have significant implications for STEM persistence in higher education and degree completion, where just 22% of Latino students and 18% of African American students who aspired to major in a STEM field complete a Bachelor's Degree in STEM within 5 years (Eagan et al., 2010).

Social/Psychological Barriers to Pursuing STEM Degrees

In addition to the structural barriers and resulting inequity in academic outcomes, research indicates that underrepresented students also face social/psychological barriers to pursuing STEM education, stemming in part from coping with stigma and marginalization. The mechanisms of stigmatization are essential in understanding the complexities and dynamics of racial and gender stigmatization, and the effects on stigmatized group members. Major and O'Brien (2005) summarized the mechanisms of stigmatization using four categories: (a) Negative treatment and direct discrimination, (b) Expectancy confirmation processes, (c) Automatic stereotype activation, and (d) Stigma as identity threat. In examining students of color within STEM fields, these mechanisms can be observed in: (a) inequitable access to resources and educational opportunities, (b) self-fulfilling prophecies, stereotype threat, underperformance, and disengagement, (c) avoidance of certain subjects and fields of study and endorsement of stereotypical beliefs, and (d) perceptions of bias and anticipation of bias.

Negative treatment and direct discrimination refers to the limited access to important institutions which affect the social status, mental and physical health, and educational opportunities of the stigmatized group. This direct discrimination includes structural barriers and inequities in K-12 education, as well as direct experiences with bias, discrimination, and micro-aggressions. Expectancy confirmation processes describes the interaction between institutions and the individual, where confirmed expectations are created by the treatment of the perpetrator, whose behavior can directly affect the target's thoughts, feelings, and behaviors, often to the point of confirming the initial erroneous expectation. Good and Brophy (1984) described this dynamic, termed the "self-fulfilling prophecy," in elementary classrooms where teachers formed expectations about students, communicated these expectations to students through conscious and unconscious mechanisms, and students modified their self-perceptions and achievement, often in accordance with the initial expectations. While there is less research on confirming expectations among underrepresented students of color in STEM, similar mechanisms are at play, where racial and gender differences in teacher perceptions of math ability and stereotypes held by teachers about which students are capable of success in math and science and behaviors can potentially impact student outcomes.

Automatic stereotype activation operates on an individual level and involves the activation of dominant cultural stereotypes without the presence of discriminatory behavior and often results in stereotype-consistent behavior among the stigmatized group. Stereotype threat studies have consistently demonstrated that individuals from negatively-stereotyped groups demonstrate decreased performance in situations where group status is highlighted, stereotypes are invoked, or evaluative scrutiny occurs. Specifically, stereotype threat has been shown to negatively impact standardized test performance among African American students (Steele and Aronson, 1995), math performance among women (Spencer et al., 1999), and white males when compared to Asians in math (Aronson et al., 1999). In addition to affecting performance, stereotype threat has also been shown to negatively impact attitudes, including engagement and identification within specific fields of study (Crocker et al., 1998). Finally, stigma as identity threat suggests that stigma affects a person's own social identity by affecting their interpretation of social contexts and their understanding of how they are viewed by others. Using the mechanisms of stigmatization to understand the complex interaction between underrepresented students of color and the STEM educational and occupational contexts allows for further examination into the ways in which underrepresented students perceive and respond to marginalization and has significant implications for understanding long-term STEM outcomes.

Perceived Barriers and Educational and Career Outcomes

Studies conducted with African American and Latino high school students demonstrate that these students report experiencing prevalent racial bias and discrimination (Sellars et al., 2006; Rosenbloom and Way, 2004), and perceive racism to be widespread in institutional and societal contexts (Fisher et al., 2000). Further, perceived racial inequality within schools has been negatively associated with academic outcomes, including grades and self-concept (Wong et al., 2003) and psychological/behavioral engagement (Scott, 2009) among African American adolescents. McWhirter (1997) found that female high school students were more likely to perceive barriers to education and career goals than males, and Latino students perceived greater educational and career barriers than white students. These findings, however, did not specifically focus on STEM fields of study, in which females and students of color are acutely underrepresented. Few studies have examined the perceptions of structural and psychological barriers to pursuing STEM studies in higher education held by underrepresented students, and the impact of these perceptions on STEM career aspirations.

Social Cognitive Career Theory (Lent et al., 2002) suggests that gender and race/ethnicity impact career decision-making by shaping the experiences which influence self-efficacy and outcome expectations. In addition, Social Cognitive Career Theory suggests that contextual factors, including perceived barriers, can impact career interests and the pursuit of specific careers (Fouad and Byars-Winston, 2005; Brown and Lent, 1996; McWhirter, 1997). Similarly, theories of coping with stigmatization suggest that perceptions of inequality, discrimination, and/or stereotypes can affect career aspirations through the disidentification, devaluing, and disengagement associated with stereotype threat (Crocker et al., 1998; Major and O'Brien, 2005; Steele et al., 2002). Experimental studies by Major et al. (1998) and Osborne (1997) demonstrate how in response to negative stereotypes, students who are members of stigmatized groups may disengage from academic domains affected by stereotype threat. Specific to STEM, stereotype threat has been shown to generate disinterest and cause female students to consider changing majors to fields not dominated by males (non-STEM; Murphy et al., 2007; Shapiro and Williams, 2012; Steele et al., 2002). Further, when women perceived greater gender stereotypes and less belonging in their math classroom, they demonstrated lower grades and decreased interest in taking math classes in the future (Good et al., 2012).

