The Troubled Success of Black Women in STEM

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ARTICLES

The Troubled Success of Black Women in STEM

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ABSTRACT

We examine the experiences of 3 high-achieving Black undergraduate and graduate women in science, technology, engineering, and mathematics (STEM). Our findings reveal that structural racism, sexism, and race-gender bias were salient in the women's STEM settings. These experiences were sources of strain, which the women dealt with in ways that demonstrate both resilience and trauma. We discuss how their experiences might motivate institutions to offer support for high-achieving students who sometimes face risks from multiple sources.

Introduction

Although careers in science, technology, engineering, and mathematics (STEM) fields are widely acknowledged as central to the future, Black women remain underrepresented in most of these fields. Only 2% of practicing scientists and engineers are Black women (National Science Foundation, 2015); their severe underrepresentation is linked to issues Black women face early in the STEM career pipeline. The low number of Black women in STEM college courses is partly attributed to limited STEM course offerings in the low-income schools that students of color disproportionately attend (Carlone & Johnson, 2007; Ong, Wright, Espinosa, & Orfield, 2011). Additionally, pervasive racial and gender stereotypes discourage some Black women from pursuing STEM pathways (Perry, Link, Boelter, & Leukefeld, 2012; Riegle-Crumb & Grodsky, 2010); the same stereotypes underlie instructor bias, which undermines the educational experience and outcomes of many Black women who do pursue STEM pathways (Hill, Corbett, & St Rose, 2010). Studies show that education professionals often steer Black girls to classes in social work and sociology, instead of encouraging them to achieve in the sciences. Black women who are steered away from rigorous mathematics and science courses in high school (e.g., Advanced Placement courses) later face limited collegiate and professional prospects related to these fields of study (Willingham & Cole, 2013).

Notwithstanding these structural and interpersonal obstacles, many Black girls and women do persist in K–16 STEM courses, majors, and careers (Espinosa, 2011; Johnson, 2011; Collins et al., 2009). Existing research illuminates the ways some students cope with racial and gender stereotypes and other forms of bias while maintaining high achievement in STEM fields (Cole & Espinoza, 2008; Museus, Palmer, Davis, & Maramba, 2011; McGee, 2014, 2015; Perna et al., 2009). STEM fields provide fertile ground for bias against Black women for at least two reasons. First, studies of tokenism document that bias tends to occur more often in fields where women make up less than 15–20% of students, which is common in many STEM fields (although no longer in biology; Kanter, 1977). Second, an influential study by Castilla and Benard (2010) found that bias is more common in fields like science and engineering, which practitioners

view as highly meritocratic. With this study, we add to this body of literature by focusing on how African American undergraduate and graduate women in STEM fields identify and respond to racialized and gendered forms of bias.

We emphasize the successes of young Black women here, but we also note unsettling aspects of their experiences that occur while achieving success in STEM (Chubin, 2007; Fries-Britt & Holmes, 2012; Gasman et al., 2009). We examine the toll taken by structural racism, sexism, and discrimination related to their status as Black women in STEM. We also highlight the diverse ways Black women interpret, respond to, and cope with racialized, gendered, and race-gendered experiences while pursuing academic degrees.

Theoretical perspective: Challenges of structural racism in STEM

Some readers might envision racism solely as blatant nefarious acts of individuals toward members of racial and ethnic groups. We offer a different analysis. Because racism has individual and institutional components (Harper, 2012), it is critical to consider racialized assumptions, policies, and practices embedded in academia in addition to individual acts of bias and racism. Other approaches that identify the consequences of learning in a racialized educational setting by showcasing a few bad actors only exacerbate the manifestations of racism. Ideologies related to colorblindness and meritocracy—which diminish or negate the realities of systemic racism—also exemplify how structural racism can manifest in educational spaces in general and STEM spaces in particular (e.g., Basile & Lopez, 2015; Lopez, 2003; Martin, 2009). Thus, we focus our attention on structural challenges associated with racism, sexism, and race-gender bias that impinge on Black women's college experiences in STEM.

Structural racism defines racism as systemic and foregrounds the reality of the United States' racialized systems, wherein economic, political, social, ideological, and educational dynamics routinely advantage Whites while producing chronically adverse outcomes for nondominant racial and ethnic groups (Bonilla-Silva, 1997). Bonilla-Silva (1997) described structural racism as racialized social systems in which economic, educational, political, and social ideologies routinely advantage White people and produce chronic adverse outcomes for people of color. For instance, structural racism helps to explain why problems such as disproportionate Black unemployment and unequal salaries of Black and White workers with similar academic backgrounds have continued for more than a century (e.g., Du Bois & Burghardt, 1899; Monnat, 2010). Moreover, this framework has been connected to racialized systems and structures with the lives and academic pathways of Black STEM students (McGee, 2016). As Feagin (2014) put it, "Systemic racism is about everyday experience. People are born, live, and die within the racist system" (p. xxi). Other scholars have articulated how structural racism manifests in Black Americans lives through everyday forms of discrimination (Essed, 1991; Miles & Brown, 2003).

In the next section, we review scholarship that guides the framing of this investigation, including (a) the challenges of structural racism in STEM, (b) African American students' success despite these challenges, and (c) the possibility of negative psychological consequences accompanying African American students' success in STEM college contexts.

Race in STEM higher education contexts

In their comprehensive review of the literature on students of color in STEM, Gasman and colleagues (2009) noted that STEM education has traditionally been characterized by a survival-of-the-fittest approach, in which the culture "attribute[s] failure in STEM to student characteristics" (p. 66). This mindset arises more frequently and intensely in STEM than in other fields (Cobb & Russell, 2015; Cole & Espinoza, 2008; Malone & Barabino, 2009; Martin, 2012; Robinson et al., 2016) and contributes to presumptions of underrepresented students' inferiority (Carlone & Johnson, 2007). A survival-of-the-fittest mindset implies, for example, that Black students are responsible for their own underrepresentation, and it sets the stage for stereotypic assumptions that many Black STEM students report experiencing in postsecondary education (Brown et al., 2016; McGee, 2016). Racism in the educational experiences of marginalized college students has been illuminated through the lens of racial microaggressions. As Pierce (1995) and Pierce, Carew, Pierce-Gonzalez, and Wills (1978) argued, racism has transformed over

time from overt, blatant forms of discrimination and prejudice to more covert, indirect, restrained, and ambiguous demonstrations, which they called *racial microaggressions*. Concepts such as racial microaggressions and racial stereotypes help to explain how subtle yet persistent forms of racism adversely affect the lives of people of color in STEM (Cvencek, Nasir, O'Connor, Wischnia, & Meltzoff, 2014; Perna, Gasman, Gary, Lundy-Wagner, & Drezner, 2010).

STEM education scholars have documented that more statistics select race of Blacks as a reason for their academic failure, as opposed to consequences of a hierarchy based on the social devaluing and stigmatization of the Black race (Gutiérrez, 2008; Martin, 2009; McGee, 2016). Martin (2009) further quantified that this society has developed a racial hierarchy of mathematics that places Whites and Asians on top and Blacks, Latinos, and Native Americans squarely on the bottom. These scholars offer research against a long-standing narrative that permeates this society that has normalized Black failure and inferiority in STEM education. Additionally, existing scholarship documents multiple ways in which racism is specifically and peculiarly entangled with traditional STEM educational cultures and environments (Parsons & Dorsey, 2015). A host of historical and contemporary practices have negatively affected Black students in STEM, including lack of a critical mass of STEM faculty of color; unwelcoming institutional climates, which often trigger psychological responses such as impostor syndrome, defined as the normalization of being perceived as a fraud in spite of high achievement in their academic domains (Vinnicombe & Singh, 2011; Young, 2011); institutional and social barriers in their departments; racial/ethnic stereotyping; a lack of role models or mentors; and high numbers of Black peers dropping out of college STEM fields (Cole & Espinoza, 2008; Malone & Barabino, 2009; Robinson et al., 2016). Black students have been found to be among those most likely to report finding it hard to position themselves—and to be seen by others—as properly scientific (Carlone & Johnson, 2007). We acknowledge the ways STEM educational cultures and environments can vary at the level of department, institution, and field, but research also highlights the ways STEM education generally can be a racialized space for Black students and educators, in context as well as content (e.g., experiences, environment; McGee, 2015; Maton & Hrabowski, 2004). Ideologies that were born of, and that privilege, Euro-/White-centric norms and theories about the intellectual inferiority of people of color are embedded in the fabric of STEM disciplines in ways that cross departmental, institutional, and field boundaries (Riley, 2014).

