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Examining Motivation as a Mechanism for the Effects of Stereotype Threat on Stem Outcomes: A Longitudinal Mediation Analysis

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ABSTRACT

EXAMINING MOTIVATION AS A MECHANISM FOR THE EFFECTS OF STEREOTYPE THREAT ON STEM OUTCOMES: A LONGITUDINAL MEDIATION ANALYSIS

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Although African-American students start STEM majors with higher levels of interest compared to their racial majority peers, they drop out of these majors at higher rates. One often tested explanation for this racial disparity is stereotype threat–the anxiety related to being judged stereotypically or the fear of confirming such stereotypes. Stereotype threat negatively impacts academic outcomes through a variety of psychological mechanisms including declined motivation. Accordingly, in this study, I examined expectancy-value beliefs as motivational mechanisms for the effects of stereotype threat on STEM outcomes. Participants were 362 African-American students in introductory chemistry and biology courses who completed surveys at three time-points within a semester. Surveys included measures of self-reputation and group-reputation stereotype threats, self-efficacy, task values, perceived costs, and intentions to persist in STEM. Students' final exam grades were also collected as a measure of STEM achievement from their instructors. Across 12 longitudinal mediation models, results suggested that self-reputation threat and group-reputation threat were negatively related to self-efficacy. Self-reputation threat was also negatively related to task values. On the other hand, self-efficacy and task values positively and perceived costs negatively related to STEM achievement and persistence. Lastly, self-efficacy mediated the relations between group-reputation threat and STEM outcomes while task values mediated the relations between self-reputation threat and STEM outcomes. These findings provide empirical evidence for the theorized relations between

cultural stereotypes and expectancy-value beliefs and also expand the stereotype threat theory by examining the mechanisms and consequences of two distinct types of stereotype threat. Results of this dissertation further sheds light on the factors that contribute to the racial opportunity gap in STEM.

This dissertation is dedicated to my parents, Nicki and Majid.

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CHAPTER I

INTRODUCTION

Reports by scientists and policymakers indicate that the United States is not producing enough college graduates in science, technology, engineering, and mathematics (STEM) disciplines to support its economy and hold its global competitiveness in the years to come (Presidents' Council of Advisors on Science & Technology, 2012). Despite efforts to increase the participation and persistence of college students in STEM, many students who enroll in STEM fields leave or switch out of these majors prior to graduation (National Center for Education Statistics, 2019). This problem is more visible in historically underrepresented minority (URM) populations, particularly for African-Americans (Chang et al., 2014; National Center for Education Statistics, 2019). Only 25% of African-American students completed their bachelor's degree in STEM within 6 years (Hurtado et al., 2012), which is much lower than their White (43%) or Asian (52%) counterparts. This is the case even though African-American students are as likely as their White-American peers to initially choose a STEM major (Dickson, 2010) and also start with higher levels of interest in STEM (Shim et al., 2008).

Recent efforts to understand such racial disparities have focused on the sociocultural and environmental factors that affect racial minority students in STEM academic settings (e.g., Estrada et al., 2016; Garcia & Hurtado, 2011; Syed et al., 2011). For example, some researchers have argued that African-American students' unique experiences with racial discrimination and biases in STEM settings have deleterious effects on their achievement and persistence (e.g., Grossman & Porche, 2014; Ong et al., 2018; Wong et al., 2003). Others have highlighted underlying psychological processes and demonstrated that the anxiety related to inadvertently confirming negative racial stereotypes –a phenomenon known as *stereotype threat*– has negative

impacts on African-American students' academic outcomes (e.g., Cadinu et al., 2003; Smith et al., 2015; Steele & Aronson, 1995; Totonchi et al., 2020). Indeed, studies that examined African-American students' achievement and persistence in STEM settings indicated that stereotype threat was associated with lower academic motivation, which subsequently led to lower grades and lower intentions to persist in STEM majors (Cadinu et al., 2003; Smith et al., 2015; Woodcock et al., 2012).

The most widely used methodologies to examine stereotype threat are controlled experimental studies (Taylor & Walton, 2011; Schmader & Johns, 2003; Steele & Aronson, 1995) and cross-sectional correlational survey studies (Chang et al., 2009; Shapiro, 2011). While experimental studies have demonstrated the causal relations between race-related perceptions and academic outcomes, more research is needed to understand these processes in authentic academic environments. Moreover, the cross-sectional relations of race-related perceptions and academic outcomes often examined in prior research limits understandings of the mechanisms through which race-related perceptions affect academic outcomes over time. Motivational beliefs are highly contextual and may be influenced by a variety of environmental and socio-cultural factors such as racial discrimination and stereotypes (Eccles & Wigfield, 2002; Wong et al., 2003). In turn, motivational beliefs relate to academic success and persistence (e.g., Andersen & Ward, 2013; Perez et al., 2014). Thus, changes in motivation may be one mechanism that explains the negative effects of race-related threats on academic outcomes.

In this study, I employed a short-term longitudinal mediation design in order to understand the effects of stereotype threat on African-American STEM students' motivation, achievement, and persistence. This methodology allowed for the examination of motivation as a mediator of the relations between stereotype threat and academic outcomes, which consequently

enhances our understanding of the mechanisms through which stereotype threat operates and impacts students' academic outcomes in authentic contexts. Findings from this study may expand our understanding of the factors that impact African-American students' achievement and persistence in STEM disciplines. This newly gained understanding will ideally inform interventions designed to narrow the racial opportunity gap in STEM. In the following sections, I briefly summarize the theoretical frameworks in this study and then conclude the chapter with the study's purpose and research questions.

Theoretical Framework

This study is grounded in two theoretical frameworks to capture the unique psychological processes underlying the achievement and persistence of African-American students in STEM: stereotype threat theory (Steele & Aronson, 1995) and expectancy-value theory (Eccles et al., 1983).

Stereotype Threat Theory

Studies with racial minority students indicate that experiences with racial discrimination is fairly common in academic environments (Fisher et al., 2000; Smalls et al., 2007; Wong et al., 2003). Students report that because of their race, they have received lower grades than they deserved, were excluded from peer activities, were called racial names, and most commonly experienced racial microaggressions (Fisher et al., 2000; Harris-Britt et al., 2007; Smith et al., 2007; Smith et al., 2016). Such experiences often communicate the message to students that they are not valued or accepted as a member of the group (Crocker et al., 1998). These perceptions could consequently diminish these students' sense of belonging, adjustment to school, motivation, and achievement (Brown et al., 2017; Feagin, 1992; Ong et al., 2009; Phelan et al., 1994; Wong et al., 2003).

Experiences with racial discrimination can provoke feelings of anxiety over being judged stereotypically or possibly self-fulfilling the negative stereotypes about one's social group (Schmader & Johns, 2003; Spencer et al., 2016; Steele & Aronson, 1995). This psychological phenomenon –or *stereotype threat*– has the potential to interfere with the stereotyped individuals' performance (e.g., Steele & Aronson, 1995). Indeed, empirical research with female and racial minority students in a variety of academic disciplines suggests that students who were exposed to stereotype threat performed poorer on standardized tests (Cadinu et al., 2003; Good et al., 2003; Steele & Aronson, 1995;), achieved lower course grades (Good et al., 2008; Spencer et al., 1999; Walton & Spencer, 2009), and were less likely to persist in science majors (Chang et al., 2009; Woodcock et al., 2012). Stereotype threat affects academic outcomes via a variety of processes including negatively impacting motivation (Cadinu et al., 2003; Totonchi et al., 2020; Steele & Aronson, 1995). Next, I discuss the motivational theory that frames this study.

Expectancy-Value Theory

The expectancy-value framework (Eccles et al., 1983) has been widely used by motivation researchers to understand the achievement and persistence of racial and gender minorities in STEM since this theory provides a comprehensive framework for understanding both the socio-cultural and psychological factors underlying students' academic success and choices (Eccles & Wigfield, 2002). Expectancy-value theory posits that students' decisions to engage and persist in a task or domain depend on their *expectations for success* in the domain and the values they hold for the domain (*task values*; Eccles et al., 1983; Eccles, 2009; Eccles & Wigfield, 2002; Wigfiled & Eccles, 2000). Existing research indicates that success expectancies and task values predict STEM achievement and persistence (Andersen & Ward, 2013; Perez et al., 2014; Wang et al., 2015). Studies with samples of ethnically diverse students indicate that

those who are more confident in their ability to succeed in STEM majors achieve higher grades in their STEM courses (e.g., Perez et al., 2014). Additionally, students who hold higher values for STEM disciplines indicate higher intentions to persist in their STEM majors (Perez et al., 2014; Wang et al., 2015).

Individuals' success expectancies and task values are contextual and shaped within their social milieu, such as stereotypes about what individuals of different genders or races/ethnicities can accomplish and what important socializers' value and expect from them (Eccles & Wigfiled, 2002). Socializers' stereotype-based evaluations (e.g., African-Americans are underachievers in math and sciences) can negatively influence individuals' expectations for success and their values for the domain (Smith, 2004). The diminished success expectations and value beliefs then, in turn, can undermine individuals' actual achievement (Eccles, 2009; Eccles & Wigfield, 2002; Wang et al., 2015). In fact, empirical research has demonstrated that motivation has a mediating effect on the relationship between identity-related threats and academic performance such that these threats undermined students' academic performance by diminishing their beliefs in their abilities to perform well academically (Steele & Aronson, 1995; Cadinu et al., 2003) and decreasing the values they held for the academic domain (Smith et al., 2015)

While there is some empirical literature to suggest that the threat of stereotypes and discrimination negatively impacts African-American students' academic outcomes through expectancy and value beliefs (Cadinu et al., 2003; Steele & Aronson, 1995; Smith et al., 2015), the methodologies that have been used to examine these relationships, which are often cross-sectional correlational surveys or controlled experimental studies, fail to examine the true mediational role of expectancy-value beliefs in the stereotype threat-academic outcome relations. A longitudinal design is needed to demonstrate whether stereotype threat precedes expectancy-

value beliefs, which in turn influence academic outcomes at a later time. Such a design would provide compelling evidence for the mediational role of expectancy-value beliefs in the relations between stereotype threat and academic outcomes.