Stress and Coping

In addition to understanding mechanism of stigmatization, the stress and coping process has been identified as a relevant framework for examining the impact of racism and discrimination on people of color (Harrell, 2000) and subsequent coping responses. The stress process involves the exposure to a stressful event or stimuli, the cognitive appraisal of the demands posed by a stressor (primary appraisal), the appraisal of resources to cope with these demands (secondary appraisal), and the ensuing response to the stressor (Monat and Lazarus, 1991). Within the context of STEM education, the exposure to stressful stimuli could include direct discrimination/bias, stereotype threat activation, and inequity in educational access and opportunity. According to this process, the individual's assessment of the demands and the availability of resources to cope with demands directly influence coping responses. Thus, it is imperative to examine not only the perceptions of barriers to STEM education (primary appraisals), but to also examine the availability and types of resources and coping mechanisms (secondary appraisals) perceived by underrepresented students in order to cope with the perceived barriers.

Using this stress and coping framework allows for the examination of the type and availability of resources to cope with perceived barriers to STEM in higher education, and also allows for an examination of the ensuing coping responses employed by students of color. Defined as cognitive and behavioral efforts to manage specific demands that are appraised as exceeding the resources of the person (Monat and Lazarus, 1991), coping responses can be adaptive or maladaptive and can be both conscious and unconscious. Literature suggests that for students of color, coping responses to race-related stress and structural disparities can include resilience and striving harder to overcome obstacles (Sanders, 1997), as well as disengagement or disidentification with a domain (Steele and Aronson, 1995; Major and O'Brien, 2005). Similarly, for female students, coping responses to gender-related stress can include decreased interest in male-dominated academic fields (Good et al., 2012) and changing career trajectories (Steele et al., 2002). Within the current study, the extent to which students perceive barriers in confidence, preparation, and anticipated discrimination in STEM in higher education is examined to understand the appraisals of structural disparities and consequences associated with these appraisals.

There is a dearth of studies examining the impact of perceived structural and psychological barriers on the desire for students from underrepresented racial groups to pursue STEM in post-secondary education. While evidence from stereotype threat studies suggests that negatively stereotyped group members are harmfully affected by societal stereotypes and threat activation, less information exists about explicit perceptions of both structural and psychological barriers specific to underrepresented racial groups and the pursuit of STEM studies. Even less information exists about the impact of these perceptions on future STEM outcomes. Additionally, the population of African American and Latino high school students who are high-achieving in math and science warrants further attention. Given that the best predictors of earning undergraduate STEM degrees are high levels of academic performance in high school (Eagan et al., 2010), studying high-performing students eliminates the lower academic aptitude, self-concept, and self-efficacy that can confound the potential relationship between perceived barriers and STEM aspirations. There is still much to learn about how perceived barriers impact the STEM career aspirations of high-performing students, and the types of coping strategies employed among high-performing students from underrepresented backgrounds, particularly as it relates to the pursuit of STEM fields of study. Some evidence indicates that high-achieving students who unconsciously perceive barriers (racism/sexism) disidentify with the specific academic domain in question and demonstrate lower performance, regardless of their aptitude (Schmader et al., 2001; Steele and Aronson, 1995). Additional evidence suggests that positive coping strategies including "striving harder" are employed by high-achieving students to persist despite perceiving racial discrimination (Sanders, 1997), and several components including developing social relationships within schools (Conchas, 2006) and promoting positive racial/ethnic ideology (Carter, 2005) are essential in assisting high-performing students of color to overcome structural barriers to academic success. Further research is needed to identify coping strategies and interventions to promote successful STEM outcomes among this population of students.

Women of color face unique challenges in pursuing degrees and careers in STEM, as they are concurrent members of both gender and racial groups underrepresented in STEM fields (Ong et al., 2011). This "Double-Bind," as first described by Malcom, Hall and Brown (1976), suggests that the effects of racial and gender marginalization may have a cumulative effect, thus impacting women of color in the sciences in ways that surpass men of color and white women. As such, it is imperative to examine within-group gender differences in both perceived barriers to studying STEM in college and ways in which perceptions of barriers impact the career aspirations of high-performing students of color.

Thus, this study seeks to contribute to understanding about underrepresentation in STEM fields by examining perceptions of barriers to pursuing STEM in higher education and analyzing the impact of these perceptions on STEM career aspirations. This study will utilize CRT in conjunction with frameworks of stress and coping (Lazarus and Folkman, 1984) and mechanisms of stigmatization (Major and O'Brien, 2005) to examine student perceptions of structural barriers and explore ways in which perceived barriers impact interest in pursuing STEM studies in higher education. Specifically, this research will: (a) Examine students' perceived barriers to STEM higher education (academic preparation, confidence, and anticipated racism/sexism), (b) Explore the relationship between perceived barriers and STEM aspirations, (c) Address the intersectionality of race and gender by assessing whether perceived internal and external barriers vary by race and gender, and (d) Examine coping mechanisms employed by students to overcome barriers to pursuing STEM studies in higher education.