Black students' racialized experiences in STEM

A historical legitimization of race-based stereotypes, biases, and other forms of discriminatory socialization (e.g., policies, laws, and commonplace practices) strongly communicate to Black people that they are assumed to be underqualified and incapable of STEM intellectual endeavors (Martin, 2013). Practically, this means that not only do Black students face the challenges common to all students pursuing STEM degrees (e.g., stresses related to highly competitive environments), but they can also face challenges associated with how others perceive their racial group (Gutierrez, Muhs, Niemann, González, & Harris, 2012; Herrera & Hurtado, 2011). Thus, although STEM is often positioned as a surefire route to financial and job success, the academic road is littered with additional obstacles for Black college students, including challenges they face as they encounter other people's notions of Black people's intellectual inferiority and presumed incompetence (Gutierrez et al., 2012).

As a result of the racialized nature of STEM education, some Black college students—despite achieving traditional measures of educational success—continue to doubt their chances of being perceived as competent, despite doing everything in their power to sustain their academic success (e.g., maintaining high GPAs, participating in STEM-intensive summer internships, taking on leadership positions; McGee, 2016; McGee & Martin, 2011). For instance, many Black students encounter college STEM environments in which they are presumed to lack the aptitude and competence to succeed (Gutierrez et al., 2012; Herrera & Hurtado, 2011).

Racialized and gendered in STEM
Many Black undergraduate women in STEM majors experience toxic environments and report feeling isolated and excluded (Ong et al., 2011; Tate & Linn, 2005). Esposito (2011) conducted interviews with female college students of color at a predominantly White institution (PWI) and found that two of her

result from facing racism daily" (p. 180), is central to our analysis of STEM students' experiences. Toxic racialized experiences generate racial battle fatigue that is operationalized by the following symptoms; "frustration, shock, anger, disappointment, resentment, anxiety, helplessness, hopeless- ness, and fear" (p. 551, Smith, Allen, & Danley, 2007), consequently creating hostile campus environments for Black students and faculty members. Pierce (1995) provided another way to characterize the struggles of students of color on campus by describing racial oppression as the control of a victim's space, time, energy, and motion (the other STEM). Racial battle fatigue helps to illuminate how the psychological and emotional energy required to manage stress in STEM academic and social contexts while dealing with systemic and everyday racism can be overwhelming (Bystydzienski & Bird, 2006; Ong et al., 2011).

Researchers have begun to examine the complexities Black students face as they respond to stresses and challenges of racism encountered in their STEM educational contexts (Griffin & Allen, 2006; S. J. Robinson, 2013; W. H. Robinson et al., 2016). Higher-status jobs, such as those obtained with a STEM degree, expose African Americans to multiple stressors, such as impostor syndrome, tokenism, and other race-related stresses (O'Connor, Mueller, Lewis, Rivas-Drake, & Rosenberg, 2011). McGee's (2016) research on high-achieving Black and Latinx[1] STEM college students showed that students often appear to achieve adaptive responses despite a host of racialized experiences (often measured by sustained academic success in STEM) while simultaneously going through mental health crises. Thus, some researchers have argued that the enthusiasm for teaching African American K–12 students about psychological traits like grit in preparation for postsecondary education, for example, ignores societal racism and the toll it takes—even on students who appear to be the toughest and most successful by standard metrics (e.g., grades, test scores; Zirkel & Johnson, 2016).

Researchers have examined these systems to generate deeper understanding of the contexts responsible for the mental, physical, and socio-emotional concerns of Black STEM students. For example, McGee and Stovall's (2015) article calls for critical race theorists to consider the mental health issues that often plague high-achieving Black STEM students by presenting the narratives of two Black female STEM majors whose resilience and grit had become unhealthy. Explorations of racialized social systems (Bonilla-Silva, 1997) deepen our understanding of the inequitable contexts responsible for the resilience and grit shown by these high-achieving underrepresented students of color. Like the aforementioned researchers, we challenge individualistic understandings of resilience that do not concurrently account for the ways in which structural racism, sexism, and other isms challenge the hardiness of students of color generally, particularly in STEM.

This study

This study draws from two studies that investigated the experiences and career trajectories of high-achieving STEM students of color. These studies had overlapping themes and interview questions, and they investigated the racialized experiences of high-achieving postsecondary Black students at different types of higher education institutions. From those two studies, we extracted the experiences of Black women undergraduate and graduate students in STEM majors at three institutions. First, we seek to understand their encounters with racism, sexism, and race-gender bias in STEM education spaces. Second, we document how these Black women responded to manifestations of these *-isms* (e.g., instances of interpersonal discrimination) in ways that evidence both resilience and trauma, with particular attention to within-group differences and similarities in the women's experiences and responses. We outline how responses that might be considered resilient can mask race-related trauma, which—if acknowledged by education leaders—would otherwise present opportunities for critical support and instruction in the interest of students' holistic success and well-being.

Consequently, our research questions flow directly from our framework, which considers resilience in the context of structural racism, sexism, and race-gender bias in STEM and is aimed at uncovering ways that high-achieving Black female students encounter, understand, and respond to these structural issues in STEM learning contexts. The questions are as follows:

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[1]We use *Latinx* to decenter the patriarchal nature of and gender binary within the terms *Latino* and *Latina*.

1. How does structural racism, sexism, and/or race-gender bias appear to be salient in Black women students' STEM educational contexts?
2. How do Black women students respond to the challenges presented by structural racism, sexism, and/or race-gender bias in STEM?
3. In what ways might Black women students' responses indicate a need for structural supports that help to disrupt structural racism?

Method and context

Phenomenological qualitative research relies heavily on in-depth interviews for data collection; it is particularly useful for investigating insider perspectives (Marshall & Rossman, 2006). In keeping with previous analyses that employ the perspective of structural racism, we present the narratives of Black women STEM students, including racialized and gendered interactions, as well as interpersonal interactions and experiences related to larger racist systems, structures, practices, and ideologies (e.g., Martin, 2009; Lewis, 2004). We designed this work as a multiple case study analysis (Yin, 2013). Our case study design arose out of the desire to understand complex social phenomena surrounding how racism and sexism manifest in students' STEM contexts and *how* students respond to them. Case studies tend to be the preferred strategy when *how* or *why* questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context. The interview format is particularly appropriate given that our phenomena of study are entrenched in participants' real-world contexts (Yin, 2013).

Participants

Data were drawn from two larger studies aimed at uncovering the experiences of high-achieving underrepresented students of color in STEM fields. In Study 1, the first author interviewed 23 high-achieving Black mathematics and engineering students (juniors, seniors, graduate students) from four Midwestern universities; these data were collected between 2006 and 2008. Their overall GPAs ranged from 2.9 to 4.4 (some students received graduate-level credits), with a median GPA of 3.4. In Study 1, participants were recruited via e-mail and in-person informational sessions through campus programs and student organizations primarily serving Black students (e.g., Black Student Union), including those in engineering and mathematics (e.g., National Society of Black Engineers). Given our interest in the experiences of high-achieving underrepresented students, criteria for participation included (a) self-identifying as Black or African American, (b) mathematics or engineering major, (c) junior or senior or graduate-level status (evidenced through unofficial transcript), (d) a 2.9 GPA minimum on a 4.0 scale in mathematics courses, and (e) completion of at least 10 mathematics and/or engineering-related courses, with an A or a B grade in at least five of those classes. The first author conducted a semistructured interview with each of the 23 participants (average interview time: 86 min). Each participant received $10 at the end of the interview.

In Study 2, the Explorations into Diversifying Engineering Faculty Initiative (EDEFI) research team, founded by the first author and Dr. William Robinson (for more information on the EDEFI research projects, visit: www.blackengineeringphd.org), interviewed approximately 70 Black engineering PhD students and postdoctoral researchers in engineering and computing from 12 US universities during the 2014–2016 academic years. The second research study sought the critical factors that make Black people one of the most underrepresented racial groups in engineering faculty positions, despite intervention programs that aim to broaden the participation of minorities in engineering. In Study 2, participants were recruited via e-mail through key professional contacts (e.g., engineering faculty and staff) and in person at a national professional conference in engineering/computing. Members of the research team conducted semistructured interviews and focus groups guided by a protocol, with the first author conducting more than 50% of all the interviews. Within this format, interviews were conducted with a degree of flexibility, which allowed the interviewee to develop ideas and help shape the order of topics covered (Yin, 1998). Interviews lasted from 45 min to just over 2.5 hr; each doctoral student or

Table 1. Participant profiles

Pseudonym	Post-secondary Level	Major(s)	Institution
Nia	Undergraduate junior	Computer Science, Math	Southern HBCU
Maya	Recent PhD graduate	Mechanical Engineering	Southern PWI
Sonya	4th year PhD student	Computer Engineering	Southern HBCU

postdoctoral researcher received a $35 incentive for participating. Participants were affiliated with diverse types of institutions: PWIs, historically Black college or university (HBCUs), private and public universities, and technological institutes.