Purpose of the Study

The main purpose of this study was to examine the role of expectancy-value beliefs in mediating the relations between stereotype threat and academic outcomes. To this end, I employed a short-term longitudinal mediation analysis and examined the indirect relations between stereotype threat and academic outcomes (STEM achievement and persistence) through expectancy-value beliefs over time. Results of this study have implications for theory and practice. The short-term longitudinal design of this study extends expectancy-value theory by providing empirical evidence for contextual factors that are hypothesized to shape motivational beliefs. Additionally, findings from this study expand our knowledge of the potential factors that contribute to the persistence and achievement of African-American students in STEM disciplines.

The study included a sample of African-American students who were enrolled in two introductory science course. Participants responded to surveys assessing stereotype threat, expectancy-value motivational beliefs, and intentions to remain in their STEM major at the beginning, in the middle, and at the end of the fall semester. Finally, students' grades were collected from the instructors of the introductory science courses. The following research questions were examined in this study:

1) Do African-American students' perceptions of stereotype threat predict their expectancy and value beliefs in science courses after controlling for baseline expectancy and value beliefs?

2) Do African-American students' expectancy and value beliefs in science courses predict their achievement and persistence in STEM after controlling for prior achievement and baseline intentions to persist?
3) Do African-American students' expectancy and value beliefs in science courses mediate the relations between stereotype threat and academic outcomes?

In the next chapter, I elaborate on the theoretical foundation of the study and review relevant research highlighting gaps in the literature and the ways in which this study addresses those gaps. Then in chapter 3, I discuss the methodology of the study. In chapter 4, I report the results of the analyses which I conducted to address the study research questions. Finally, in chapter 5, I discuss the meaning of the findings and their implications for practice and future research.

CHAPTER II

LITERATURE REVIEW

This chapter begins with a review of the literature on the impact of experiences with racial discrimination and stereotype threat on African-American students' academic outcomes. Next, the role of various psychological variables in mediating the relation between stereotype threat and academic outcomes is discussed. Focusing on motivational beliefs as the main mediator, the key components of the expectancy-value motivation framework is presented and the relevant research that examines the relations among these motivational beliefs, stereotype threat, and the achievement and persistence of African-American students are reviewed. This chapter concludes with the study research questions and associated hypotheses.

African-American Students' Experiences with Racial Discrimination

Racial achievement disparities have received abundant research attention by educational and social psychologists. However, more research is needed to understand the environmental and socio-cultural factors that precipitate unequal opportunities for racial underrepresented minority students in educational settings and lead to such achievement differences (i.e., opportunity gaps). Studies with African-American students at a variety of educational levels indicate that experiencing racial discrimination in academic environments is common (Fisher et al., 2000; Neblett Jr. et al., 2006; Smalls et al., 2007; Wong et al., 2003). Racial discrimination is defined as "beliefs, attitudes, institutional arrangements, and acts that tend to denigrate individuals or groups because of phenotype characteristics or ethnic group affiliation" (Clark et al., 1999, p. 805). Harris-Britt and colleagues (2007), in a study with African-American 8th-graders, found that nearly 94% of the students had experienced at least one racial discrimination event within the past three months. These events included students receiving lower grades than they thought

they deserved, receiving unfair after-school detention, and being called racially offensive names by other students.

Fisher and colleagues (2000) conducted a similar study with a group of ethnically-diverse adolescents in urban public schools. The researchers suggested that, particularly for African-Americans, racial discrimination may be a prevalent stressor in their day-to-day life as students. The authors found that students of all ethnic groups reported experiencing discriminatory treatment at both the level of the institution and from peers. The reports of institutional discrimination included being perceived as unintelligent and dangerous because of ethnic prejudice. On the other hand, students also reported experiencing peer discrimination such that they were excluded from peer activities because of their race or they were called derogatory names. In both of these studies, the researchers found that more reports of racial discriminatory experiences were related to lower self-esteem. The researchers argued that continuous experiences with discriminatory behavior may have negatively affected how students viewed the self.

Smith and colleagues (2016), in a qualitative study with male African-American undergraduate students, found that experiences of racial discrimination, particularly in the form of microaggression, were prevalent for students in academic and campus-social spaces. Students reported experiencing subtle and overt racial insults, and perceived being “out of place” when they were on campus. Additionally, African-American students reported that they were perceived as being unintelligent or academically incompetent. The students reported that they were rarely able to engage in intellectual and meaningful discussions and they were perceived as unimportant members of the campus society. Such experiences negatively affect student’s mental health and well-being (Bernard et al., 2017; Cokley, et al., 2017) and at the same time diminish

their motivation to remain in school and strive to succeed academically (English et al., 2016; McGee, 2016; Wong et al., 2003).

The Effects of Racial Discrimination on Academic Outcomes

Racial discrimination often communicates the message that individuals from certain racial groups are devalued. Experiences with discriminatory behaviors and attitudes also convey to individuals that they do not belong and are not part of the "in-group" (Crocker et al., 1998). In academic environments, such perceptions have implications for targeted students' sense of belonging, adjustment to school, motivation, and achievement (Feagin, 1992; Phelan et al., 1994; Wong et al., 2003). For instance, in a two-wave longitudinal study with African-American adolescents, Wong and colleagues (2003) found that students' perceptions of racial discrimination–relayed by peers and teachers–were negatively associated with students' achievement motivation. African-American students who reported more frequent experiences with racial discrimination, evaluated the importance of school to be less than students who had less frequent experiences with racial discrimination. Additionally, these students held lower utility value for school and were less confident about their academic abilities. However, the researchers did not find a significant association between perceived racial discrimination and students' grades.

In another study on African-American students in Grades 7-10, Smalls and colleagues (2007) found that students who reported higher number of racial discrimination experiences in the past year, were less likely to identify with an academic orientation. These students demonstrated being uncomfortable with being perceived as academically competent, intelligent, and receiving good grades because they were worried about being teased by other students for being a "nerd." The students who reported more frequent racial discrimination experiences were

also more likely to indicate that they would give up in the face of academic difficulty or failure (Smalls et al., 2007). Experiences with racial discrimination do not affect all individuals equally. Indeed, there is variation in the degree to which individuals of stigmatized groups are vulnerable to discrimination and group-based mistreatment (Pinel, 1999; Brown & Pinel, 2003). To capture such individual differences, researchers have introduced a variety of psychological constructs including stereotype threat. In the next section, I review the literature on stereotype threat theory and provide a summary of the empirical research that has linked stereotype threat to achievement motivation and academic performance.

Stereotype Threat Theory

Experiences with racial discrimination can provoke anxiety over being judged stereotypically or possibly self-fulfilling the negative stereotypes about one's social group (Steele, 1997; Steele & Aronson, 1995). This psychological process–referred to as *stereotype threat*–was first conceptualized by Steele and Aronson (1995) to explain the underperformance of African-American students, compared to White-American students, on diagnostic tests. Stereotype threat involves a cognitive imbalance among three core concepts: (1) one's concept about the self, (2) one's concept about their group, and (3) one's concept about the one's ability in the domain. This cognitive imbalance starts with a situational cue that hints that the concept of the group is in contradiction with the concept of ability (e.g., people of my group do not have this ability). A variety of contextual and situational cues may activate this negative relation (Schmader et al., 2008). For instance, being in the numerical minority in academic environments (Inzlicht & Ben-Zeev, 2000; Sekaquaptewa & Thompson, 2003; Totonchi et al., 2019) could covey the message that persons of one's group lack the ability to be successful in academic environments (Inzlicht & Ben-Zeev, 2000; Sekaquaptewa & Thompson, 2003; Totonchi et al.,

2019). Additionally, experiencing subtle or blatant discrimination from students, professors, or important others in academic environments who hold negative stereotypical beliefs about the abilities of individuals from certain groups conveys the message that the group is deficient in the academic domain (Emerson & Murphy, 2015; Goff et al., 2008; Logel et al., 2009). Thus, experiencing racial discriminatory treatment in academic environments directly activates the cognitive imbalance responsible for the experience of stereotype threat.

This process combined with a positive relation between the concepts of group and self (e.g., I am like people of my group) can lead to a stereotypically threatening experience. Indeed, studies demonstrate that experiences of stereotype threat were more salient for individuals who had a stronger identification with their group (Schmader, 2002; Woodcock et al., 2012). Lastly, the positive relation between the concepts of self and domain ability completes the activation of this cognitive imbalance (e.g., I have this ability). Threatened individuals link their self-concept with doing well in the domain typically because of an expectation for success or a heightened motivation to excel. Indeed, studies indicate that high-achieving individuals who are highly invested in the domain are affected by stereotype threat the most (Steele, 1997). Moreover, prior research shows that individuals are more likely to experience stereotype threat when performing well in the domain is personally important (Aronson et al., 1999; Stone et al., 1999). Therefore, according to this model, one has to believe that one has the ability to be successful in that domain and that being successful in that domain has some value in order for stereotype threat to be activated.

This cognitive imbalance, then, functions as a stressor and causes a variety of impaired physiological, cognitive, and emotional responses (Major & O'Brien, 2005). Being in contexts where the domain ability of in-group members is questioned may motivate the threatened

individuals to perform in a manner that disconfirms the ability-related stereotypes about their group. Ironically, this extra motivation to perform well can interfere with individuals' performance by increasing their physiological stress response, increasing monitoring the situational cues that triggered the threat, heightening negative thoughts and affect in the situation, overloading the working memory, and engaging in impaired efforts to suppress the negative thoughts and emotions caused by the threatening experience (Schmader et al., 2008).

Stereotype Threat and Academic Performance of African-American Students

Since Steele and Aronson's (1995) conceptualization of stereotype threat, this construct has been used widely by educational and psychological researchers to explain the African-American opportunity gap in various academic fields. Numerous studies have demonstrated that experimentally induced stereotype threat has deleterious effects on academic outcomes of students with marginalized identities (e.g., Cadinu et al., 2005; Froehlich et al., 2016; Osborne, 2001; Picho & Schmader, 2018; Schmader & Johns, 2003; Steele & Aronson, 1995; Steele & Aronson, 1998). For instance, in multiple studies, researchers induced stereotype threat by exposing African-Americans to high-stakes evaluative situations while priming them that their performance would be indicative of their intellectual ability (Cadinu et al., 2003; Osborne, 2001; Steele & Aronson, 1995; Steele & Aronson, 1998). Specifically, African-American and White-American students were asked to perform on portions of the GRE test. The participants were then divided into the control and stereotype-threat conditions. The participants in the stereotype-threat condition were told that their performance on the GRE test is indicative of their intellectual ability and thus triggering anxiety over self-fulfilling intelligence-deficit stereotypes for African-American students. Findings in such studies indicated that African-Americans in the stereotype threat condition, for whom this anxiety was triggered, reported lower performance

expectancies and worse actual performance compared to African-Americans in the control group and compared to White-Americans (Cadinu, et al., 2003; Steele & Aronson, 1995). Although, these studies highlighted the negative effects of stereotype threat on performance expectancies, additional research is needed to distinguish whether students' low performance expectancies were due to their anticipation of being graded unfairly or due to their lowered beliefs in their abilities to succeed. In the present study, I examined whether perceptions of stereotype threat would affect students' science self-efficacy or their confidence in their abilities to succeed in science.