Methodology and Data Sources

Research Questions

(1) To what extent do high-achieving students of color perceive internal and external barriers to pursuing STEM in higher education?

(2) Do perceived internal and external barriers vary by demographic variables?

(3) What is the relationship between perceived internal and external barriers and STEM career aspirations?

(4) To what extent do participants demonstrate confidence in overcoming barriers and what coping responses are employed in response to perceived barriers?

Participants

Students participating in a 5-week summer math and science program in the San Francisco Bay Area (n=160) were invited to participate in this research through a verbal invitation given during program orientation. Ninety-five percent (n=152) of all students consented to participate in the research. Students were selected to participate in the summer program based on merit criteria including grades, performance in math and science courses and assessments, and teacher recommendations. All students were members of racial/ethnic groups underrepresented in the STEM fields, with the majority being Latino (46%), African American (25%) and Vietnamese (9%), with other Southeast Asian and multiracial students comprising the remaining 20%. The sample was equally divided based on gender, with 49% of scholars being female. There were slightly more tenth graders in the sample (37%) than 11^{th} (32%) and 12^{th} (31%) graders. The mean age was 16 and the majority of students qualified for Free/Reduced Price Lunch (64%) and will be the first in their family to complete college (67%). All students attended high schools in the San Francisco Bay Area; with 92% attending public schools.

Data Collection and Analysis

Quantitative and qualitative data were collected through both surveys and focus groups. All participants took online surveys, which assessed variables including perceived barriers, attitudes towards math and science, identification with math and science, STEM career aspirations, and self-concept, among other variables. Descriptive analyses were used to assess the frequency of perceived barriers to studying STEM in higher education and to determine if significant differences in perceived barriers existed based on demographic characteristics. Multivariate analyses were then conducted to determine whether student perceptions of barriers to STEM studies in higher education were significantly associated with outcome variables including future STEM aspirations, attitudes towards math and science, and confidence in achieving aspirations, while controlling for demographic variables. Finally, interaction terms were calculated and tested in regression models to examine any moderating effects on later STEM aspirations.

A group of 15 students participating in an affiliated academic year technology program participated in two focus groups. These students had previously participated in the 5-week summer program and were invited to participate in the focus groups, which were videotaped and transcribed in order to collect additional qualitative data examining perceived barriers to STEM education and coping responses. Focus group transcripts and qualitative survey answers were analyzed utilizing qualitative analysis software, and qualitative and qualitative data were triangulated to synthesize findings.

Study Instruments

Study instruments consisted of a comprehensive online survey and a focus group protocol. All participants completed a pre- and post- survey, which included the scales examined within this project: (1) Perceived barriers to STEM, (2) Confidence in overcoming barriers, (3) Attitudes towards mathematics and science, (4) STEM career aspirations, and (5) Confidence in achieving aspirations.

The perceived barriers in STEM scale (α=.83), consisted of 7 items assessing student beliefs about both external (structural) and internal (social/psychological) barriers to pursuing STEM in higher education. The perceived barriers items were adapted from McWhirter's (1997) perceived barriers to education and career questions. The revised perceived barriers items contained two subscales: External Barriers (α=.79) and Internal Barriers (α=.79). The external barriers subscale included 3 items assessing beliefs about external forces limiting opportunities within STEM including, "In college (studying STEM), I will probably have to deal with… being treated differently based on race" and "...teachers thinking I am not as smart as my peers." The internal barriers subscale consisted of 4 items assessing internal beliefs about individual capacity to be successful in STEM, including, "In college (studying STEM), I will probably have to deal with…not being as smart as other students," and "…not having enough confidence." All 8 items were measured on a 5-point Likert scale with higher values indicative of higher perceived barriers (1=Strongly Disagree, 5=Strongly Agree).

The confidence in overcoming barriers scale (α=.91) consisted of 7 items assessing the level of confidence students have in overcoming internal and external barriers to pursing STEM in higher education. This scale contained two subscales: Confidence in overcoming internal barriers (α=.88) and confidence in overcoming external barriers (α=.87). Sample items include, "Please rate your confidence in overcoming…not having enough confidence" and "…being treated differently based on my race." All items were measured on a 5-point Likert scale with higher values indicative of higher levels of confidence (1=Not at all confident, 5=Very confident).

The attitudes towards math scale (α=.76) consisted of four items assessing student attitudes towards math, including "How much do you care about doing well in math?" and "How much do you like or dislike math?" The attitudes towards science scale (α=.80) consisted of four items assessing student attitudes and interests in science, including, "How much do you care about doing well in science?" and "How much do you like or dislike science?" All items were scored on a 5-point Likert scale with higher values reflective of more positive attitudes. The STEM career aspirations scale (α=.91) consisted of 2 items assessing students' intentions to pursue careers within STEM fields, including, "I want to get a job in STEM when I grow up." Finally, the confidence in achieving aspirations scale consisted of 4 items assessing students' confidence in achieving their college and STEM goals, including, "I am confident I will get accepted to college," and "I am confident I will pursue a degree in STEM." All items were scored on a 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree).

The focus group protocol consisted of 8 questions examining student perceptions of barriers in academic preparation, anticipated bias/discrimination based on race and gender, perceptions of gender and racial/ethnic differences in science and math ability, and strategies to cope with obstacles and barriers.