Per the guidelines for conducting case study research, the interview and focus group formats were semistructured and guided by a clear list of issues to be addressed and questions to be answered. Within this format, interviews were conducted with a degree of flexibility, which allowed participants to develop ideas and help shape the order of topics covered. All the individual and focus group interviews were audio-recorded. Participants who attended an in-person interview were also video-recorded with their permission. All interviews were professionally transcribed. Because both research studies were focused on better and more holistic understandings of the postsecondary experiences of high-achieving Black STEM students, we found commonalities by posing similar interview questions to the participants. These questions guided our selection of the three cases from the two larger studies (Creswell, 2012):

- How would you describe yourself in terms of your race and/or ethnicity?
- Do you believe that your race a plays a role in achieving in your STEM field? If so, how?
- Did the racial makeup of the faculty and/or students play a role in your choice of college?
- How would you describe the environment of your STEM program and your overall institution?
- If you were a man, do you think your STEM experiences would be different, and if so, how?
- If you could change one thing to better promote the academic success of Black students in STEM fields, what would it be?

We looked for cases that evidenced the three main parts of our framework: (a) experiences linked to structural racism, sexism, and/or race-gender bias in STEM contexts, (b) expressions of resilience in response to these experiences, and (c) responses to those experiences that might show a need for institutional support (e.g., evidence of related distress). Thus, we chose cases sequentially (e.g., Small, 2009), so that each case added to our understanding of students' experiences and responses. Consistent with case study sampling approaches used by other scholars studying complex phenomena among harder-to-reach and/or historically underrepresented populations (Yin, 1998), we identified similar and contrasting cases. We wanted to show how racialization affects the experiences and well-being of Black women at different points in the STEM postsecondary pathway (one undergraduate, one doctoral, and one post-doctoral researcher) and at different institutional types with contrasting demographics (two from PWIs and one from an HBCU; see Table 1).

Data analysis

A phenomenological approach was used to analyze the data. A phenomenological approach is appropriate for exploring the meanings and perspectives of research participants (Creswell, 2012). The goal of this approach was to develop a composite description of whether and how Black female STEM students and postdoctoral researchers experienced structural racism in the context of their daily schooling (Creswell, 2012). The coding team consisted of the two authors, a postdoctoral researcher, and one master's-level student. The second author and the master's student originally coded selected transcripts of Black female STEM undergraduate students from three studies carried out by the first author to inductively identify recurring patterns and topics. This process yielded five participants and helped to inform part of the overall architecture. Because we sought a more in-depth narrative of how structural racism manifested at different points of the STEM pipeline, we decided to use only one of the original five participants and choose two new Black female participants at doctoral and postdoctoral

levels from study 2 detailed previously. In the Findings section, we briefly describe each case study participant, including each one's areas of study and some of their personal background, before the case analysis.

Each transcript was chunked into segments of standalone text that conveyed meaning apart from the rest of the transcripts. Each segment of text was linked to the unique identifier of the speaker, the geographic location and date of the interview and focus group, the interview guide question, and any other stimuli (i.e., prompts, comments of other participants) that appeared to influence the individual's statement. After the coding process, we reviewed the quotes organized under each code, noting emerging patterns and connections between codes.

This winnowing process led to summarizing, packaging, repackaging, and aggregation of the transcripts (Miles & Huberman, 1994). We shared the summarized transcript of one participant with a group of eight visiting scholars in the areas of diversity, higher education, and STEM education. The scholars' expert input gave us "analytical notes on" potential "linkages to various frameworks of interpretation" (Miles & Huberman, 1994, p. 92). The last phase of repackaging and aggregating the textual data included the construction of conceptual matrices, in which we entered segments of text into a table that also contained analytical notes to aid in the identification of "themes and trends in the data overall" (Miles & Huberman, 1994, p. 92). Analysts used these matrices to make sense of the data, reducing the amount of coded text and selecting segments that most clearly illustrate linked themes of racism in STEM, resilient responses, and aspects of the responses that indicated the need for additional support. We refined and edited conceptual matrices in an iterative process and used them to facilitate more advanced phases of analysis pertaining to within-case and cross-case comparisons and to generate tentative hypotheses.

Positionality statement

Two Black women form our team of authors and lead researchers (one faculty member and one doctoral candidate); it is important that we acknowledge our positions and subjectivity (Berger, 2015: Milner, 2007). Our backgrounds are diverse, and include being a former electrical engineering for a Fortune 500 company, and years of teaching students of color in public schools. We come to this work understanding that millions of Black women remain marginalized and stereotyped: Black women who are disproportionately suffering from poverty, overt criminalization, and whose bodies and sexualities are objectified, commodified, fetishized, racialized, disciplined, and controlled through a wealth of representational regimes and ideologies, social practices, policies, and legalized directives (Brah & Phoenix, 2013). Indeed, we conceived the larger project from our interest in understanding trends in the field and our own experiences and observations, particularly as members of groups historically underrepresented in the academy. We have written about negative racial and gendered experiences that discourage Black women from pursuing academic careers in engineering (Robinson et al., 2016). For a variety of reasons, including differences in current discipline, age, and academic position, our experiences and aspirations differ from those of the study participants. Therefore, although we recognize that we might share some experience with our participants, we remained attentive to the particular narratives of the participants under study and minimized our own subjectivity.

Findings

We organized our findings by cases. Within each case, we grouped data by themes related to structural racism, sexism, and race-gender bias in STEM. Here we present themes of functional resilience and other responses that could be opportunities for support and critical learning (Table 2).

Even as we analyzed and interpreted aspects of students' expressions of resilience, however, we did not problematize their characters, their competencies, or their choice of adaptive strategies. Rather, we do problematize the tendency to recognize only their STEM success while overlooking the ways they might be placed at unacknowledged forms of risk.

Table 2. Participants' encounters with racism, sexism, and race-gender bias in STEM contexts

Pseudonym	Structural –isms	Response	Opportunity for Support/Learning
Nia	Lack of representation	Passion and commitment to her discipline	Possible monolithic views of Black people (e.g., as uninterested in math)
	Encountering racial stereotypes and biases	Focus on individual effort/proving others wrong	Faced dual stresses of STEM student demands and having to prove racist assumptions wrong
	Experiences with race-gender and gender bias	Indifference	Only woman in some of her classes; experienced narrow gender role expectations
Maya			
Sonya	Black underrepresentation, discrimination, and departmental culture	Focused on academic excellence and supporting Black peers; spent time questioning whether some of the treatment she received was related to her social identities	Departmental culture of racial segregation and favoritism meant that Sonya (with few Black students, and no Black faculty) was often left unsupported
	Sexually harassed, abused, and stereotyped in department and profession	Silenced; avoided spaces with potential offenders unless Black male friends were present	Subjected to harassment and felt the need to be quiet about it to avoid retaliation; was unprotected from abusive men in authority roles

Case 1: Nia

At the time of the interview, Nia was a junior with a double major in computer science and math at an HBCU in the Southeast. When Nia was 12, her mother moved the family (her husband and two daughters) from Pine Bluff, Arkansas, to Memphis, Tennessee, after accepting a job as a clinical researcher for a hospital (Nia's mother has an undergraduate degree in biology and a master's in health sciences). Nia described herself as being in "culture shock" after the move. She didn't wear make-up, and did not enjoy listening to rap or dancing, and even confessed to not "doing anything fun," which was in stark contrast from her new peers. Throughout her K–12 schooling, Nia was a high-achiever and had taken accelerated mathematics and science classes. She recalled many supportive teachers from those days and how often she was singled out for being smart. After high school, Nia decided to attend an HBCU because her cousin who had attended this institution had given it a positive review and because it had awarded her a full scholarship. In addition, during a campus visit a supportive campus administrator explained the university's honors program to Nia and her family and assured Nia's mother that she "would take care of" her daughter. The university's College of Engineering has consistently ranked in the top five in the nation for the number of degrees awarded to African Americans at the undergraduate level and is a leading producer of African American engineers with master's and doctorate degrees. This HBCU conducts a significant amount of academic and scientific research annually in comparison to other HBCUs (worth over $35 million), and the campus houses more than a dozen research centers and institutes. When Nia worried that attending an HBCU would limit her exposure to other cultures, her mother said, "If you want diversity, you'll get diversity for the rest of your life, but right now it's important to love yourself." Nia decided on her double major because "math is … vaster than people assume" and computer science can be used "anywhere, in any industry."