In other studies, researchers induced stereotype threat in African-American participants by asking them to indicate their race (Steele & Aronson, 1995; Steele & Aronson, 1998; Nguyen et al., 2003) or complete a racial identity scale (McFarland et al., 2003) before taking a difficult test. It was hypothesized that priming African-American students with their racial identity before taking a test would provoke anxiety over being treated stereotypically. Findings indicated that African-Americans for whom stereotype threat was activated performed poorer on the tests compared to African-Americans for whom stereotype threat was not activated and compared to White-Americans (Steele & Aronson, 1995; Steele & Aronson, 1998). In a meta-analysis study conducted by Walton, Spencer, and Erman (2013), the authors summarized evidence of the effects of stereotype threat on performance and reported that stereotype threat was responsible for, conservatively, 17% to 29% of the achievement gap on the SAT scores between African-American and White-American students. Overall, this research highlights the deleterious effects of experiencing stereotype threat for African-American students.

Stereotype Threat is Multi-Dimensional

Shapiro and Neuberg (2007) argue that the threat of being treated stereotypically is qualitatively different from the threat of possibly confirming stereotypes of the group. In the former, the target of the threat is the self and how one will be viewed through the lens of stereotypes (i.e. self-reputation threat); whereas in the latter, the target of the threat is the group and whether one's actions could reinforce the stereotypes about their group (i.e. group reputation threat). Thus, Shapiro and Neuberg introduced the multi-threat framework and argued that the target of threat varies in different situations and for different groups of people resulting in triggering different types of stereotype threat. empirical evidence

Indeed, in a study with students of different marginalized identities (race/ethnicity, religion, weight status, and disability status), Shapiro (2011) found that students distinguished between the two types of threat and report higher levels of self-reputation threat. Further, Shapiro argued that self-reputation threat requires individuals to believe that others endorse the negative stereotypes. That is, one's own endorsement of stereotypes and/or their identification with the group is irrelevant in their experiences with self-reputation stereotype threat. Results indicated that all four groups with marginalized identities indicated relatively high self-reputation threat as students of all marginalized groups believed that others endorse stereotypes about their marginalized identities. However, differences emerged between groups in group-reputation threat. Students from the mental illness and weight stigmatized groups had low identification with their groups and thus indicated lower group-reputation threat. In contrast, students from the race/ethnicity and religion stigmatized groups had higher identification with the group and reported higher group-reputation threat. That is, for students of marginalized race/ethnicity and religion identities, tainting the image of their race or religious group due to their misbehavior or

poor performance was a salient concern. These findings suggested that stereotype threat functions via different mechanisms for individuals of different groups. However, even though Shapiro found that different minority groups are vulnerable to different types of threat, the distinctions between these perceived threats were not examined through factor analyses.

Cohen and Garcia (2005) introduced the concept of collective threat as individuals' concern that other in-group members may confirm the negative stereotypes about their group. In multiple studies that were conducted with high-school and undergraduate students with multiple marginalized identities (race and gender), the researchers assessed collective stereotype threat (e.g., "In school, I worry that people will draw conclusions about my racial group, based on the performances of other people in my race"). The researchers also assessed basic threat of being stereotyped (e.g., "In school, I worry that people will draw conclusions about me, based on what they think about my racial group"; what Shapiro would call as self-reputation threat) and stereotype threat (e.g., "In school, I worry that people will draw conclusions about my racial group based on my performances"; what Shapiro would call as group-reputation threat). Their findings suggested that racial minority students rated collective threat and the threat of being stereotyped (self-reputation threat) as more worrisome than stereotype threat (group-reputation threat). Additionally, for these students, higher collective threat predicted lower GPA, self-esteem, and self-efficacy.

Similar results were found by Zhang and colleagues (Zhang et al., 2012) who conducted multiple studies with female undergraduate students and assessed their perception of threat in math. The researchers found that women generally reported higher self-reputation threat compared to men. Also, perceptions of self-reputation threat were higher for women who more strongly identified with math than women with lower math identification. Interestingly, results

demonstrated that self-reputation threat mediated the relationship between gender and math performance such that women were more likely to have higher self-reputation threat and higher self-reputation threat was in turn negatively related to women's math performance.

While the existing empirical research provides some evidence for the differences between the self- and group-reputation threat in predicting various psychological and educational outcomes, more research is needed to understand the mechanisms through which self- versus group-reputation stereotype threat operate and affect African-American students' performance. A few studies that have recognized this construct as unidimensional have identified a number of mechanisms through which stereotype threat affects academic performance.

Mediators of the Stereotype Threat-Academic Performance Relation

Research has demonstrated that stereotype threat affects academic performance via a variety of mechanisms. Among the most widely examined mediators are heightened anxiety (e.g., Bosson et al., 2004; Osborne, 2001; Spencer et al., 1999), working memory depletion (e.g., Brodish & Devine, 2009; Schmader et al., 2008), and declined motivation to succeed (Cadinu et al., 2003; Totonchi et al., 2020; Woodcock, et al., 2012).

Declined Motivation

Research has examined the role of a variety of motivational variables in mediating the relationship between stereotype threat and academic performance. The basic notion is that under stereotype threat conditions, individuals will be motivated to perform in a manner that disconfirms the negative stereotypes. Ironically, this desire has negative effects on individuals' performance through harming their motivation to succeed. For instance, Steele (1997) explains that continuous experiences with stereotype threat in academic environments could lead students to gradually cease to care about their performance and place less importance on the academic

domain. This phenomenon referred to as academic disidentification could hurt the actual performance of these students and potentially lead them to disengage from the domain. Indeed, in a study with African-American and Hispanic science students, Woodcock and colleagues (2012) found that Hispanic students who had higher perceptions of stereotype threat early in the first year of college, indicated lower identification with science in the second year. Lower identification with science in the second year was, in turn, related to lower intentions to pursue a science career in the third year both for African-American and Hispanic students. However, the indirect effect of stereotype threat on career aspirations through science identification was only significant for the Hispanic students. These results provided partial support for the role of science identification in mediating the relation between stereotype threat and academic outcomes suggesting different processes for different groups.

Experimental research has also shown that stereotype threat diminishes performance through changes in effort (Hess et al., 2003; Jamieson & Harkins, 2007; Skorich et al., 2013). Investing or ceasing effort in a task is indicative of individuals' motivation such that those who have higher motivation to achieve and succeed are more likely to invest effort in the task and persist in the face of difficulties (e.g., Cole et al., 2008; Wigfield, 1994; Wigfield & Eccles, 2000). In an experimental study with men and women of varying ages, Hess and colleagues (2003) found that older individuals who were in an age-stereotype threat condition recalled fewer words on a free-recall task compared to younger individuals and older individuals who were not in the age-stereotype threat condition. Interestingly, this effect was mediated by individuals' effort in using strategies to cluster the words together for better recall. Results showed that older individuals in the stereotype threat condition invested less effort in clustering the words for better recall.

Self-efficacy is another variable that has been shown to mediate the stereotype threat-performance relationship. Chung and colleagues (2010) in a cross-sectional correlation study with African-American job candidates found that those who had higher perceptions of stereotype threat also reported higher state anxiety. High anxiety in turn was related to reports of lower domain-specific self-efficacy, which was associated with lower performance on a high-stakes exam (Chung et al., 2010). However, studies that have examined self-efficacy as a mediator of the stereotype threat-performance relation have yielded mixed results as a number of these studies reported null findings with regards to the mediating role of self-efficacy (Mayer & Hanges, 2003; Spencer et al., 1999). The rationale for the mediating role of self-efficacy comes from the hypothesis that stereotype threat harms individuals' confidence in their abilities to perform well (Steele & Aronson, 1995). Decreased self-confidence, in turn, has negative effects on performance (e.g., Zimmerman et al., 2017).

A construct similar to self-efficacy is performance expectancies for which multiple studies have found significant mediating effects (Hess et al., 2009; Cadinu et al., 2003; Rosenthal et al., 2007; Steele & Aronson, 1995). For instance, Steele and Aronson (1995) as well as Cadinu and colleagues (2003) conducted very similar experimental studies with African-American individuals where they exposed a group of the participants to stereotype threat and asked that group to estimate their success on an upcoming GRE test. In both studies, African-American participants for whom stereotype threat was activated predicted that their scores on the GRE would be lower compared to White-Americans and African-American participants for whom stereotype threat was not activated. Similarly, Rosenthal and colleagues (2007), in an experimental study with male and female undergraduates, found that women who received a stereotype threat buffering intervention predicted higher scores for themselves on a math test

compared to women who did not receive a stereotype-threat buffering intervention. These women also scored higher on the math accuracy test supporting the role of performance expectancies in mediating the relation between stereotype threat and performance.

Expectancies for success has been identified as an important belief in students' achievement motivation. In expectancy-value theory, Eccles' and her colleagues (Eccles et al., 1983) hypothesized that a variety of socio-cultural and psychological factors influence students' expectancies for success and ultimately their performance and persistence in academic domains. Next, I introduce this prominent motivation theory and review related literature with regards to the effects of stereotypes on students' motivation and the implications for academic outcomes.

Expectancy-Value Theory

Expectancy-value theory (Eccles et al., 1983; Eccles & Wigfield, 2020) has been used widely as a model for explaining the differences in achievement and persistence of underrepresented students. The model is a comprehensive framework that accounts for the contextual and socio-cultural factors that shape students' motivation and, ultimately, their achievement-related choices (Eccles & Wigfield, 2002). According to Eccles and colleagues, students' decisions to pursue and persist in a task are most proximally determined by their expectations for success in the task and the values they hold for the task (Eccles et al., 1983; Eccles, 1994, 2011; Wigfield & Eccles, 2000, 2002). Engagement and persistence in tasks are highest when individuals have high success expectancies and highly value the task. Next, I discuss success expectancies and task values in more detail and review their associations with academic outcomes.