Findings

Perceived Internal and External Barriers to STEM in Higher Education

On average, students within this sample perceived moderately high levels of both internal barriers (e.g., confidence) and external barriers (e.g., gender/race discrimination) to STEM in higher education (*M*=2.87, *SD*=.81). As reported in Figure 1, the most frequently perceived internal barriers included feeling not as smart as other students (46%) and not feeling prepared enough to succeed in STEM (41%). The most frequently perceived external barrier was the fear of being treated differently based on race (45%). Males and females differed in their perceptions of both internal and external barriers, and females reported higher levels of every barrier. Females were far more likely than males to indicate perceiving barriers in confidence (44% compared to 26%), preparation (51% compared to 34%), and encountering negative teacher perceptions of their abilities (51% compared to 33%). Forty-three percent of female students perceived gender discrimination and female students were more likely to perceive racial discrimination than males (51% compared to 38%; Figure 1).

Figure 1. Perceived Internal and External Barriers, by Gender

Studying Science, Technology, Engineering, or Mathematics (STEM) in college, I will probably face… (% strongly agree/agree)		**Male**	**Female**	**M-F Diff**	**Total**
INTERNAL (α=.88)	…Not being as smart as other students	42%	52%	10	46%
	…Not having enough confidence	26%	44%	18	35%
	…Not fitting in	27%	33%	6	30%
	…Not being prepared enough	34%	51%	17	41%
EXT	…Teachers thinking I am not as smart as other students	33%	51%	18	34%

	…Being treated differently because of my gender	5%	43%	38	24%
	…Being treated differently because of my race	38%	51%	13	45%

A One-Way Analysis of Variance (ANOVA; Figure 2) was used to stratify participants by demographic characteristics and determine if significant differences existed between participants' internal and external perceived barriers based on demographics. Results revealed that there were no significant differences between racial/ethnic groups (African American, Latino, Southeast Asian, Other/Mixed), nor were there significant differences between students who were eligible for Free/Reduced Price Lunch and those who were not on the outcome of perceived internal or external barriers. There were also no significant differences in perceived internal or external barriers by high school grade (10^{th}, 11^{th}, and 12^{th}), nor in perceived internal barriers by first-in-family status. However, students who will be the first-in-family to complete college were significantly less likely to perceive external barriers than their peers, $F(1,148)=4.25$, $p<.04$, partial $\eta2=.03$.

When examining gender, large differences between male and female students existed. Male students perceived significantly fewer internal barriers to studying STEM in higher education than female students ($F(1,148)=6.38$, $p<.01$, partial $\eta2=.04$) and significantly fewer external barriers to STEM ($F(1,148)=10.14$, $p<.00$, partial $\eta2=.06$). The gender difference in perceived external barriers existed even when removing the question specifically addressing perceived future gender discrimination ($F(1,148)=7.86$, $p<.01$, partial $\eta2=.05$; Figure 2).

Figure 2. One-Way ANOVA: Perceived Internal and External Barriers by Demographics

	INTERNAL			**EXTERNAL**		
Independent Variable	*F*	*Sig.*	*Partial η²*	*F*	*Sig.*	*Partial η²*
Race/Ethnicity	1.31	.28	.06	1.73	.11	.08
Gender	6.38	.01*	.04	10.14	.00*	.06
Free/Reduced Price Lunch Eligibility	.85	.36	.01	.21	.65	.00
First-in-Family to Complete College	.08	.78	.00	4.25	.04*	.03
H.S. Grade	.77	.46	.01	.68	.51	.01

*p<.05, **p<.01.

Perceived Barriers and the Impact on Pursuing STEM in Higher Education

Correlation analyses using Pearson's product-moment correlation coefficient were conducted (Figure 3) to determine whether there were significant relationships between Internal and External Barriers and (a) Attitudes towards Math, (b) Attitudes towards Science, (c) STEM Career Aspirations, and (d) Confidence in Achieving Aspirations. Perceived internal barriers were significantly negatively correlated to confidence in achieving aspirations ($r=-.18$, $p<.05$) and non-significantly negatively related to attitudes towards math, attitudes towards science, and STEM career aspirations. Perceived external barriers were non-significantly, negatively correlated to attitudes towards math, science, career aspirations and confidence in achieving aspirations ($r=-.07$, $r=-.09$, and $r=-.02$, and $r=-.09$, $p>.05$, respectively). Finally, attitudes towards math and science were positively correlated to STEM career aspirations (r=.20, p<.05 and r=.23, p<.01 respectively; Figure 3).

Figure 3. Means, Standard Deviations, and Pearson Correlations between Scales

	IB	EB	AM	AS	SCA	CAA
Internal Barriers						
External Barriers	.29**					
Attitudes-Math	-.13	-.07				
Attitudes-Science	-.05	-.09	.12			
STEM Career Aspirations	-.13	-.02	.20*	.23**		
Confidence in Achieving Aspirations	-.18*	-.09	.13	.09	.26**	
Mean	1.58	1.49	4.36	4.52	4.43	4.49
Standard Deviation	.50	.50	.57	.55	.79	.61

IB=Internal Barriers, EB=External Barriers, AM=Attitudes towards Math, AS=Attitudes towards Science, SCA=STEM Career Aspirations, CAA=Confidence in Achieving Aspirations, *p< .05, **p< .01

Hierarchical linear regression analyses (Figure 4) were run to determine whether perceived internal and external barriers are significantly related to STEM outcomes, including attitudes towards math and science, STEM career aspirations, and confidence in achieving aspirations. All linear regression analyses were run using the stepwise method with control variables of race, SES, and grade to determine the unique contribution to the outcome variables. Perceived internal and external barriers were non-significant predictors of attitudes towards math (F(1,145)=1.35, p>.05 and F(1,145)=1.09, p>.05) and attitudes towards science (F(1,145)=1.21, p>.05 and F(1,145)=1.48, p>.05). Perceived external barriers was also a non-significant predictor of STEM career aspirations (F(1,145)=2.8, p>.05).