At the time of the interview, Nia was averaging just 3 hr of sleep per night, which created significant stress and anxiety. Nia's interview revealed a history of mental illness. Her previous White psychiatrists had been cold and measured ("They just checked off boxes and gave me pills"), but the HBCU counseling center was much more affirming and empathic. Nia acknowledged the pressure associated with being in a highly competitive major, but she maintained a positive outlook by attending church, listening to inspiring songs (mostly gospel), and running cross-country. She planned to enroll in a PhD program after obtaining her undergraduate degree. Nia was determined to receive fellowships to pay for her PhD and hoped to work in government, but was open to other possibilities. Her dream job was to become a

software developer because she enjoyed starting from a blank slate, writing code, and creating amazing software that would do "just about anything."

Lack of racial representation

Although she discussed the underrepresentation of Black students in both mathematics and computer science, Nia viewed the lack of Black representation in mathematics as a bigger issue than in computer science. Her observation aligns with the national reality over the past few years: Only 4–5% of bachelor's degrees in mathematics and statistics are awarded to African Americans (American Physical Society, 2016), whereas annually in recent years about 10% of computer science bachelor's degrees were awarded to Black students (National Science Foundation, 2015). Nia attributed her achievement in mathematics to her passion for the discipline: "At this point, I'm a junior math major so I have a very intimate relationship with math. … We really do think math is beautiful." As she reflected on the small number of Black Americans pursuing mathematics degrees, she pondered why this might be the case:

> People usually don't go that far with math as a Black person. I don't know as far as culturally why we [Black Americans] don't like math. I don't know. Maybe some type of thing that goes back to being Black back in the day or the way we think. Somebody said once that Black people like more hands-on things; it was something about teaching Black students, and they were saying that Black students like to be more hands-on. So, I think that might be why they tend to do more tangible things like engineering. Because I think math is even too abstract for the engineers.

Nia's broad, sweeping statements about Black Americans' relationships with mathematics show an opportunity for critical instruction. Though she has obtained success in math due to her love for the subject, it appears that her schooling experiences may not have given Nia opportunities to analyze the variety of reasons Black Americans are severely underrepresented in mathematical fields. For example, too often Black students do not have access to quality mathematics instruction and, therefore, have limited opportunities to embrace the subject (Basile & Lopez, 2015). Additionally, "fewer African American high school students than high school students from other ethnic groups are encouraged to enroll in advanced math classes, although these classes are often required for entry into more advanced math and science college courses" (Alliman-Brissett & Turner, 2010, p. 199; ASEE, 2000).

Interestingly, however, research suggests that Black students at the primary and secondary school levels cite math as their favorite subject more often than nonminority students do (ASEE, 2000). In light of such research on the multifaceted nature of Black underrepresentation in mathematics, Nia's understanding suggests that she may have internalized explicit and/or implicit teachings from a White-dominated schooling system that portrays minority cultures as monolithic and not smart when it comes to STEM fields (e.g., Solorzano, Ceja, & Yosso, 2000).

Encountering racial stereotypes and biases

Nia shared experiences that showed her awareness of the trickle-down effects of structural racism on her own and her friends' experiences as Black STEM students. She told a story about a friend who received racist questions from some White peers at a STEM conference (e.g., are there "smart people at HBCUs?"). In telling the story, Nia connected the assumptions about HBCU students' (presumably Black students) intelligence to STEM-related racial biases she experienced on her educational journey:

> So people assume that we're somehow below them, like, even though we … have degrees in math and science, … our HBCU degree can't hold up to their degree from a White school. Like it's below because we go to the school that is the reject school in their eyes.

Presuming that HBCUs are inferior to PWIs has been well documented (e.g., Bettez & Suggs, 2012); Nia's experiences illustrate how this manifestation of structural racism (i.e., stereotyped assumptions about the quality of a university whose mission has historically been the education of Black people) revealed itself in her personal experiences as a STEM student. Nia coped with these types of racial biases by focusing on her work. When prompted to consider what she might do in response to lowered expectations by certain people within her field who may see her educational preparation—and subsequently, her own capabilities—as inferior because she attended an HBCU, Nia shared a strategy she employed: "I

mostly respond [to lowered expectations] by doing … I say, 'Look, I can do the same work that you can do.' And, usually, once I show them that, they back off." This adaptive strategy appeared to pay off for Nia academically, as she was a high-achieving advanced undergraduate STEM student. However, studies that reveal the strategy of proving oneself as a response to the stereotype of Black students being intellectually inferior can produce signs of stress, trauma, and strain (Ong et al., 2011; Solorzano et al., 2000; Tate & Linn, 2005). The overwork of some Black students has led to mentally and physically detrimental consequences (e.g., exhaustion, anxiety attacks, seizures; McGee & Stovall, 2015). This stress adds to the pressure to achieve that is intrinsic in STEM educational contexts. All STEM students may be able to relate this sort of stress to some degree, but the fact that Nia also had to face racial bias, which she combatted with relentless effort, may have placed her in a position to endure unhealthy levels of stress.

Experiences with race-gender and gender bias

Nia recalled that, as the only Black woman in her first gifted and talented class, her White male peers would treat her as if she was out of place. Once they recognized her high academic achievement, however, they "backed off." Nia noted similar experiences in her undergraduate program. She described her classes as male-dominated, saying she was often the only woman in these classes:

> I was in a discrete math class, which is a class for computer science majors, and I was the only girl in the class out of maybe 30, not quite 30. Well, there might have been 30 on the roster, but they didn't [all] show up. But I was the only girl.

In response to a question about gender bias in her classes, Nia said she did not feel she experienced discrimination because she was a woman. Upon further reflection, however, she acknowledged that in her HBCU, assumptions may have been made about her abilities based on traditional, static gender roles:

> It [being the only woman in a class of 30] just made me realize that I'm underrepresented as a woman and I guess I think people expect men to do better or be more assertive. … When I'm outspoken, people are surprised. People don't expect me to be outspoken as much.

However, Nia did not seem to interpret these gendered experiences as particularly stressful or damaging to her experiences as an HBCU student in STEM. Her recurrent strategy of proving her ability to those who perceive her as inferior may have mitigated the potentially negative effects of the gender bias she encountered. Whether defying lowered expectations related to race (and her attendance at an HBCU) or those related to her gender, Nia repeatedly relied on her academic prowess as a means to address discrimination.

Case 2: Maya

Maya, who at the time of the interview had recently earned her PhD in mechanical engineering at a southern PWI, was interviewed by phone for just over an hour. Her doctoral institution is a public research university in the Southeast and has an enrollment of more than 34,000 students, making it one of the largest universities in the state. The dearth of Black engineering faculty members was one of her motivations to pursue a PhD in mechanical engineering. She commended her doctoral advisor for providing a host of opportunities for all his doctoral students. Maya's peers described her as "having a lot of guts" for standing up for herself, as well as her peers. Maya described her church community as "very, very, very instrumental" in maintaining her mental health and keeping her connected to life outside of STEM. Maya's parents are both from a small town in Georgia; she considered them lucky for securing good government jobs with decent wages. Maya's parents pushed her and her older sister (who also attended an HBCU) to attend college.

Maya had originally planned to go directly into industry after receiving her PhD. After attending a workshop that encouraged students of color to pursue faculty positions, however, she decided to pursue an academic career, though she feared her publication record would make her a less attractive candidate. Maya's encounters with structural racism in higher education began with her enrollment at an HBCU.

An engineering program not intended or designed for HBCU students

Her undergraduate engineering program at the HBCU was a joint partnership with a PWI in a neighboring community. Maya complained that the program was not designed with the HBCU students in mind, and thus her cohort of 10 mechanical engineering Black undergrads from the historically Black institution were treated like a burdensome afterthought. In Maya's words, "We are always made to feel like the minority." Furthermore, she reported:

> Making it through undergrad was very tough for me. It just so happened it was a cohort of us of about 10 and we weren't necessarily built in, meaning that the sense that the [PWI] university kinda set us aside, which forced us to only interact with each other. Because it was set up for us to gravitate towards each other and that's really how I made it through, especially those last 2 years.