Expectations for Success

Expectations for success are individuals' perceptions of how they will perform on some future task. Expectation for success is conceptually similar to one's beliefs in their abilities to succeed in the task domain (i.e. self-efficacy). In empirical studies, expectancies for success and academic self-efficacy have demonstrated high intercorrelations. In fact, Eccles and Wigfield (1995; 2002) have frequently highlighted the strong relations between expectancy and self-efficacy beliefs. Thus, many researchers have used a composite of these constructs or have used expectancies and self-efficacy interchangeably (Lee et al., 2014; Totonchi et al., 2020). In the present study, students' success expectancies for STEM are assessed by measuring their self-efficacy beliefs.

Perceived Task Value

Task values are students' reasons for engaging in a task. Eccles and colleagues (1983) identified four sources that contribute to the overall value of a task. First, intrinsic value is the joy gained from engaging in a task or the interest in the task domain. Individuals are more likely select and persist in a task if they anticipate enjoying it or are interested in the domain. Second, attainment value is the importance or alignment of a task to one's identity. Individuals are more likely to value a task if they see close ties between the task and their salient identities. Third, utility value is defined as the usefulness of a task for an individuals' future goals (Eccles, 2009, Wigfield & Cambria, 2010). When a task is aligned with one's future goals, the task will be more highly valued.

There is extensive evidence these three sources of values are interconnected (Eccles, 2009; Kosovich et al., 2017; Robinson et al., 2018). For instance, theoretically, having high intrinsic value for a task could lead to higher engagement in the task which could in turn result in

developing competence in doing the task. The newly developed competence could then become important to one's sense of self and identity and thus increase the attainment value for the task (Eccles, 2009). Furthermore, utility value is the value of a task in relation to future goals. If these future goals are closely connected to one's identity, the utility value of the task would be associated with its attainment value (Wigfield et al., 2017).

The fourth component of task value is perceived costs. Unlike the other three values, which focus on the positive aspects of engaging in tasks, perceived costs focus on the anticipated drawbacks associated with a task. Eccles and colleagues (1983) identified three types of perceived costs. First, effort cost is the perception that the amount of time and effort needed to complete a task is not worth the outcome. Second, opportunity cost is the perception that engagement in a task would result in the loss of other valuable opportunities. Finally, psychological cost is the negative emotional and psychological consequences associated with fear of failure. While more recent research has identified other potential types of perceived costs (e.g., Barron & Hulleman, 2015; Flake et al., 2015; Wigfield et al., 2017), in the present study I focused on these three kinds of perceived cost.

Success Expectancies, Task Values, and Academic Outcomes

Contemporary expectancy-value theory was first introduced by Eccles and her colleagues (1983) to understand processes underlying career choice; more specifically, why women were less likely to choose a career in math. Since then, this theory has been applied widely to understand achievement-behavior and persistence in a variety of other domains (Eccles & Harold, 1991; Harackiewicz & Hulleman, 2010; Chen & Liu, 2009). Aligned with the purpose of this dissertation, I discuss the literature that highlights the associations among success expectancies, task values, persistence, and academic achievement.

Persistence

There is extant empirical research that suggests expectancy, value, and cost beliefs have significant influences on students' academic choices such as course enrollment decisions, intentions to persist in a major, and aspirations to pursue a particular career (e.g., Eccles et al., 2004; Jacobs et al., 2002; Linnenbrink-Garcia et al., 2018; Meece et al., 1990; Perez et al., 2014, Robinson et al., 2018). For instance, in a short-term longitudinal study with ethnically diverse undergraduates who were enrolled in an introductory chemistry course, Perez and his colleagues (2014) investigated students' expectancy, value, and cost beliefs at the beginning and at the end of a semester. Results from a cross-lagged path analysis indicated that values negatively and cost perceptions positively predicted end-of-semester intentions to leave STEM majors. The researchers did not find significant effects of expectancy beliefs on intentions to leave STEM, controlling for values and costs. These results are in line with the hypothesis and other empirical findings that suggest task values are typically stronger predictors of students' choice behaviors and expectancy beliefs are stronger predictors of students' achievement (Eccles, 2009).

In a two-year longitudinal study, Robinson and her colleagues (Robinson et al., 2019) measured expectations for success, value, and cost beliefs in a sample of engineering college students. The researchers examined these motivational beliefs at three time points during the first two years of an engineering program and examined whether change in motivational beliefs predicted the likelihood of graduating with an engineering degree. The results of conditional latent growth analyses suggested that intrinsic value early in the first semester (the intercept) positively predicted retention in an engineering major. Additionally, the findings revealed that the rates of change (the slopes) in expectancy, value, and cost beliefs were related to retention in

engineering. Specifically, students whose expectancy and value beliefs decreased more rapidly and those whose cost perceptions increased more steeply were more likely to leave engineering.

Studies with racial minority students have yielded similar results. Zarrett and Malanchuk (2005) examined African-American and White-American adolescents' intentions to pursue a career in Information Technology (IT). Their research suggested that African-American students were as likely to intend to pursue a career in IT as their White-American peers. The authors also reported these intentions were influenced by expectancy and value beliefs for both racial groups such that, students' perceived math ability and value for the domain significantly shaped their intentions to pursue a career in IT.

Andersen and Ward (2014) compared African-, White-, and Hispanic-American high-school students' expectations for success, self-efficacy, and values for STEM domains and the effects of these psychological variables on students' STEM career aspirations. To measure STEM career aspirations, the researchers asked students to indicate what occupation they expect to have at age 30. The results indicated that for African-American and White-American students, science attainment value positively predicted the likelihood of selecting a STEM occupation. For Hispanic students, science attainment and utility value positively predicted STEM career aspirations. Neither expectations for success nor self-efficacy predicted career aspirations for any of the racial groups.

Overall, these studies demonstrate that expectancy and value beliefs are important determinants of choice behaviors, particularly decisions to pursue or persist in certain careers or domains. Next, I will review the literature on the relations among expectancy-value beliefs and achievement.

Academic Achievement

Numerous cross-sectional, longitudinal, and experimental studies with students of a variety of ages in different academic domains demonstrate the significant effects of expectancy, value, and cost beliefs on students' achievement (Harackiewicz et al., 2016; Meece et al., 1990; Perez et al., 2014; Trautwein et al., 2012). For instance, in a cross-sectional latent structural modeling study with a sample of German students in secondary schools, Trautwein and his colleagues (2012) found that expectancy beliefs as well as attainment, intrinsic, and utility value positively predicted math and English achievement; whereas, perceptions of cost negatively predicted Math and English achievement.

Moreover, experimental studies suggest that interventions that increase students' values for the domain can help close the achievement gap between racial minority and majority students in STEM disciplines. For instance, in a study with underrepresented minority and majority undergraduate students in biology, Harackiewicz and her colleagues (Harackiewicz et al., 2016) increased students' utility value by asking them to write essays about the relevance of the course materials to their lives. Their results suggested that the utility value intervention increased biology grades for all students who were in the intervention group. Additionally, for underrepresented minority students, biology achievement was higher in the intervention group relative to the control group and compared to racial majority students. In other words, the findings suggested that the intervention especially improved the motivation and achievement of underrepresented minority students, which resulted in a significant reduction of the achievement gap between racial minority and majority students. Moreover, in a longitudinal study, Linnenbrink-Garcia and her colleagues (2018) tested the efficacy of a motivational intervention on a sample of ethnically diverse college students' expectancy-value beliefs. Results of their

study suggested that the intervention increased students task value perceptions, which in turn positively predicted later science achievement (Linnenbrink-Garcia et al., 2018).

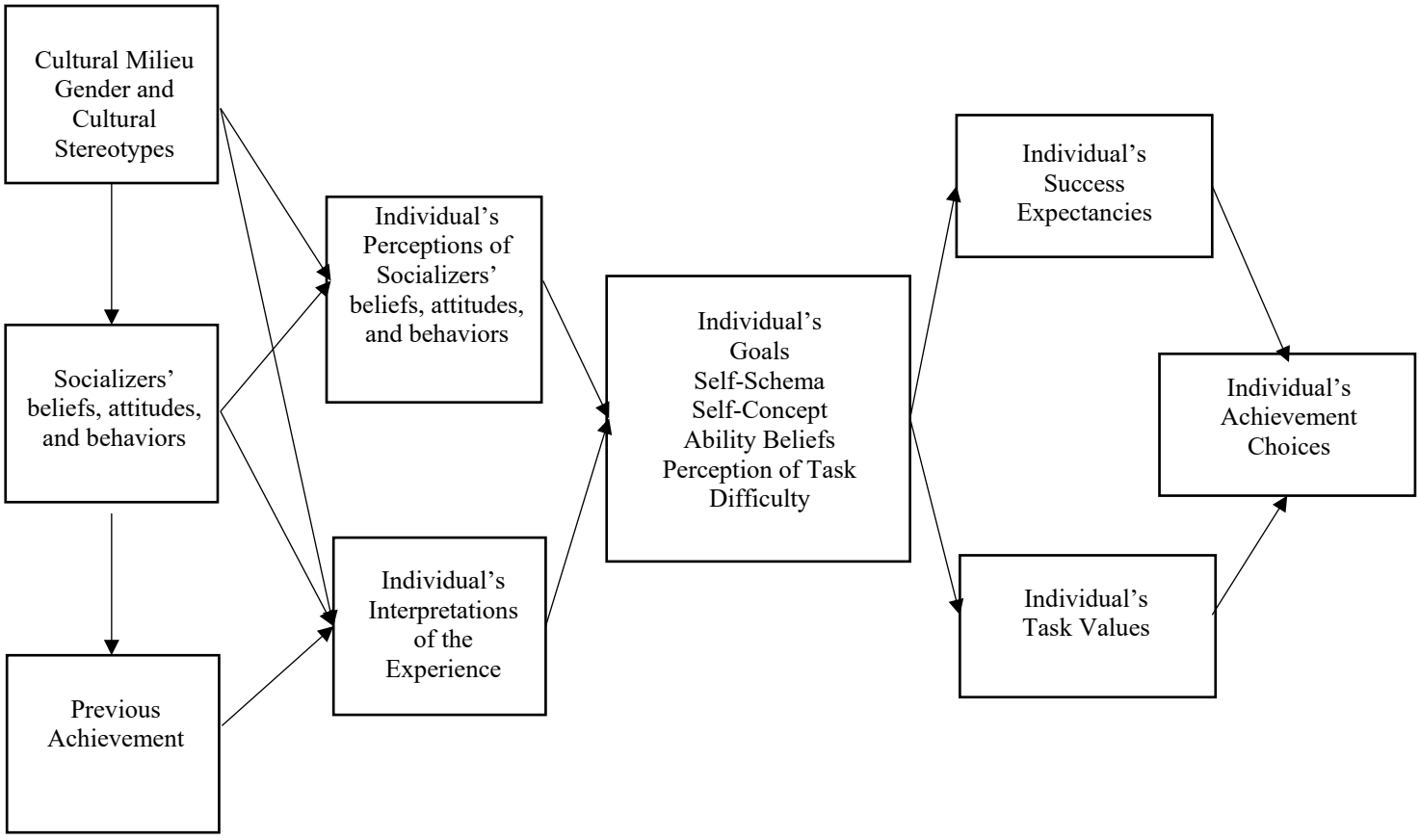
Additionally, a number of short- and long-term longitudinal studies have examined the effects of early motivational beliefs as well as the changes in such beliefs on students' grades in various subjects (Kosovich et al., 2017; Perez at al., 2014; Robinson et al., 2018). For instance, Kosovich and his colleagues (2017) conducted a study with a White-majority sample of undergraduates enrolled in an introductory psychology course. The researchers assessed students' expectancy and utility value beliefs three times within a semester. The results of latent growth model analyses revealed that expectancy beliefs early in the semester were related to exam grades early in the semester (exam 1). Additionally, the decrease in expectancy beliefs and utility value was related to lower exam grades later in the semester (exam 3). Other longitudinal studies with undergraduate students in STEM disciplines have yielded similar results. Robinson et al.'s (2019) growth analysis with engineering students and Perez et al.'s (2014) cross-lagged analysis with STEM students enrolled in an introductory chemistry course have suggested that expectancy beliefs earlier in the college career are significant predictors of grades later on. Additionally, in a similar short-term longitudinal study with Korean middle school students, Jian and colleagues found that expectancy-value beliefs early in the semester related to achievement in the middle of the semester. Specifically, self-efficacy positively and costs negatively predicted students' midterm math exam grades (Jiang et al., 2018, study 2).