Perceived internal barriers was a statistically significant predictor of STEM career aspirations (F(1,145)=3.9, p<.05), where higher levels of perceived internal barriers significantly predicted a decrease in STEM career aspirations (B= -.53, SE=.26, p<.05). Perceived internal barriers and perceived external barriers were both statistically significant predictors of confidence in achieving aspirations (F(1,145)=3.69, p<.01 and F(1,145)=1.81, p<.05, respectively). Higher levels of perceived internal and external barriers predicted a decrease in confidence in achieving higher education aspirations (B=-1.48, SE=.39, p<.01 and B=-1.01, SE=.40, p<.05, respectively; Figure 4).

Figure 4. Hierarchical Linear Regression Analyses: Perceived Internal and External Barriers as Predictors of STEM Outcomes

Criterion Variable: Attitudes towards Math					
Predictors	***R²***	***B***	***SE***	***F***	***t***
Perceived Internal Barriers	.04	-.48	.38	1.35	-1.27
Perceived External Barriers	.03	-.26	.37	1.09	-.70
Criterion Variable: Attitudes towards Science					
Perceived Internal Barriers	.03	-.27	.36	1.21	-.74
Perceived External Barriers	.04	-.51	.39	1.48	-1.45
Criterion Variable: STEM Career Aspirations					
Perceived Internal Barriers	.10	-.53	.26	3.9	-2.1*
Perceived External Barriers	.07	-.07	.13	2.8	-.52
Criterion Variable: Confidence in Achieving Aspirations					
Perceived Internal Barriers	.09	-1.48	.39	3.69	-3.75**

Perceived External Barriers	.05	-1.01	.40	1.81	-2.55*

All hierarchical linear regression analyses were run using the stepwise method, with control variables of race, SES, and grade entered in the first step; *p<.05, **p<.01.

Given the significant differences in perceived internal and external barriers by gender, with female students perceiving barriers at a higher level than male students, an analysis of variance was run to examine interactions between perceived barriers, gender and STEM outcomes. There were no significant interactions between perceived barriers, gender and STEM aspirations and confidence in achieving aspirations, suggesting that there are no significant differences in the impact of perceived barriers on STEM outcomes by gender (Figure 5).

Figure 5. Two-Way ANOVA: Perceived Barriers x Gender

Outcome Variables	**Perceived Internal *Gender**		**Perceived External *Gender**	
	F	Sig.	F	Sig.
STEM Aspirations	.30	.68	2.99	.33
Confidence in Achieving Aspirations	.11	.79	--	--

*p<.05, **p<.01.

Confidence in Overcoming Barriers to Pursuing STEM Studies in Higher Education

Descriptive analyses were used to assess the levels of confidence in overcoming internal and external barriers to studying STEM in higher education. On average, students within this sample reported high levels of confidence in overcoming internal barriers to STEM (*M*=4.11, *SD*=.83, Range=1-5). Students were less confident in their ability to overcome external barriers, on average (*M*=3.16, *SD*=.63, Range=1-5). One-Way ANOVA analyses were used to examine confidence in overcoming perceived internal and external barriers by demographic groups (Figure 6). No significant differences existed in confidence in overcoming internal and external barriers by race, free/reduced price lunch eligibility, first-in-family status, and high school grade. Male students, however, reported higher levels of confidence in overcoming internal barriers than female students (F (1,148)=6.02, p<.05). There were no significant gender differences in confidence in overcoming external barriers (Figure 6).

Figure 6. One-Way ANOVA: Confidence in Overcoming Internal and External Barriers by Demographics

	Confidence in Overcoming Internal Barriers			**Confidence in Overcoming External Barriers**		
Independent Variable	*F*	*Sig.*	*Partial η²*	*F*	*Sig.*	*Partial η²*
Race/Ethnicity	1.39	.22	.07	.92	.49	.04
Gender	6.02	.02*	.04	2.62	.11	.02
Free/Reduced Price Lunch Eligibility	.01	.91	.00	1.61	.21	.01
First-in-Family to Complete College	.01	.91	.00	.00	.99	.00
H.S. Grade	1.04	.36	.01	.50	.61	.01

*p<.05, **p<.01.

Further analyses were then conducted to determine whether confidence in overcoming internal and external barriers could moderate the impact of perceived barriers on STEM aspirations.

Two-Way ANOVA analyses were conducted (Figure 7) to examine interaction effects of: (1) perceived internal barriers and confidence in overcoming internal barriers, and (2) perceived external barriers and confidence in overcoming external barriers, on STEM career aspirations. There was homogeneity of variance between groups in both analyses as assessed by Levene's test for equality of error variances.