The construct of structural racism manifested in the fact that her HBCU's engineering program was defunded and the associated PWI received more than $10 million to enhance its engineering program. The partnership between the two universities included a shared engineering program, but the HBCU had more than $10 million of its budget removed from its general operating revenue and moved to the PWI. Republican politicians made a concerted effort to split the two engineering schools, which Democrats, activists, and the HBCU's students and faculty viewed as a racist attempt to create separate and unequal colleges. Moreover, the PWI continues to grow, often at the expense of the neighboring African American communities. This tumultuous time has produced frustration and low morale among this HBCU's faculty and students. Thus, Maya's sense of marginalization during her undergraduate years aligned with those of many other African Americans, who connected the defunded HBCU with broader issues of structural racism.

The damage done by colorblindness

Maya described her doctoral experiences at her public southern PWI as "fairly good." She felt that her advisor did "go the extra mile" to support her academic needs and generally cared about her as a person. However, Maya's frustrations associated with being a woman of color at her institution were unacknowledged. When she talked to her advisor, a White man, about the lack of women of color in the lab and the uneasiness she endured in that space, he told her, "Just be the person you need to be and don't worry about the color of your skin and your sex. Just worry about the engineering."

Maya's advisor was asking her to ignore and dismiss the intersectionality of her raced and gendered experiences produced by racism and sexism. The ideology expressed by Maya's advisor is known as colorblindness. The colorblind approach to combating racism is not an accidental phenomenon; rather, it is the result of a colorblind-style, meritocratic-leaning education values and training, which White Americans in particular have employed to devalue the power of racism (Bonilla-Silva, 1997). Lewis (2004) argued that the effects of colorblindness on students of color require them to swallow their own narratives that expose racism and to bury their own emotions. The longer-term manifestations of suppressing these feelings can lead to isolation because colorblind ideology limits the stories that get told, thereby allowing Whiteness to be protected while racism thrives. Also, Maya's advisor's comment could suggest that her skin color is associated with a negative connotation. Asking Maya to not worry about her color could imply that her skin color is a problem, which is akin to saying "I can see who you are despite your race."

The stress of overcompensating

Maya said that the labor-intensive work of getting a doctoral engineering degree was extra laborious for her because she was the only Black woman:

> STEM majors, I think just in general, are very, very rigorous, but … if you took away the factors of being a woman of color, it's almost to the point where it's so strenuous to get things done and you feel like even when you do, it's not enough. As a Black woman, I can't fail because if you fail, then you have like the weight of the world on your shoulders and it almost has this front of that everybody's succeeding and everybody's doing great, but if you're not doing great, what's wrong with Black people? So it's this constant thing hanging over you: I have to, I have to always do great. My test scores have always got to be great; every time I present, I always have to be great; or, when I, you

know, come up with a research idea or whatever, it has to be the top of, the top whatever because if I don't, then, then I'm gonna get kicked out or I don't belong to, I don't deserve to be here. So, it can be very taxing.

A key issue for women of color in STEM doctoral programs is the emotional turmoil of feeling isolated—not having anyone to speak to about their experiences as raced and gendered persons—which often results in their handling problems alone (McGee, 2016). One study documented this issue; the researchers interviewed 60 scientists who were women of color (Williams, Phillips, & Hall, 2014). The study identified a pattern of bias: 42% of the Black women participants and 38% of the Latinas felt that social interactions with colleagues could adversely affect the perceptions that others have of their competence. There was a general acknowledgement of a sense of awkwardness on the part of Whites in dealing with people of color. Being a Black woman in STEM has different structural implications than being a White woman in STEM. For example, one of the rare studies that compared White women scientists with women scientists of color found that the White women reported higher levels of influence in their departments than did the women of color (Settles, Cortina, Malley, & Stewart, 2006).

Maya admitted to camouflaging parts of her identity and tempering her emotions because of the pressure she felt to "properly" represent Black people, particularly Black women. Maya spoke of frequent experiences with her peers and faculty members in mechanical engineering in which she felt obligated to display a persona that countered stereotypes about Black people, and Black women in particular. However, doing so caused fatigue and anxiety:

The only Black interaction that they'll have is me. I might be the only person in the department. Especially … international students; they may not have met any Black person ever, so it's me. So it's kind of like I have to be a representative for the race and I can't come off certain ways because I don't want to turn them off [and make them think,] "Well, Black people act this way, well Black women act this way," especially with the angry Black woman stereotype. It sometimes makes me so upset, but I can't get angry even though, shit, … I'm well within my right to get angry. I don't want to feed into the, the perceptions that they may have and say "See! That's how they act, that's how they all act." And I don't—I try not to feed into that.

Anti-Blackness, stress-induced illness, and racial battle fatigue

The suffering of Black students in educational spaces is, in part, a result of the anti-Blackness of society and the world. *Anti-Blackness* manifests as Black people being viewed with disgust and disdain, as non-humans worthy of violence and death (Dumas, 2016a, Dumas & Ross, 2016b). Anti-Blackness is a deep-seated ingrained global construct, which often begins with the unconscious (but increasingly conscious) belief that Black children are either biologically or culturally uneducable (Dumas & Ross, 2016b). For example, the global nature of anti-Blackness in Western immigration history has openly denied immigration access to phenotypically Black persons from African countries (Bashi, 2004). Thus, we couch Maya's suffering within the larger frame of global disdain for Black people. This ideology helps to explain why some international students appear to associate exclusively with people from their home country and why US Whites and some international students shun Blacks, Hispanics, and all other minority groups (Althen, 2009). Hanassab (2006) surveyed 640 international students and found that discrimination also extends to these students' interactions with professors, university staff members, classmates, potential employers, and the larger community. Students' examples of discriminatory acts include comments such as "Latinos cannot be logical or scientific" (Hanassab, 2006, p. 162). To combat stereotypes harbored by international students, some researchers argue that international students must be educated about race.

Maya's attempt to stay with the partnership between the HBCU and the PWI for her doctoral degree proved detrimental to her mental and physical health. As a result of the racialized stress of trying to "prove myself" in that racially charged environment (e.g., students called the Black engineering students "monkeys" and engineering faculty members at the PWI routinely talked down to the HBCU students in their classes), she developed Bell's palsy:

Again, it was so difficult studying in an environment that seemed to loathe your very presence. So, as I was gearing up to take the qualifier the spring of 2010, I studied so hard and I stressed so hard I ended up getting sick, really sick. I don't know if you know what Bell's palsy is. Bell's palsy is when a part of you may be paralyzed and one of the causes is stress. And so, I ended up, the right side of my face was paralyzed. And it ended up going away, but

from then on, I was like, "I gotta take care of myself." But … that's how hard I studied. I took the qualifying exam; 14 people took it at that time I believe. And I ended up failing; I failed that time.

Racial battle fatigue (Smith, 2004) is evident in Maya's physiological responses to chronic race-related stress exposures and hostile racial climate. As Smith and colleagues noted (Smith et al., 2007), the dissonance that Black students experience in the face of racial marginalization is often stressful, time-consuming, and psychologically taxing. These physiological manifestations of chronic exposure to the outpourings of structural racism, such as poor racial climate and microaggressions, are not given sufficient attention, particularly as they affect the achievement and experiences of Black women in STEM. Yet there is still hope in Maya's narrative. Her own experiences of racial isolation in her engineering program inspired Maya to become a professor:

> There are other students like me at every level, that never experienced a Black faculty member and [are] kind of getting discouraged, and not wanting to continue on. So if I'm in the position to do this, then I have an obligation, in my mind, to do this. People that need to know that, that we're out here, and that this could be you, too. A lot of times, some people just need someone to say, "Well, you can do this." 'Cause there's no one in my life that has done [that]; I never, I never had an example for it. The Black representation piece is key because a lot of times I—some of the classes I struggled in because I didn't want to go to the professor's office hours, or I didn't feel that the person was reachable. I just felt like by going to their office hours, they would make me feel dumb or they wouldn't listen to me as a person and they would just say, "Hey, see? These Black kids can't cut it."