Cultural Stereotypes, Discrimination, and Development of Expectancy-Value Beliefs

A number of proximal and distal social, contextual, and cognitive factors shape expectancies and task values. For instance, expectancies and task values are proximally shaped by students' beliefs in their abilities, their goals, the difficulty of the tasks they are engaged in,

and their affective memories. Eccles and Wigfield further argue that such social-cognitive factors are in turn shaped by a number of socializing influences. In their comprehensive expectancy-value model (Eccles & Wigfield, 2020; Wigfield & Eccles, 2002; see Figure 2.1), Wigfield and Eccles depict that socializer's beliefs, expectations, and attitudes which may be strongly influenced by cultural and societal stereotypes, have direct effects on individuals' self-schemas, short- and long-term goals, and ability beliefs, and indirect effects on perceptions of expectancies and task values (Wigfield & Eccles, 2000). Importantly, stereotypes and identity-related threats may also directly affect individuals' beliefs about the self and abilities. Individuals' beliefs about the self and their abilities are shaped by the attitudes, beliefs, and expectations of important others (Spencer, 1999). Most expectancy-value research has focused on the more proximal determinants of expectancies and values such as goals and self-beliefs and more research is needed to examine the influence of the more distal socio-cultural factors such as perceptions of stereotypes and discrimination on expectancies and values (Eccles & Wigfield, 2020).

Figure 2.1
A simplified Model Based on the Expectancy-Value Framework (Eccles & Wigfield, 2000)



Eccles and her colleagues (Eccles et al., 2006) argue that, experiencing or anticipating experiencing racial discriminatory treatment by important socializing agents (e.g., teachers and peers) in academic environments communicates messages to students that their race/ethnicity is devalued by the out-group members in those environments. Such devaluation can in turn lead to negative developmental outcomes for students in the long run. For instance, Eccles and colleagues suggest that in order for students to develop success expectancies, they should have positive beliefs about their academic self-concept and their abilities to succeed. Thus, socializer's negative and stereotype-based evaluations (e.g., women cannot do math; Black students are

underachievers) can negatively impact self-beliefs for students of stereotyped groups and therefore diminish their expectations for success (Wigfield & Eccles, 2002).

Additionally, persistent exposure to racial discrimination could lead individuals to protect their self-esteem from the negative effects of discrimination and stereotyping. However, ironically, such protective strategies often harm individuals' motivation and achievement. Researchers argue that stereotypes have more deleterious effects on individuals who identify strongest with the stereotyped domain. That is, individuals whose identities and self-worth are closely tied to success and competence in a particular domain are more likely to be threatened by stereotypes that question their competence (Aronson et al., 1999; Major et al., 1998; Steele, 1997; Steele et al., 2002). Disidentification from the domain occurs gradually as the experiences with stereotypes and discrimination accumulates, which then results in placing lower importance on the stereotyped domain. As such, disidentification may substantially decrease task values for the domain. Students may struggle to see the importance of the domain to their identity and/or their future goals. Thus, disidentification could lead to lower attainment value and/or utility value. Eventually, such disidentification with and devaluation of the domain may result in a complete withdrawal from the stereotyped domain (Steele, 1997; Major et al., 1998; Schmader et al., 2001; Woodcock et al., 2012).

Empirical research supports these claims. In a cross-sectional study with African-American high school students, Irving and Hudley (2005) reported that students who distrusted White-Americans to treat them fairly in different contexts (a construct labeled as cultural mistrust) had lower achievement motivation. More specifically, the correlational results revealed that African-American students with higher cultural mistrust reported lower expectancies to

achieve favorable educational outcomes. These students also reported that they held lower values for those educational outcomes.

Eccles, Wong, and Peck (2006) examined the effects of racial discrimination on African-American adolescents' achievement motivation and investigated the role of achievement motivation in mediating the relation between perceptions of racial discrimination and academic achievement. The results of a cross-sectional path analysis suggested that African-American students' perceptions of racial discrimination by peers significantly and negatively predicted students' value for school. Value for school was measured by assessing students' perceptions of the utility of education and the necessity of doing well for later success. Students' perceptions of discrimination by teachers did not significantly relate to value for school; however, it was significantly and negatively related to students' academic ability self-concept. Results showed that higher perceived discrimination by teachers negatively influenced students' evaluation of their mathematical and other general academic abilities. More importantly, lower value for school and lower academic ability self-concept were in turn related to students' lower grade point averages, supporting the role of expectancy-value beliefs in mediating the relation between perceived racial discrimination and achievement.

Similar results have been found with college students. In a cross-sectional study with female science undergraduate students, Smith, Brown, Thoman, and Deemer (2015) assessed students' perceptions of stereotype threat in science majors. The researchers also measured women's confidence in science as an index of expectations for success. Furthermore, women reported their communal and agentic utility value for science. Communal utility value tapped into the usefulness of science for the community whereas the agentic utility value assessed the usefulness of science for individuals. The researchers also tested the role of confidence and

utility value in mediating the relation between stereotype threat and women's intentions to pursue science research in the future. The path analysis results indicated that stereotype threat negatively related to women's confidence in science and communal science utility value. Furthermore, lower confidence in science and communal value, in turn, related to lower intentions to pursue science research in the future.

Gaps in the Literature and the Contributions of the Current Study

This study addressed multiple gaps in the literature. First, the existing expectancy-value research has more commonly focused on the proximal factors that shape expectancy and value beliefs such as goals and self-concept. Thus, there is little existing research examining the socio-cultural factors that could shape these motivational beliefs. The present study contributes to the expectancy-value literature by shedding light on the socio-cultural factors such as stereotype threats that could fundamentally influence expectancy and value beliefs in STEM courses.

Related to the gap in expectancy-value literature, there is less research on perceived costs as a component of the expectancy-value framework relative to expectancy and value beliefs. Although previous research has established some associations between stereotype threat and expectancy-value beliefs, this research has overlooked perceived costs in the analyses. Given that more recent research suggests that perceived costs are independently related to important academic outcomes (Flake et al., 2015; Gaspard et al., 2017; Perez et al., 2014; Perez et al., 2019), it is important to include perceived costs as an independent component of the expectancy-value model. Empirical studies have established associations between race-related threat and psychological constructs such as anxiety (e.g., Bosson et al., 2004; Osborne, 2001; Spencer et al., 1999), that could have implications for perceived costs. Stereotype threat is activated when one fears that one's poor performance could confirm the negative stereotypes about his or her racial

group (Steele, 1997; Steele & Aronson, 1995). This fear and anxiety may be tied to individual's anticipation of failure, which is a psychological drawback associated with engaging in the task. Therefore, it is expected that stereotype threat could potentially relate to perceptions of psychological cost in particular.

Moreover, stereotype threat is found to be associated with effort investment such that individuals who anticipate experiencing discrimination are more likely to withdraw effort and engage in self-handicapping behavior (Keller, 2002; Stone, 2002). Individuals may perceive that investing effort and time in a task is particularly costly when they expect that the outcome would nevertheless be unfavorable due to discrimination and stereotypes. Thus, stereotype threat could potentially be associated with effort cost as well. Furthermore, as students experience stereotype threat, they may cease identifying with the stereotyped domain (Spencer, 1999; Steele & Aronson, 1995; Woodcock et al., 2012). Such disidentification in turn could lead students to place less value on the stereotyped domain (Smith et al., 2015; Spencer, 1999) and more value on an alternative domain that is not associated with the threatened identity. Therefore, having to engage in the stereotyped domain and missing out on engaging in other non-threatening domains may provoke perceiving greater opportunity cost. In this study, three types of perceived costs were combined into one single cost construct and were included in the examination of the relations between the expectancy-value beliefs and stereotype threats.

Also, while prior research sheds light on the mediating role of motivation in the relation between perceived racial threat and academic outcomes, most of these studies were cross-sectional. Mediation analyses are often conducted with the aim of establishing the causal chain from the predictor to mediator and from the mediator to outcomes. Establishing causal relations requires the predictor to precede the mediator and outcome in time (Holland, 1986; Hume, 1978;

Sobel, 1990). Therefore, inferring causal (and hence mediated) relations based on cross-sectional data is limited. Longitudinal designs allow for a more rigorous examination of mediation relations than cross-sectional mediation models (Cole & Maxwell, 2003; Sobel, 1990). Accordingly, in this study, I employed a short-term longitudinal mediation design to examine the role of expectancy-value beliefs in mediating the relation between stereotype threats and academic outcomes.