No significant interaction was present between the effects of perceived internal barriers and confidence in overcoming internal barriers on STEM aspirations ($F(1,144) = .79$, $p>.05$), nor between perceived external barriers and confidence in overcoming external barriers ($F(1,144)=.84$, $p>.05$; Figure 7).

Figure 7. Two-Way ANOVA: Perceived Barriers and Confidence in Overcoming Barriers on STEM Aspirations

Criterion Variable: STEM Career Aspirations		
	F	*p*
Perceived Internal Barriers *Confidence in Overcoming Internal Barriers	.79	.38
Perceived External Barriers *Confidence in Overcoming External Barriers	.84	.36

*p<.05, **p<.01

Coping with Perceived Internal and External Barriers

Given that students reported high levels of confidence in overcoming barriers to pursuing STEM studies in higher education, qualitative data from focus groups and open-ended survey items were used to further examine the types of coping responses that students described employing (or thinking about employing) to overcome the barriers they perceive. The coping responses were overwhelmingly positive and adaptive, falling into three main categories, two of which were positive and adaptive, and one of which was less positive and more maladaptive: (1) Striving harder to overcome barriers, (2) Seeking and relying on external sources of support, and (3) Lowering expectations to avoid disappointment.

Striving harder to overcome barriers. The most frequently-described coping response was to "ignore" barriers and strive harder to overcome any obstacles in the way of achieving goals. Students believed if they can simply ignore racism, sexism, and "other people's opinions" that they will be able to succeed. One student described ways to overcome barriers as "just knowing that I have every right to be there and that no one can take that away from me," and another mentioned ensuring that he would "not let other people affect the way I think of myself." Even while acknowledging the existence of racism and sexism, students demonstrated determination in overcoming these external barriers, commenting "my gender and race shouldn't stop me from doing what I want to do…I will just bear it if I have to, but it's not going to stop me from following my path."

Students repeatedly mentioned motivation, confidence, persistence, mental strength, and believing in themselves as fundamental components in overcoming barriers and succeed in STEM. Several students also described having a strong "will" to overcome barriers and the desire to prove naysayers wrong. One student commented, "I want to prove that even though I didn’t have the best income, I still strived for the best.” Another student described using past struggles as motivation, describing his process as, “thinking about my past and all the things I already overcame,” while yet another student described looking to the future for motivation, “I need to look deep inside myself for the confidence that I have. Even when I feel like giving up or lose all faith in hope, I will remind myself of all of the dreams that I want to accomplish.” While these responses from students demonstrate an understanding of their marginalized position and the ways in which they might be viewed or treated by others in pursuit of their dreams, they also demonstrate tremendous resilience.

Seeking and relying on external sources of support. Another frequently-mentioned coping response to counteract the effects of potential barriers and obstacles to studying STEM in higher education was to seek out the support and wisdom of external sources, including parents, peers, and role models. Students spoke extensively about how their family can be a general source of support and encouragement to get them through difficult times. One student commented, “If I was struggling with something, I know my family would be there to help me,” and another one spoke about family providing a source of confidence, saying “my family will give me confidence to overcome (it).”

Beyond general support from family, students also described seeking out peers from similar backgrounds to develop support networks to buffer against obstacles. Students indicated that a way to cope with obstacles to studying STEM in college would be to “find people that are facing the same obstacles as me and finding where I fit in,” “to look for friends who have been through these experiences,” and “to get to know other students that are in the same situation.” One student described how meeting a network of peers of color who are interested in STEM provided a sense of belonging and motivation to continue to pursue STEM studies, “I was sort of thinking, 'maybe I'm the only one that thinks this', and to then hear other people say the same thing and to think the same thing that I thought is definitely, it gives you a sense of, like, maybe I'm not the only one...hey, I'm around people who think the same things as me and have the same goals as I have.”

Furthermore, students believed that mentors who have been through similar experiences and come from the same backgrounds could be a tremendous resource. Students described seeking out mentors, and “talking to my mentors about my plan to overcome challenges of not fitting in or having enough confidence.” Another student commented, “my mentors can give me advice on what to do when I am lost.” More specifically, one student mentioned, “It would be nice to have someone I can talk to who has already experienced these challenges. By doing this, I could receive some tips on how to overcome challenging obstacles in college.”

Lowering expectations to avoid disappointment. While mentioned with much less frequency than the other proactive coping responses, several high-performing students within this study described the coping response of lowering their expectations in order to avoid disappointment associated with not reaching their goals. In response to perceived internal and external barriers, several students mentioned lowering their academic expectations by saying, “It could just be doubting yourself, better to leave the bar really low so you know you can jump over it when you get there (college). If you say you’re going to do great and expect to do great, then if you don’t, it is more of a disappointment.”

While this student wasn't specific about the ways in which he would lower his academic expectations, several possibilities could include declaring less rigorous majors, taking less rigorous courses, and altering STEM career aspirations. Despite the fact that these students demonstrated a history of high levels of achievement within STEM subjects, their perceptions of barriers in preparation, confidence and anticipated discrimination led to maladaptive coping responses. One student commented, "the way that STEM majors are talked about, because I also have thought that I won't be able to succeed very well because it's like, very competitive…For me, it does seem like, well if my expectations are that high, then it's impossible for me and I won't ever be able to do it." This comment clearly demonstrates how the perceptions of challenges in pursuing STEM studies can lead to disengagement and lowered expectations, despite actual aptitude and potential. Although this coping response was not frequently mentioned by students within this sample, it does demonstrate the potential maladaptive coping responses which can emerge in response to perceived barriers and provides important information about potential areas for targeted interventions.