Maya highlights the numerous ways in which structural racism manifests in the education arena: As a doctoral student, she had never had a Black faculty member, and the overwhelming stereotype that Black students are intellectually subpar and/or underprepared aroused angst around seeking support from her non-Black professors. Although she did not discuss this angst in detail, one can imagine the potential academic and psychological ramifications of feeling like office hours are unsafe due to one's race—above and beyond the typical hesitation many students feel about interacting with professors. Maya's reflection on her experiences and her potential role as a future faculty member suggests that though she is aware of the challenges she could face as a Black female faculty member, she is motivated by a personal commitment to Black students.

Case 3: Sonya

At the time of her interview,[2] Sonya was in her fourth year as a computer information systems doctoral candidate at an HBCU, a public land-grant institution located in the mid-South. She described her undergraduate experience with the mentorship of an African American professor who "took [her] under his wing and basically brought [her] up to his standard." After earning her bachelor's degree, she had had offers from several prominent private companies and was recruited for a doctoral program at a competitive STEM-focused university. She worked in industry for a few years before completing her master's degree in engineering at a PWI.

Prior to attending college, Sonya described herself as "basically a juvenile delinquent from Milwaukee" who was bent on "self-destruction." She credits her mother with pushing her to use her talents in mathematics and science at an HBCU in the South. Sonya was motivated to obtain a PhD after she taught briefly at a magnet high school that primarily served middle-class Black students. She learned there that most of her students did not know one Black PhD in engineering, and she wanted those students to have the opportunity to experience one Black engineering professor. She started her PhD at Caltech, but the suicide of another doctoral student caused her to seek out the same affirming environment she had had as an undergrad. However, Sonya soon discovered that the culture and climate of her engineering department had drastically changed. As a result of her toxic experiences as a Black doctoral student, her career plans shifted toward industry. Sonya has a child with disabilities, and in addition to working at

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[2]Sonya participated in a two-person focus group interview with an African American male engineering doctoral student at her institution.

her HBCU for sometimes 12-hr days, she also had to work as a gas station attendant some nights to support her family. Sonya was frequently referred to as a strong Black woman, which she defined as a public endorsement to berate, overwork, and underpay her; she concluded, "That's not an accolade that I want; it's tomfoolery." In contrast to her expectations based on her undergraduate days, Sonya's experience as a doctoral student was characterized by a lack of support and by endless troubling incidents stemming from structural racism, sexism, and discrimination. Sonya's interview was replete with examples of the poor treatment, which she described as constant hazing, that she endured as a Black woman in STEM at one HBCU.

Black underrepresentation, discrimination, and departmental culture

Sonya described differences in the racial makeup of her department during her undergraduate and graduate years, which she connected to the poor climate she experienced as a PhD student:

> [During her undergraduate years] you would see African Americans all times of the evening, studying in the engineering building. I mean, I … I'm sure we had at least 70 to 80% African American population in the College of Engineering. And the students performed extremely well. When I returned back, like, they're scarce. Seldom will I run into a group of African Americans, a cluster in the engineering building now. Like, you can peek into the classrooms and we're just not there. … So, um, I came back because I believe in what was instilled in me. But I'm afraid that that no longer exists. And it's sad. It really is sad.

She went on to talk of how the departmental culture positions Black students as outsiders, despite the department's location in an HBCU. She said that the majority students are prioritized:

> Yeah, I think the focuses are not on us [Black students]. So, the majority of the program is Saudi Arabian. … So, the focus is on those individuals. And they have a network. They have a network. Oh, my God, they have a network that's out of this world. So it's not that they're brighter; they just passed out homework [with the solutions].

Here, Sonya referred to connections among students from Saudi Arabia whereby they supported each other while excluding Black students. However, the few Black students in the college also relied on each other for support and often worked long hours independently to maintain high achievement while balancing busy family lives, lack of funding, and little support from faculty.

In addition to isolation from her majority peers, Sonya discussed how faculty members favored non-Black students, and in at least one instance purportedly engaged in an act of academic dishonesty:

> Our faculty plays favorites. One of the students told me out of his own mouth that our advisor wrote his paper, right, that got accepted in this journal. I'm just saying, like, "I can't get [him] to comment on … you know, critique my stuff." And he [the professor] actually wrote it. So there are so many differences going on.

Her advisor was unsupportive and disengaged from her doctoral experience overall, in contrast to the support he afforded other non-Black students:

> I'm dissertation stage. He didn't even know that I wanted to be faculty. How is that possible? How … you've been with me now for years. How do you not know what I want to do when I leave here? But because we have this cultural difference … and he em—and sometimes it does feel funny when he embraces the other cultures and … and leaves me out.

In other words, Sonya was forced to question whether her professor's treatment was related to her social identities. We believe Sonya's observation reflects a global entrenchment of anti-Blackness, which relies on cultural and biological arguments in official statements declaring that Blacks and people of darker skin color are unsuited to the demands of STEM education and employment (Bashi, 2004). Ironically, anti-Blackness is playing out at HBCUs and against the recent mantra of diversifying STEM fields. Global anti-Blackness operates without the use of overtly racist language, using ambivalent language about increasing diversity in STEM while keeping intact racial hierarchies in STEM (Martin, 2009).

Sonya summed up her sentiments toward her doctoral experience by saying, "It's just … it's buffoonery. I can't wait to get out this damn program. Like the more we talk about it, more it's just like, 'What the hell are we doing over here?'" Her eagerness to leave the unsupportive environment was a type of

active coping in the face of distress (Neblett, Philip, Cogburn, & Sellers, 2006). Despite poor treatment, Sonya did not seem to internalize these experiences relative to her own abilities and remained committed to becoming a faculty member. When asked whether her doctoral experiences had changed her career goals, she responded:

> I would definitely want to be faculty. I will do things so differently. Like that's why I'm so grateful for Dr. X [a Black female faculty member in another department]. Because she is the … she's like a breath of fresh air. I mean, she just … she has her … her stuff together.

The two professors Sonya identified as major supporters during her postsecondary education were Black professors at her HBCU—one man, one woman. Yet Black professors were not the majority. Over the decade or so between her bachelor's and doctoral degrees, the racial demographics and culture of the College of Engineering shifted. Black students were marginalized and left unsupported by peers and faculty members alike; the majority Saudi Arabian students were favored, embraced, and given professional development opportunities that were not afforded to Black students. The fact that such dynamics exist in an HBCU highlights the pervasiveness of anti-Black racism in STEM. Ironically, Black students are not safe from marginalization and discriminatory treatment even in an institution founded to support Black students. Sonya did not perceive her experiences within a shifting College of Engineering demographic and culture as isolated instances of discrimination perpetrated by non-Black faculty members at an HBCU. She spoke about broader structural issues that contributed to the drop in Black faculty members and students at her HBCU (e.g., defunded scholarships for Black students), alongside racist ideologies (e.g., stereotypes that Middle Eastern and Asian professors are smarter), which led to an increase in non-Black faculty members—most of whom showed no commitment to supporting Black students and, often, were not accountable for doing so. Given the shifting demographics in many institutions, Sonya's experiences raise questions about the racial climates of STEM programs in HBCUs today (Gasman, 2013).

Sexually harassed, abused, and stereotyped

Sonya reported several experiences of sexual harassment by men in her program and in her profession: inappropriate touching, sexual advances, and stereotyped expectations from men of her own and other racial backgrounds. Often she was treated as a commodity, rather than a scholar and colleague. When asked what it is like to be a Black woman in engineering, she replied:

> You need to become comfortable with sexual advances, which is cumbersome. Um, it really is. Because how do you prove it? You know, who do you … who do you confide in, how do you combat it? You just don't. You just suck it up and say, "I've got 1, 2 more years left. I can't wait to get the hell out of here," you know. And it's not just here, because it is here, make no mistake. Um, but even when I go to conferences, … I've had a number of men ask to be on my committee, and then solicit me for sex. And so, uh, it sucks. … Some days I feel very powerless. Um, I feel like they make me their work wife. So, any time someone needs to take notes or run and get an errand and grab something to eat—flunky stuff—it's typically me who gets those directives.