I examined students' motivational beliefs and stereotype threat at three times within a semester. In STEM disciplines, a single class, particularly introductory and gateway courses, could be the difference between succeeding and earning a degree versus failing and having to drop out (Goudas & Boylan, 2012). Negative experiences in a course such as interacting with STEM faculty who believe that intelligence is an innate ability and cannot be developed negatively impacts achievement in the course particularly for students of underrepresented groups (Canning et al., 2019). On the other hand, positive experiences in a course, such as promoting feelings of belonging, improve achievement in the long run particularly for students of underrepresented groups (Walton & Cohen, 2011). Therefore, based on the type and frequency of experiences students have within a single-semester course, their motivational beliefs as well as persistence and achievement outcomes may dynamically change. Indeed, short-term longitudinal research suggests that students' expectancy and value beliefs decrease (Kosovich et al., 2017) while perceptions of stereotype bias increases over a semester in introductory and gateway courses (Cromley et al., 2013). Therefore, it is important to examine the short-term processes that could result in success or failure of students in STEM disciplines.

Last, a noticeable gap in stereotype threat research is the utilization of a unidimensional approach in studying this construct. Although recent studies suggest that individuals of

stereotyped groups experience multiple threats to their identity and despite the fact that these multiple threats are found to be qualitatively different (Shaprio, 2011; Shapiro & Neuberg, 2007), the majority of stereotype threat research has included stereotype threat as a unidimensional construct. The different dimensions of stereotype threat may operate via different mechanisms and may differ in the direction and strength of their effects on student outcomes. In this study, I incorporated a multi-dimensional approach to understanding the distinct mechanisms through which each dimension of stereotype threat affects student outcomes.

Research Questions and Hypotheses

To address the gaps in the literature the following research questions and associated hypotheses were examined in this study:

RQ1: Do African-American Students' Perceptions of Stereotype Threat Predict Their Expectancy and Value Beliefs in Science Courses After Controlling for Baseline Expectancy and Value Beliefs?

Based on experimental studies that suggest stereotype threat negatively predicts expectancies and values (e.g., Cadinu et al., 2003; Smith et al., 2015), I hypothesized that these stereotype threats would have negative longitudinal associations with self-efficacy and values after controlling for baseline levels of expectancy and value beliefs. No prior research to my knowledge has examined the associations between stereotype threat and perceived costs specifically. However, based on the existing literature on the relations between stereotype threat, anxiety, and effort (e.g., Bosson et al., 2004; Keller, 2002; Stone, 2002), I hypothesized that racial stereotype threats would positively associate with perceived costs later in the course after controlling for baseline levels of perceived costs.

RQ2: Do African-American Students' Expectancy and Value Beliefs in Science Courses Predict Their Achievement and Persistence in STEM After Controlling for Prior Achievement and Baseline Intentions to Persist?

Based on the extant correlational, experimental, and longitudinal research that suggests expectancies and values positively and perceived costs negatively relate to academic outcomes (e.g., Eccles & Wigfield, 2000; Perez et al., 2014; Robinson et al., 2019), I expected that after controlling for prior achievement and persistence intentions, self-efficacy and task values would positively and perceived costs would negatively predict STEM outcomes (achievement and persistence) at the end of the semester.

RQ3: Do African-American Students' Expectancy and Task Value Beliefs in Science Courses Mediate the Relations between Stereotype Threat and Academic Outcomes?

Based on a number of cross-sectional studies that have examined the mediating role of expectancies (e.g., Eccles et al., 2006; Cadinu et al., 2003) and values (e.g., Eccles et al., 2006; Smith et al., 2015) in the relation between race-related threats and academic outcomes, I expected that early-semester stereotype threat would lead to lower expectancy and value beliefs later in the semester and that lower motivational beliefs in turn would result in undermined end-of-semester achievement and intentions to persist in STEM. I expected associations in the opposite direction with perceived cost as the mediator; such that, stereotype threat early in the semester would be associated with higher perceptions of cost later in the course and higher perceived costs would lead to lower achievement and persistence intentions in STEM at the end of the semester.

In the next chapter, I discuss the methodology and analyses that were employed to examine the research questions.

CHAPTER III

METHOD

The main purpose of this study was to understand the relations among stereotype threats, motivational beliefs, and STEM outcomes in African-American science students. As a primary aim, I investigated the role of motivational beliefs (expectancies, values, and costs) in mediating the relations between the predictors (self- and group-reputation stereotype threat) and the outcome variables (intentions to persist in STEM and STEM achievement). To increase the rigor of the mediation analyses, the relations between stereotype threats, motivation, and STEM outcomes were assessed longitudinally over one semester. The research questions were:

1) Do African-American students' perceptions of stereotype threat predict their expectancy and value beliefs in science courses after controlling for baseline expectancy and value beliefs?
2) Do African-American students' expectancy and value beliefs in science courses predict their achievement and persistence in STEM after controlling for prior achievement and baseline intentions to persist?
3) Do African-American students' expectancy and value beliefs in science courses mediate the relations between stereotype threat and academic outcomes?

This chapter describes the methodology for this study. In the following sections, I elaborate on the research design, anticipated participants, measures, procedures, and data analyses.

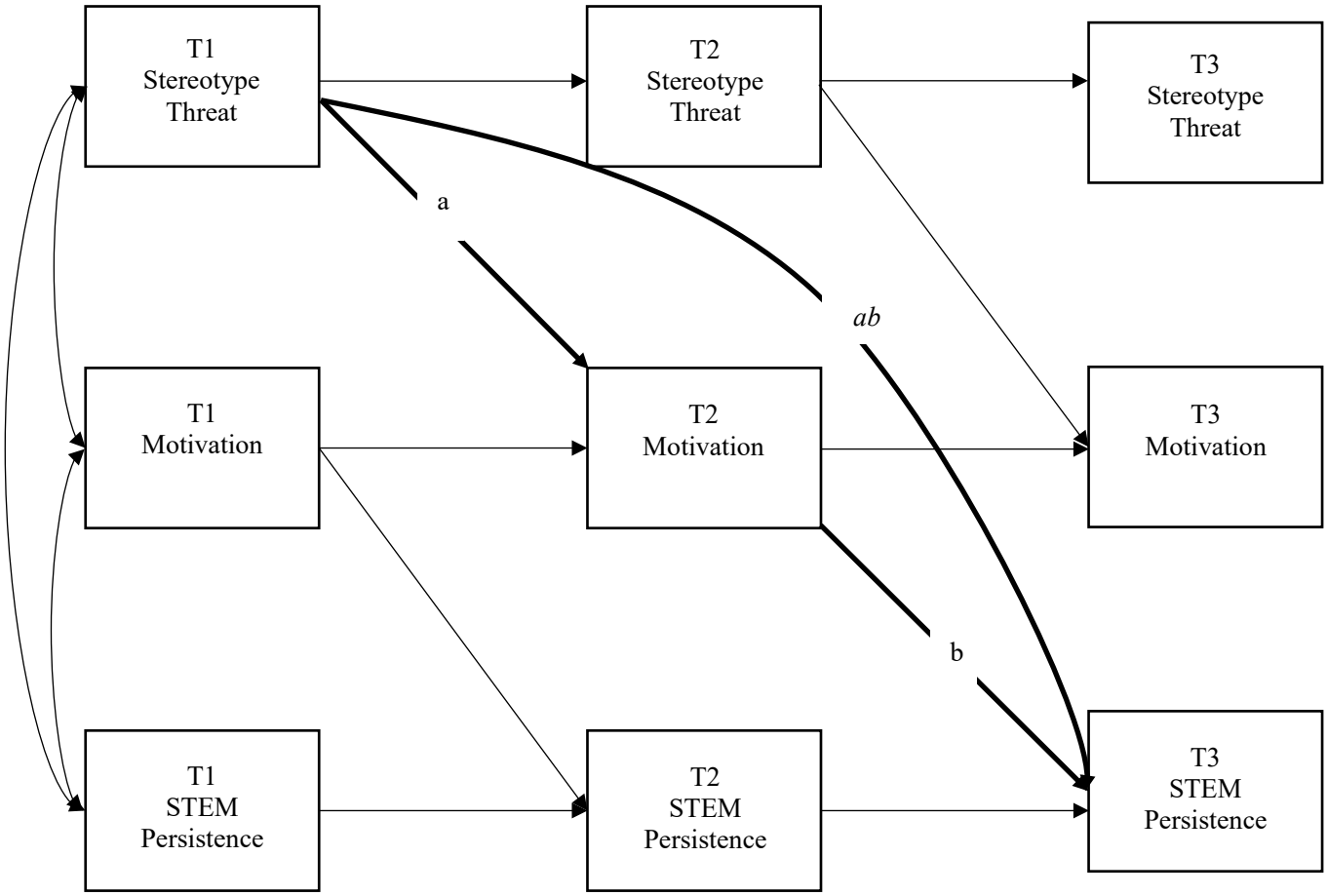
Research Design

I employed a short-term longitudinal mediation design in this study to understand the mediational role of expectancy-value motivation beliefs in the relations between stereotype threats and STEM outcomes over time. This methodology allows for an examination of the direct

paths from the predictors to mediators (X → M), the direct paths from the predictors to outcome variables (X → Y), the direct paths from the mediators to outcome variables (M → Y), and the indirect paths from the predictors to the outcome variables via the mediators (X→ M→Y). In longitudinal mediation models, all variables including predictors, mediators, and often outcome variables are assessed at all time-points. This design permits controlling for the confounding effects of the prior levels of the mediators and outcome variables (Gollob & Reichardt, 1991). Cole and Maxwell (2003) argue that inferences of causal paths can only be made under the following conditions: there is a time-lag between the predictor (assessed at time T-1) and the outcome variable (assessed at time T), and potential confound exogenous variables are controlled. Controlling for prior levels of mediators and/or outcome variables in a longitudinal design satisfies both of these conditions.