Discussion

Among this population of high-achieving high school students of color, high levels of both internal barriers (e.g., confidence and preparation) and external barriers (e.g., gender/race discrimination) were perceived by students. This suggests that despite their academic successes and potential to pursue degrees and careers in STEM, they identify and acknowledge obstacles in beliefs about their ability, preparation and belongingness in fields in which they are underrepresented and disadvantaged in comparison to students from other racial/economic backgrounds. For example, over 40% of students believed that if they pursued STEM studies in higher education, they would "not be as smart" or "not be as prepared" as other students. Another 45% perceived that they would encounter being treated unfairly based on race if they pursued a STEM major in college, thus perceiving the biases associated with being a marginalized group member including perceptions of ability associated with STEM fields of study.

Findings demonstrated that there was evidence of a "double-bind" or unique challenges associated with being both female and a member of an underrepresented racial group among the female students within this study. While there were no differences in perceived barriers by race, socioeconomic status, or high school grade, significant differences existed by gender. Male students perceived significantly fewer internal barriers (e.g., doubts about abilities and preparation) to studying STEM in higher education than female students and significantly fewer external barriers (e.g., anticipated inequitable treatment) to pursuing STEM in college than females. The gender difference in perceived external barriers existed even when removing the question specifically addressing perceived future gender discrimination, suggesting women of color are more attuned to the existence of racial and gender biases existing within STEM academic contexts.

Despite the widely held perceptions of internal and external barriers to pursuing a degree in STEM, these perceptions did not have a significant impact on attitudes towards math and science. Thus, perceiving barriers did not result in a significant decrease in identification and interest in doing well in the content areas of math and science. Yet, higher levels of perceived internal barriers were significantly related to a decrease in STEM career aspirations, suggesting that there may be significant long-term effects associated with perceiving barriers to STEM. While attitudes towards STEM subject matter may not be significantly impacted, this data suggests that the desire to pursue STEM degrees and careers can be negatively affected. Interestingly, perceived external barriers did not significantly impact STEM career aspirations, suggesting that the internal processes associated with confidence, self-efficacy, and belonging had a greater impact on STEM career aspirations than did the anticipation of negative treatment by race/gender. Despite the fact that there were large and significant differences in perceptions of barriers by gender, there were no differences in the impact of perceived barriers on STEM outcomes by gender. As anticipated, the more likely students were to perceive both internal and external barriers, the less confident they were that they would achieve their higher education aspirations.

On average students reported high levels of confidence that they could overcome barriers or obstacles to STEM in higher education. Male students, however, reported higher levels of confidence in overcoming internal barriers than female students. This is consistent with literature demonstrating that male students demonstrate higher levels of self-concept in math and science (Eccles, 1994), and provides further evidence that women of color face additional challenges beyond those associated with racial background. There were no significant gender differences in confidence in overcoming external barriers. Though students had high levels of confidence in overcoming perceived barriers, confidence did not significantly moderate the effect of perceived internal barriers and confidence in overcoming internal barriers on STEM aspirations, nor between perceived external barriers and confidence in achieving aspirations. This suggests that confidence alone cannot counteract the effects of perceived barriers on STEM career aspirations and confidence in achieving aspirations.

Given the widely-held perceptions of internal and external barriers to STEM in higher education held by this population, students were asked to describe coping mechanisms employed to overcome these barriers in order to examine whether these responses were adaptive or maladaptive, and whether these coping responses could offer insight into ways to buffer the effects of perceived barriers on later STEM career aspirations. Students described three main coping responses: (1) Striving harder, (2) Seeking and relying on external networks of support, and (3) Lowering expectations to avoid disappointment. The "striving harder" response, which was the most frequently cited, is consistent with existing research from Sanders (1997) who found that African American middle school students with high levels of awareness of racial discrimination cope with this discrimination by striving harder academically. This data is also consistent with Valenzuela's (2006) findings that Chicana/Latina students demonstrated significant inner strength and confidence in overcoming obstacles in science and math, which she termed the "inner fire to succeed." While this coping strategy is proactive in that it allows students to remain focused and committed to pursuing their STEM educational goals, it can also be seen as burdensome on students because of the sole reliance on further challenging themselves, as opposed to challenging the contextual/environmental factors impeding their success.