There are several notable points in Sonya's response. First, the idea that one should "become comfortable with sexual advances" suggests that instances of sexual harassment were regular in her experiences as a doctoral student and an endemic problem in her engineering program and her field. Second, her feelings of powerlessness against male faculty members' sexual advances and demeaning directives show the effects of the race-gender hierarchy on Sonya's well-being. Third, implicit in her statement is that, as a Black woman, she was held to different (lower) expectations than women of other races and men in her program and field. The role expectations male faculty members and engineers held for her align with stereotypical tropes assigned to Black women as *Mammy* (e.g., caretaker of all, especially Whites) and *Jezebel* (e.g., promiscuous and compliant; Reynolds-Dobbs, Thomas, & Harrison, 2008; Thomas, Witherspoon, & Speight, 2004). In addition to structural sexism present in STEM fields and broader society (De Welde & Laursen, 2011), racial and race-gender stereotypes weigh on some Black women's experiences in ways that warrant concern. Sonya summed up her experiences with sexual harassment and abuse by discussing the importance of two of her Black male graduate student colleagues:

> I am always on the defense in this program, trying to make sure, you know … just I want to maneuver through. Um, I find safety [with] what I call my brothers. … I feel safe amongst them. I don't feel safe when they're not here.

Sonya shared ongoing inappropriate sexist/racist remarks and dismissiveness from several male professors, including her advisor. For instance, Sonya suggested that her primary advisor viewed her stereotypically and "punished" her for behaving in ways that did not align with his cultural expectations of women:

> [My] primary advisor is from a different culture. And there's this … Black women walk this … this very thin line of assertiveness versus aggressive[ness]. And so, learning when to speak and how to present the information so that it's … it's, um, appropriate or … um, like, my advisor's kind of passive-aggressive. So if he becomes angry, he just disappears into the … the night. So, I might see him 3 months later. Well, if you're a PhD student, that's problematic.

Sonya also gave examples of how African American culture, and African American women in particular, were positioned from a deficit perspective by male faculty members in her program. She recalled the following exchange:

> One of our professors [from a] different culture, he said, "You could learn a lot from the women in my culture." Because [he's] telling me to do something, I'm saying, "Okay, well, that sounds good, but in my class I learned this procedure. You don't think that this would be a better procedure?" He just looked at me. "You could learn a lot from women in my culture." So basically you're telling me to shut the hell up, is what you're saying to me.

Sonya gave another, more explicit example:

> There's a Caucasian male who used to be faculty here, who told me that African Americans don't have culture. I just looked at him and tried to keep it moving. I tried to keep my mouth shut. He made it his business to get in my face and say something stupid to me. Either about the African American culture, or about the fact that Black women don't get married. "You don't want to keep trying to get all these degrees. You'll never get married. I hear Black women never get married once they get their doctorates."

Altogether, Sonya's time as a doctoral student in engineering at an HBCU was rife with experiences of harassment and neglect, which she explicitly and implicitly connected to her male professors' stereotypical perspectives on the abilities and social place of Black women. The regularity of these instances left Sonya feeling unsafe and exhausted, yet she remained optimistic about her future as a faculty member. In many cases, she seemed to cope with the manifestations of racism, sexism, and race-gender bias by avoiding people and spaces where she felt unsafe. She also drew on her close Black colleagues/friends, who provided support, for example, by being there when she needed someone to talk to (e.g., "Tell me I'm not crazy. Let me tell you what just happened to me"). She offered the same to them, though her Black male colleague in the focus group agreed that within the hierarchical culture of their program, as a Black woman, Sonya was treated worse than Black men were.

Although she managed to succeed by traditional metrics (e.g., conference acceptance, research awards), Sonya sacrificed family time and her personal well-being (e.g., sleep deprivation) to survive a program and field where she was not expected to thrive, and she was mistreated and neglected. Moreover, she had to endure these experiences within an underfunded HBCU, which left her in financial limbo with no health insurance.

Discussion

The purpose of this study was threefold. First, in our analyses of Black women's experiences in STEM majors/fields, we foregrounded structural racism and sexism to examine how these forces bear on the experiences of academically successful students. We sought cases that would allow us to highlight similarities and differences in how Black women understood and responded to the daily manifestations of racism and sexism in STEM while pursuing undergraduate and graduate degrees at different types of universities. Second, given the tendency to overlook the well-being of high-performing students, we chose women who were succeeding in STEM majors by traditionally valued metrics (e.g., grades, GPA); we aimed to uncover in them the often-undetected psychological consequences of racism, sexism, and race-gender bias in Black women's lives. We wanted to understand strategies the women used to respond

to and cope with stressors related to their race or race-gender while maintaining high academic performance. Third, by critically examining Black women's experiences in STEM from an antideficit perspective (e.g., we did not sit in judgment of their strategies but considered opportunities for support and growth), we highlighted teachable moments in these women's trajectories, with implications for how to address structural bias in K–12 and postsecondary STEM classes, departments, and beyond.

All participants encountered stereotyped expectations based on their social identities as women, specifically Black women, but noteworthy differences emerged, mainly related to how they made sense of, and responded to, their experiences. For example, Nia seemed to attribute African American underrepresentation in mathematics to individual factors (e.g., fear of the subject and inclinations toward more practical fields), whereas Sonya connected the severe underrepresentation of Black women in engineering at her university to problematic structural racism and sexism in the unit. All three women discussed or alluded to feeling the pressure to conform (or at times defy) the strong Black woman stereotype. Harris-Perry (2011) tackled the ideal of the "strong black woman" (p. 101) as a self-sacrificing superwoman figure, revealing the personal and political problems it creates. Though the strong Black woman is often viewed as a positive and necessary character in Black communities, she, too, is a misrecognition that some Black women are mentally invincible. Sonya and Maya remained troubled about the pressures of being seen as invincible in spite of being hospitalized for Bell's palsy (in Maya's case) and mentally and physically exhausted from overwork. Harris-Perry (2011) described the stress, anxiety, and fear that Black women experience as they strive to organize their personal lives in ways that enable them to escape proscribed perceptions of their academic, professional, and social abilities. Better understanding of how embedded racialized and gendered experiences are in postsecondary institutions, including HBCUs, and their effects on Black women students, could lead to more holistic programming to address the compounding bias this group endures.

One conclusion the readers could straightforwardly agree on is that these three Black women in STEM are resilient. They all have rebounded from a challenging, and at times debilitating, set of circumstances. However, we run the risk, in calling these Black women resilient, of ignoring the multitude of factors that they must contend with where institutions could provide supports and equitable services, so Black women would not have to rely so much on their inner-strength. Resilience, perseverance, and inner-fortitude are not in endless supply and, thus, need to be accumulated and protected for multiple forms of self-care necessary for healthy well-being (McGee & Stovall, 2015). For those who do engage in resilience research, we endorse more ecologically robust conceptions of resilience frameworks. For example, Margaret Beale Spencer's Phenomenological Variant of Ecological Systems Theory of human development (known as PVEST) examines the interaction between environmental context and identity development, and starts with the assumption that an individual's perception of her environment and context is crucial to understanding her experiences and responses. A PVEST-informed vulnerability–resiliency perspective accounts for the *vulnerability* of women of color who are burdened by unique, and often underexamined, levels of risk while acknowledging potential sources of support.

Another contribution of our study is the documentation of a phenomenon that has received little attention: racial battle fatigue among high-achieving Black STEM students. We rejoice in the triumphs of these academically successful STEM students, but we do not want to overlook possible negative consequences of their success. All three women expressed distress related to their status as Black students/Black women in STEM; ongoing exposure to structural racism threatened their well-being in ways that are consistent with Smith and colleagues' theory and empirical work on racial battle fatigue (e.g., Smith, 2004; Smith, Yosso, & Solorzano, 2006; Smith et al., 2007). Although Nia did not report psychological strain or health issues at the levels of severity reported by Maya and Sonya, she did mention instances in which race was salient and that pushed her to work harder. None of the women discussed institutional supports for dealing with stressful experiences. In fact, both Maya and Sonya (at a PWI and HBCU, respectively) said their concerns about being severely underrepresented and unsupported were dismissed, which suggests that a silencing of, and strain among, Black women in STEM is not confined to certain institutional types. Future research should investigate the potential psychological and physical damage done to Black students as they achieve STEM success in a setting of White racism, sexism, and marginalization; this damage manifests in lowered expectations, assumed inferiority, and lack of institutional support. Along

with the need to celebrate students' accomplishments is an equally great need to study their long-term health, for success in such oppositional spaces sometimes comes at a price.