In this study, participants responded to surveys assessing stereotype threat, expectancy-value motivational beliefs, and STEM outcomes at three time-points: at the beginning (week 4), in the middle (week 8), and at the end (week 12) of a 15-week academic semester. STEM achievement was assessed only at the end of the semester. The predictors included stereotype threats (self-reputation and group-reputation threats). The mediators were self-efficacy, task values, and perceived costs, and the outcome variables were intentions to persist in STEM and final grades in the course. The direct relations between Time 1 stereotype threat and Time 2 expectancy-value beliefs were examined after controlling for the effects of T1 expectancy-value beliefs. Similarly, the direct relations between Time 2 expectancy-value beliefs and Time 3 STEM persistence and final grades were examined after controlling for the effects of Time 2 STEM persistence and prior achievement. See Figure 3.1 for the hypothesized relations among the variables.

Figure 3.1
An Example of a Longitudinal Mediation Model



Note. This model represents stereotype threat as the predictor, motivation as the mediator, and STEM persistence as the outcome variable. All variables are assessed at three time-points. The paths representing the longitudinal mediation relations are in bold. Path a represents the direct relation between the predictor and the mediator, path b represents the direct relation between the mediator and the outcome, and path *ab* represent the indirect effect from the predictor to the outcome through the mediator.

Participants

Participants were 362 African-American undergraduate students enrolled in introductory chemistry (N = 164) or biology (N = 198) courses at a minority serving university. Students in the sample ranged from 18 to 53 years of age (M_{age} = 19.60, SD = 3.27). Overall, the sample was a majority female (71.0%) with 28.5% men and 0.5% who selected "other." The majority of the sample were freshmen (37.6%) and sophomores (37.8%) and the rest were Juniors (16.9%) and Seniors (7.7%). Almost all of the students in the sample were enrolled as full-time students (93.4%) and less than half of the sample were first-generation college students (43.1%). Nearly 59.8% of the students indicated that their fathers had at least some college/community college education and 77.9% of the students indicated that their mothers had at least some college/community college education. See Table 3.1 for the demographic information for the sample.

Table 3.1

Demographic Information for the Sample

Category	*n*	Percentage
Gender		
Male	103	28.5
Female	257	71.0
Other	2	0.6
Year in College		
Freshman	136	37.6
Sophomore	137	37.8
Junior	61	16.9
Senior	28	7.7
Full-Time/Part-Time Status		
Full-Time	337	93.4
Part-Time	24	6.6
First-Generation Status		
First-generation	156	43.1
Not first-generation	206	56.9

Table 3.1 Continued

Category	*n*	Percentage
Father's Education		
Did not graduate from high school	39	10.9
Graduated from high school	105	29.3
Some college/community college	96	26.8
Bachelor's degree	60	16.8
Graduate degree	58	16.2
Did not respond	4	1.1
Mother's Education		
Did not graduate from high school	18	5.0
Graduated from high school	62	17.1
Some college/community college	13	37.8
Bachelor's degree	80	22.1
Graduate degree	65	18.0

The Context of Introductory Science Courses

When examining the stereotype threat experiences and motivational beliefs of students, it is important to understand the context within which students endure such experiences and develop motivational beliefs. Students in this study attended introductory biology and chemistry courses that were required for pursuing most STEM majors, including health sciences, offered at the institution. Therefore, it was expected that success or failure in these courses would have

direct effects on students' persistence in STEM majors and the likelihood of graduating with a STEM degree.

An examination of the students' majors revealed that a little over half of the students (approximately 54.5%) were majoring in either biology, chemistry, or biochemistry. The rest were majoring in computer science and IT (4%), engineering (10%), health sciences, including public health, human movement, physical sciences, health sciences (8%), exercise science (13%), psychology (3%), and the remaining were in oceanography, physics, sports management, earth sciences, political science, and some were undecided (7.5%). This analysis suggests that nearly half of the sample were not majoring in natural sciences such as biology or chemistry; and therefore, they might have experienced less motivation for such courses. As an example, for students who were majoring in engineering, the utility of learning about plant and animal cells might have been less tangible and thus the engineering students might have experienced higher cost associated with learning biology compared to students who were majoring in biology or biochemistry.

Another important contextual factor is the gender composition of the sample. Our prior research with science students in the target institution suggests that biology students are a majority female (Totonchi et al., 2017). Similarly, the sample of African-American science students in this study was 71% female. More specifically, 82.7 % of the biology students and 56.2 % of the chemistry students were women. This demographic composition is important to keep in mind as I examine the motivational beliefs and stereotype threat perceptions of students in science disciplines. Existing research suggests that women, compared to men, hold lower motivational beliefs in STEM disciplines (Hellman, 1996; Goldman et al., 2020). Additionally, due to the intersectionality of multiple marginalized identities, female students might experience

additional stereotype threat burdens compared to male students (Ong et al., 2011). Differences in means between men and women on stereotype threat and motivational beliefs are described in Chapter IV.

Measures

The same battery of surveys was administered at all three time-points. The surveys included: multi-dimensional stereotype threat, self-efficacy, values (intrinsic value, utility value, attainment value), perceived costs (effort, opportunity, and psychological), and intentions to persist in a STEM career (see the Appendix for all survey items). The stereotype threat and motivation constructs were adapted to assess students' beliefs in chemistry/biology science courses. Additionally, the Time 1 surveys also included demographic items. With students' consent, I collected chemistry/biology exam grades as a measure of achievement in the course. Factor analyses and Cronbach's alpha test of reliability were conducted on all measures at each time-point. To test the structural validity of the measures, confirmatory factor analyses were performed on all measures at all time-points (see the data analyses section in this chapter for the confirmatory factor analysis results). Additionally, the correlations among variables were explored to establish the construct validity of the measures at each time-point (see Chapter IV for the correlation results). The study measures are described in detail next.

Demographics

Students responded to a variety of demographic items including age, gender, ethnicity, first-generation status, family income, parent's education, year in college, and major.

Stereotype Threats

I adapted and used the multi-threat measure of racial/ethnic stereotype threat created by Shapiro (2011). This measure distinguished between the self and the group as targets of

stereotype threat. Each dimension was assessed with three items. A sample item for the self-reputation threat was: “I am concerned that because of my race, my actions in this chemistry/biology course will influence the way other people interact with me.” A sample item for the group-reputation threat included: “I am concerned that my actions in this chemistry/biology course will reinforce the negative stereotypes others have about people of my race.” Students rated their agreement with each statement on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Both of the subscales have demonstrated adequate internal reliability (α = .88 for the self-reputation threat and α = .79 for the group reputation threat) in prior research (Shapiro, 2011). In the present study, Cronbach’s alpha reliabilities for self-reputation threat at Time 1 through Time 3 were .93, .95, and .95, respectively and the Cronbach’s alpha reliabilities for group-reputation threat at Time 1 through Time 3 were .95, .97, and .97, respectively.

Self-Efficacy

Students’ self-efficacy in the science course was measured using an adapted version of the Midgley et al., (2000) perceived competence scale. The original 5-item scale has demonstrated high reliability across multiple time-points (average Cronbach’s α = .91; Totonchi et al., 2020). A sample item included: “Even if the work in this chemistry/biology course is hard, I can learn it.” Students rated their agreement with each statement on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). In this study, Cronbach’s alpha reliabilities for self-efficacy at Time 1 through Time 3 were .83, .90, and .90, respectively.

Perceived Value

Students’ interest, attainment, and utility value were assessed using an adapted version of Conley’s (2012) task value scale. Each of the value scales include 5 items and they have all demonstrated high internal reliability with undergraduate students (average Cronbach’s α for

intrinsic, attainment, and utility were respectively .93, .86, and .86; Totonchi et al., 2020). Sample items for intrinsic, attainment, and utility value respectively included "I enjoy this chemistry/biology course"; "being good in this chemistry/biology course is an important part of who I am"; and, "This chemistry/biology course will be useful for me later in life". Students rated their agreement with each statement on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). In this study, the Cronbach's alpha reliabilities at Time 1 through Time 3 were .94, .95, and .95 for intrinsic value; .84, .87, and .90 for attainment value; and .89, .90, and .91 for utility value. The Cronbach's alpha reliabilities at Time 1 through Tine 3 for the combined task value scale were .94, .95, and .96.

Perceived Costs

Perceptions of cost were assessed using an adapted version of the cost scale used in Perez and colleagues' study (Perez et al., 2019). This scale distinguished between three types of cost: effort cost (4 items), opportunity cost (4 items), and psychological cost (5 items). Previous studies have reported adequate internal reliability for these subscales (average Cronbach's α across two time-points for effort, opportunity, and psychological costs were respectively .82, .89, and .86; Perez et al., 2019). Sample items for effort, opportunity, and psychological costs respectively included: "Studying for this chemistry/biology course requires more effort than I'm willing to put in"; "I have to give up a lot to do well in this chemistry/biology course"; and, "I worry that others will think I am a failure if I do not do well in this chemistry/biology course". Students rated their agreement with each statement on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). In the present study, the Cronbach's alpha reliabilities for Time 1 through Time 3 were .74, .75, and .79 for effort cost; .85, .88, and .87 for opportunity cost; and .80, .83, and .81

for psychological cost. The Cronbach's alpha reliabilities at Time 1 through Tine 3 for the combined perceived cost scale were .85, .86, and .87.

Intentions to Persist in STEM

Students' intentions to remain in STEM majors were assessed using three items adapted from Perez and colleagues' 6-item scale that measured intensions to leave STEM (Perez et al., 2014). The researchers reported Cronbach's $\alpha = .93$ for the 6-item measure. The items used in this study included: "I am likely to leave my science major or science related track"; "I intend to switch to a major in the social sciences, arts, or humanities and/or leave my STEM-related track before I graduate or complete my program of study"; and, "I am likely to remain in my STEM-related major through to graduation or completion of my program of study." The first two items were reverse coded to indicate students' intentions to remain in STEM. Students rated their agreement with each statement on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). In the present study, the Cronbach's alpha reliabilities at Time 1 through Time 3 were .75, .75, and .77.

Institutional Data

Exam grades. With students' consent, students' grades on their final chemistry/biology exam were collected from their instructors and used as the Time 3 STEM achievement outcome variable. The scale for the final exam grades differed for chemistry and biology courses. Therefore, I computed *Z* scores for final exam grades for biology and chemistry students separately and used the *Z* scores instead of the raw final exam grades in the path models.