Conversely, students also described seeking external networks of support to help motivate, guide, and mentor them through challenging circumstances. Students were especially interested in gaining support from peers and role models from similar backgrounds with comparable experiences and goals. Developing networks and gaining access to peers from the same racial, ethnic, and/or socioeconomic background can be an essential coping strategy for underrepresented students of color; Research demonstrates that these networks can be a fundamental component in the retention and success of college students of color (Gandara and Maxwell-Jolly, 1999; Harper, 2006). In addition, mentoring from faculty members, especially faculty from minority backgrounds, can decrease isolation and improve outcomes (Maton and Hrabowski, 2004; McHenry, 1997; Price, 2010). The third coping strategy discussed by students was to respond to obstacles and barriers to STEM in higher education by lowering expectations in order to avoid disappointment. Similar to findings indicating that responses to racial and gender bias and discrimination can include disidentification and disengagement (Major and O'Brien, 2005; Schmader et al., 2001; Steele & Aronson, 1995), these students described lowering their expectations as a way to deal with perceived barriers. This maladaptive coping response demonstrates a mechanism by which high-achieving students who are capable of success may avoid more challenging majors based on perceived potential obstacles. Overall, however, students tended to demonstrate positive coping strategies which were more indicative of resiliency than disengagement and disidentification. Moreover, their coping strategies of soliciting support from networks of peers and mentors provide potential opportunities for intervention.

Conclusion and Implications

Within the fields of Science, Technology, Engineering, and Mathematics, students of color are acutely underrepresented relative to their populations, and research has sought to determine both causes for this underrepresentation and potential solutions. Given the existence of structural barriers in educational access and opportunity and social/psychological barriers in responses to disparities and social stigmatization, this study aimed to examine the extent to which high-performing students of color perceive these internal and external barriers, and what impact these perceptions have on STEM aspirations.

Despite the high levels of academic achievement and interest in science and mathematics demonstrated by study participants, students still overwhelmingly anticipated facing internal barriers, including not feeling as confident, smart, or prepared as other students. They also anticipated facing external barriers, including being treated unfairly due to race and/or gender in pursuit of a STEM degree in higher education. While there is some literature demonstrating racial differences in self-concept in math and science (Leslie et al., 1998; Stevens et al., 2004) and belonging in STEM (Seymour and Hewitt, 1997), the current findings suggest that even high-performing students with a demonstrated interest in STEM studies perceive significant obstacles associated with their marginalized status to pursuing a degree. Further, the perceptions held by these participants do not demonstrate a view of STEM fields as inclusive, inviting, and equitable, but rather as an area where some individuals are privileged and other face significant obstacles to entrance. In fact, these widely-held perceptions negatively impact the desire to pursue STEM careers. These findings extend existing research literature examining responses to inequity and discrimination among marginalized groups (Major and O'Brien, 2005; Schmader et al., 2001; Steele and Aronson, 1995) and clearly suggest that there is a detrimental impact on

STEM career aspirations of high-achieving students of color. Additional research conducted with various populations, including students with less demonstrated interest in STEM and/or less successful academic records, can provide additional insights into the perceptions of barriers to entering STEM fields held by a more robust and diverse sample of underrepresented students of color. This study was conducted with high school students and assessed anticipated barriers, and a relevant follow-up study tracking these students once they have entered higher education (e.g., major, grades, attitudes) to examine actual effects of perceived barriers would add more depth to the study findings. These findings have implications for practice in understanding the barriers (structural and social/psychological) faced by students from underrepresented groups, and ensuring educational programs, curriculum, extracurricular opportunities, and policies seek to address these barriers in order to increase the representation of these groups in STEM fields.

The double-bind facing female students of color in this study was readily apparent. Male students of color perceived significantly fewer barriers to studying STEM in higher education than did females, indicating a more intense burden facing female students of color. This finding extends McWhirter's (1997) conclusion that female students perceive greater educational and occupational barriers than males and that students of color perceived greater barriers than White students, by demonstrating the double-bind for female students of color existing specifically within the STEM fields. While gender did not have a differential effect on the impact of perceived barriers on career aspirations, the large differences in perceived barriers between males and females suggest that additional outcomes could be impacted by these perceptions (e.g., confidence, motivation, belonging) which could ultimately impact desire to pursue STEM careers. Studies extending this work, examining in greater detail the perceptions held by women of color and how they qualitatively differ from those held by men of color, and examining endorsement of racial/gender stereotypes among women of color, would be illuminating. Additionally, this research did not focus on gender differences in coping responses to perceived barriers, which would be essential to understanding implications associated with gender differences in perceived barriers. These results can inform programming to ensure STEM-focused programs and interventions targeting underrepresented groups address the obstacles perceived by students and explicitly focus on the specific challenges facing women of color (Ong et al., 2011).

Lastly, while students perceived significant barriers in preparation, confidence, and anticipated discrimination, they also demonstrated coping strategies and resilience to persist. Students described striving harder and looking to networks of supportive peers, mentors, and family members. While several students described lowering expectations, a coping response detrimental to STEM outcomes, this was not a pervasive coping mechanism and the vast majority described positive and proactive coping responses. This research involved asking students to anticipate their coping strategies since they were not current college students, and as such, further research is needed to understand the coping mechanisms and strategies implemented by college students who persist despite obstacles, in comparison to those who end up changing majors and/or career paths. These findings have implications for programming and practice, in providing insights on interventions designed to give students tangible tools to counteract barriers to STEM in higher education.

In sum, high-achieving underrepresented students of color perceived obstacles to pursuing

STEM in higher education, and these perceptions negatively impacted the likelihood of these students pursuing careers in STEM. Further research is needed to understand the long-term implications of perceived barriers, gender differences in coping responses, and the coping mechanisms and strategies implemented by students who persist despite obstacles, in order to inform programming, research and practice on increasing opportunities for students of color in STEM.

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