Our attention to how Black women respond to racialized and gendered experiences while pursuing their STEM goals is another contribution to the field. Faced with the stresses and challenges of structural racism in their academic, professional, and personal lives, the three women responded with a variety of strategies. Consistent with existing research (e.g., McGee, 2016), all three women discussed the need to prove themselves as intellectually capable and to counter stereotypes of Black women (e.g., loud, aggressive, unintelligent). Proving themselves appeared to take a differential toll on the women, perhaps due to differences in the centrality and salience of race and/or gender to their identities, which informs how individuals understand racialized (Sellers, Smith, Shelton, Rowley, & Chavous, 1998) and race-gendered experiences (Settles et al., 2006). Additionally, all three participants highlighted the importance of social support from Black peers, although Maya reported the consequences of an absence of such support during her doctoral studies. An interesting finding (but disheartening, considering the context) was that in Sonya's experience, two Black male colleagues were instrumental in providing a sense of safety in her program, where she endured many instances of sexual harassment and race-gender discrimination. Research on African American students often discusses the importance of peer social support generally (Espinosa, 2011; Fries-Britt, & Holmes, 2012; Harper, 2012; Maton, Hrabowski, & Schmitt, 2000; Maton & Hrabowski, 2004), but to our knowledge few discuss the "brotherly" protective role some Black men may play (intentionally or not) in STEM spaces where Black women feel unsafe due to sexual harassment. We are not suggesting that Black men should have to play the traditional gender roles of protector; however, in light of the hostilities Sonya described, we believe it is important to consider the implications of other Black male students playing such roles (including risks to Black male students in addition to the risks faced by Black female students). Most important, departments and institutions must take a proactive role in ensuring that such abuses do not occur and that students are supported in reporting any cases of sexual harassment, intimidation, verbal abuse, and the like.

Sonya displayed a form of active coping that involved avoidance (e.g., not going to institutional spaces where she might encounter perpetrators of abuse). Although such an approach is adaptive in an immediate sense, it raises concerns about the well-being of Black women in STEM. Avoidance during the PhD process can be detrimental for the longer-term success of all students, but in particular for Black women in STEM, who are severely underrepresented, hypervisible, and often already neglected. Future research should examine how Black women in STEM manage to navigate hostile, unsafe environments in ways that run less risk of harming their success. Most of all, we need examples of STEM initiatives, departments, and colleges that proactively address race-gender climate to prevent these experiences.

Implications and conclusion

Findings in this study suggest several possibilities for practice. Each woman appeared to understand race and gender differently—both as parts of their individual identities and in relation to structural biases—but each told of salient events that highlight the pervasiveness of racism, sexism, and race-gender bias for Black women in STEM. Nia's experiences might indicate gaps in her analyses of the effects of structural racism in STEM: She highlighted individual efforts and/or shortcomings, rather than structural biases, as reasons that African Americans are underrepresented in STEM. Milner (2013), Ladson-Billings (1995) and other scholars have cited critical consciousness development (e.g., through culturally relevant pedagogy) as an important element of facilitating Black (and other historically marginalized) students' holistic success. Therefore, building on these students' success according to traditional measures of achievement might also mean ensuring that underrepresented STEM students develop competencies in the sociohistorical significance of race, gender, and other identities in the STEM workforce. Such teachings might also bolster students' academic resilience through an understanding of their collective struggles (e.g., O'Connor, 1997).

Visiting the web site http://www.thedemands.org/, one will find a compilation of demands from Black college students and their allies all over the country, starting with this one: "1. WE DEMAND at the minimum, Black students and Black faculty to be reflected by the national percentage of Black folk in the

country." Although many postsecondary institutions have reported that achieving this would be difficult, if not impossible, recent work demonstrates that there is currently a viable pool of minority scientists from which to increase academic diversity (Gibbs, Basson, Xierali, & Broniatowski, 2016). Although some people claim there is a lack of talent, this research cites data from the National Science Foundation showing that there are thousands of Black, Latinx, and Native American PhD scientists. Per the web site, unlike scientists from well-represented racial and ethnic backgrounds, and despite a large and growing pool of scientists of color, there is currently no linkage between the size of the underrepresented minority (URM) talent pool and the number of new URM assistant professors hired. Thus, the demands from the students who form the Black Liberation Collective Demands organization are realistic, and they can be achieved to a much larger extent than many institutions report. In the meantime, we propose that current STEM faculty members participate in antiracism professional development training that introduces and discusses definitions of power, White privilege, White supremacy, global anti-Blackness, the model minority myth, institutional racism, class barriers, and internalized oppression.

There is also a need to self-educate about the lack of neutrality and objectivity in technology. Racism exists in technological fields, and the STEM community has built a culture that refuses to acknowledge and be accountable for a recurring pattern of both casual and blatant oppression (Benjamin, 2016; Daniels, 2015). USA Today recently reported that Google photos of Black users being tagged with labels of gorillas and apes (Gunnyn, 2015), gaming apps that rely heavily on negative racial stereotypes (Williams, Martins, Consalvo, & Ivory, 2009), automated soap dispensers that fail to recognize Black skin, Apple's iWatch's sensors were not properly calibrated for minority users (Hankerson et al., 2016), are just a few examples. Antiracist professional development would minimize the stress of racialized experiences for Black women and minoritized students in STEM and would make STEM innovation itself more equitable.

Another practical implication relates to the need for more race- and gender-conscious mentoring for Black STEM students. All three women expressed interest in continuing careers in STEM after completing their degrees, despite (in Maya and Sonya's cases) stressful and unsupportive experiences. It is promising that both doctoral students said their interest in pursuing faculty careers stemmed from a desire to mentor and serve as role models for other Black students. Yet we know from prior research that chronic encounters with discrimination in one's environment can lead to battle fatigue (Smith et al., 2007), and that fatigue could push these women to reconsider their commitment to pursuing faculty careers, or even to STEM careers entirely (De Welde & Laursen, 2011; Turk-Bicakci, Berger, & Haxton, 2014). Thus, as the politics students encounter while moving up the career ladder might intensify, structured ongoing support from knowledgeable Black mentors could act as a buffer against the potentially detrimental effects of Black women's racialized and gendered postsecondary experiences. Institutional support for such efforts could help universities achieve retention and recruitment goals for historically underrepresented women of color.

In her investigations of sexual violence against Black women, intersectionality scholar Kimberle Crenshaw (1989, 1991, 1993) concluded that identity politics is manufactured such that it often privileges gender subordination yet fails to account for racial domination. Thus, the hierarchical treatment of gender over race, coupled with the positioning of race and gender as mutually exclusive marginalizes and distorts the experiences of women of color rendering most feminist research ineffective in addressing the needs of women of color who are victims of sexual harassment. Crenshaw further illuminated that feminist discourse has yet to fully incorporate issues of race in their intersectional analysis and antiracist discourse often fails to include intersecting effects of gender and sexual orientation, leaving unmet advocacy for women of color, which is devastating not only for raced women but for the antiracist and feminist movements themselves. Moreover, adopting a Black feminist stance for understanding and tackling sexual abuse facing Black women in STEM, should begin with an understanding that the enslavement of Black bodies in the United States should be characterized a political sexual economy, that forced Black women (and some Black man) into reproductive sexual labor to reproduce the enslaved workforce (Davis, 2008), shape broader thinking and solutions for sexual violence against Black people. This has present-day implications as recent studies have shown that the average sentencing for the rape of a Black woman is 2 years, while for the rape of a White women the sentencing is around 10 years, making Black

women further discriminated against in the distribution of resources and punishment in the criminal system (Crenshaw, 1991). This makes sexual violence against Black women a structural and systemic issue and institutions of higher education should be attentive to the multiple forms of vulnerability that Black women endure.

Our work implies the need for institutional change to make space for Black women (and other students of color) to (a) develop resilience-boosting critical consciousness and (b) receive support through mentoring by other scholars with shared experiences of gender and racial bias. It also addresses the psychological and behavioral (e.g., avoidance of certain locations on campus) symptoms of racial battle fatigue that highly competent underrepresented students such as Black women may experience. As previously mentioned, every one of the academically successful women students interviewed in the larger studies discussed negative events and incidents related to their status as Black students/Black women in STEM. That these students could not cite institutional supports to help them cope with these challenges is a critical problem. Our work raises the call for institutions to provide structured, formal support to address the psychological strain of encountering discrimination in competitive STEM fields and to help students think through productive ways to navigate hostile climates. Although the ultimate goal is, of course, to end the need for such support by eliminating the racism and sexism that cause such distress, institutions should consider leveraging their existing student counseling resources to meet the needs of Black women and other underrepresented students pursuing STEM graduate degrees, who are frequently overlooked because of their academic success.

Acknowledgments

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