Prior achievement. With student's consent, their high school GPAs were collected from the institution as a measure of prior achievement. The high school GPA was on a 5.0 scale and students' grades ranged from 2.21 to 4.52.

Procedure

With instructors' permission, in the fourth week of class, I announced the study and aims to the students who were in attendance in the introductory chemistry/biology class. At the same time, all students received an invitation email to participate in the study. The email included a link to the consent form and Time 1 measures. Additionally, I asked students' permission to obtain their institutional records. Time 1 surveys included the demographic questions, stereotype threat measures, self-efficacy, task values, and perceived cost questionnaires, and persistent intentions items. Time 2 and Time 3 surveys were distributed in the eighth and twelfth week of the semester, respectively. These surveys included all the measures distributed at Time 1 except for the demographic items.

The surveys at all three time-points were delivered to students using Qualtrics (an online survey platform) and students were given one week to complete each survey. During the weeks of survey administration, students who did not complete the survey received regular reminders to complete the surveys up until the deadline. With the instructor's permission, biology participants were compensated with 5% extra-credit and chemistry students were compensated with 1% of extra credit toward their final course grade. Students who did not wish to participate in this study had the opportunity to earn an equal amount of extra credit by completing an alternative course assignment. Grades were collected from their instructors at the end of the semester. See Table 3.2 for the timeline of the data collections.

Table 3.2

Data Collection Timeline

Stage	Week	Assessment
Exam 1	3	–
Initial recruitment email and T1 surveys	4-5	Recruitment email, consent form, demographic variables, stereotype threat, motivational beliefs, and STEM outcomes surveys
Exam 2	6	–
Time 2 surveys	8-9	Stereotype threat, motivational beliefs, and STEM outcomes surveys
Exam 3	10	–
Exam 4	12	–
Time 3 surveys	12-13	Stereotype threat, motivational beliefs, and STEM outcomes surveys
Final exam	15	–

Data Analyses

This section includes an overview of the data analysis procedures used in the study including, screening for outliers, testing assumptions, handling of missing data, confirmatory factor analyses, and longitudinal measurement invariance, power analyses, intraclass correlation analyses to test the clustering effects of the instructors, descriptive statistics, and the primary analyses to address the study hypotheses and research questions.

Screening for Outliers

In order to screen for univariate outliers, I examined the values that were substantially deviant from the interquartile range (IQR) using box plots (Leys et al., 2013). After identifying 10 univariate outliers, I investigated multivariate outliers by using the Mahalanobis test. This test calculated the distance of each case from the intersection of the mean of X and Y of the other cases. Next, using the Mahalanobis distance for each case and the degrees of freedom for each test (equal to the number of variables), I calculated the *p* value for the χ^2 for each case. Significant χ^2 indicated a multivariate outlier case. I found 12 multivariate outliers, five of which were also univariate outliers. I removed all 12 outliers. After removing those 12 cases, there still remained five cases that were only univariate outliers (all for the final exam variable). I replaced them with the closest values in the dataset using the winsorize technique.

Assumption Checks

Prior to conducting the main analyses, I screened the data for potential violations of the assumptions for path modeling using SPSS version 27. These assumptions included: linearity, normality, multicollinearity, and homogeneity of variance.

Linearity. Linearity is the assumption that the relations among predictor and outcome variables should be linear (Keith, 2005). To screen for this assumption, I conducted the curve estimate analyses in SPSS. This function generates a regression line that fits the data in a scatter plot. If a non-linear regression line fits the data better than the linear line (the change in R^2 is significant when moving from a linear model to a non-linear model), this assumption is likely violated. I examined the linearity of the relations between the Time 1 predictors and the Time 2 mediators, between the Time 1 predictors and the Time 3 outcomes, and between the Time 2 mediators and the Time 3 outcomes. Results indicated that the quadratic models were significant

for all of the relations except for the relations between Time 3 outcomes and Time 1 predictors. Although the curvilinear models were significant for most relations, the changes in R^2 moving from the linear model to the curvilinear model were minimal. Therefore, I concluded that the assumption of linearity was not violated.

Normality. I explored histograms and generated probability-probability (P-P) plots for the mediator at Time 2 and outcome variables at Time 3 to screen for normality. I also calculated and reported kurtosis and skewness for these variables (results reported in Tables 4.2 and 4.3 along with the correlations and descriptives). Furthermore, the Shapiro-Wilk test was used conducted to test the data for normality assumptions. The assumption was met if the Shapiro-Wilk test yields non-significant results. Results indicated that skewness and kurtosis for all of the variables were within the normal range (values between -2.0 and +2.0 are considered acceptable and indicate a normal distribution; George & Mallery, 2010). The Shapiro-Wilk test; however, was statistically significant for Time 2 self-efficacy (statistic = .99, p = .003) and Time 3 persistence (statistic = .92, p < .001) which suggested that these two variables were not normally distributed. An examination of the histograms and P-P plots also suggested some skewness for self-efficacy and asymmetry for persistence. Due to the violation of the normality assumption, I used the maximum likelihood estimator with robust standard errors (MLR) in MPLUS. MLR estimator generates estimates that are robust to non-normal distributions.

Multicollinearity. Multicollinearity, which occurs when the predictors are strongly correlated, can lead to biased results (Keith, 2005). I tested for collinearity by examining the values for tolerance and variance inflation factor (VIF). Using Keith's guidelines (Keith, 2005), ideally, tolerance values should be close to 1 and VIF values should be smaller than 6. Collinearity can also be detected when examining the eigen values. Using guidelines by

Pedhazur (1997), eigen values that are close to zero and when variance proportions of at least two of the variables is higher than .50 could signal potential collinearity. In this study, Time 1 stereotype threats, motivation, and STEM outcomes, were predictors for the same variables at Time 2 and Time 2 variables were predictors for the same variables at Time 3. Therefore, I tested the multi-collinearity between the different combinations of stereotype threats, motivational variables, and STEM outcomes at Time 1 and Time 2. The Tolerance, VIF, eigenvalue, and variance proportion values were all within the normal range and suggested that the multi-collinearity assumption was not violated.

Homogeneity of variance. Lastly, to test for homogeneity of variance I first computed the Z-scores for each variable and then I generated scatterplots of the residual and predicted values for these Z-scores. Inspecting the shape of the scatterplots suggested that the random disturbance in the relation between the predictors (including mediators) and outcome variables were the same across all values of the predictors. Therefore, I concluded that the assumption of homogeneity of variance was not violated.

Missing Data

Full information maximum likelihood estimation (FIML) was used to account for missing data. FIML handles missing data by using all available data to estimate the model rather than imputing missing values (Davey & Savla, 2010). FIML assumes that data are either missing completely at random (MCAR) or missing at random (MAR), suggesting that the missingness is not related to the missing values. MCAR is the only mechanism that can be tested and ruled out effectively (Enders, 2011). The missingness may be at random or not at random. Enders (2013) suggest that if the data is MAR, using Maximum Likelihood (ML) estimation may help with reducing the influence of missingness by maximizing the probability of capturing what has been

observed. If the missingness is not MCAR and is related to a particular variable, that variable must be entered as an auxiliary variable in all of the models. I conducted the Little's MCAR missing completely at random test for all of the variables at all three time-points. I used gender and first-generation status as the categorical variables for the analyses and selected the Expectation Maximization function to calculate the means and covariances for missingness in the variables. Results suggested that the variables had between 16.6% to 22.3% missing values; however, these data were likely missing completely at random based on the non-significant Little MCAR's results, χ^2 (220) = 244.24, p = .126. Therefore, I proceeded with using FIML as a means of handling missing data for the path analyses.

Confirmatory Factor Analyses

Confirmatory factor analyses (CFA) were conducted to test the construct validity of the scales. Fit indices including chi-square (χ^2), comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR) were examined to determine whether the model fit the data. Using Hu and Bentler's (1999) guidelines for CFA fit indices, the model fits data excellently if the chi-square is non-significant, RMSEA is smaller than .06, CFI is greater than .95, and SRMR is smaller than .08. The model fits the data adequately if CFI is greater than .90, RMSEA is smaller than .08, and SRMR is smaller than .08. See Table 3.3 for the CFA results.

Stereotype threat. I conducted CFA analyses on the two-dimensional stereotype threat measure (self-reputation vs group-reputation threat) at each time-point. Results indicated that the two-dimensional model fit the data excellently at all three time-points and the standardized factor loadings for the items were greater than .82 across the three time-points. These results suggested that participants distinguished between self-reputation and group-reputation threat and that this

two-dimensional measure of stereotype threat demonstrated structural validity at all three time-points.

Self-Efficacy. The results of the CFA suggested acceptable values for CFI and SRMR but unacceptably large RMSEA values at Time 1 and Time 3. An investigation of the modification indices suggested that the residuals for one of the items "I'm certain I can master the skills taught in this chemistry/biology course" was highly correlated with the residuals for other items in the measure. This item, however, had the lowest mean-level correlations with the other items in the measure (*r*s between .26 and .36) and explained the lowest amount of variance (R^2 = .36) in self-efficacy, compared to the other items. Therefore, I removed this item and conducted the CFA analyses with the remaining four items. Results demonstrated excellent fit for the revised measure at all three time-points. The standardized factor loadings for the items were above .73 across the three time-points. The Cronbach's alpha reliabilities for the 4-item measure were .83, .89, and .90 at Time 1 through Time 3, respectively.

Task values. I conducted a second-order CFA for task values, which included a second-order task value factor and three first-order factors including intrinsic, attainment, and utility values at Times 1 through 3. Results suggested adequate fit at all three time-points, suggesting that the three different task values all corresponded to a task value second-order factor. Therefore, combining the three task values into one task value variable was appropriate. The standardized factor loadings for the items were greater than .58 across the three time-points. The standardized factor loadings for the second-order factor were greater than .72.

Costs. I conducted a second-order CFA for task values, which included a second-order task value factor and three first-order factors including intrinsic, attainment, and utility values at Times 1 through 3. Results suggested poor fit as indicated by CFI < .90. An investigation of

modification indices suggested that an effort cost item "I am not sure I have the energy to do well in this chemistry/biology course" was strongly cross-loading on the psychological cost factor and was highly correlated with the opportunity and psychological cost items. Also, a psychological cost item "doing poorly in this chemistry/biology course would make me feel bad about myself" had low factor loadings (.33 at Time 1) and was cross-loading on the effort cost factor. I removed the problematic effort cost and psychological cost items in that order and achieved acceptable fit for the cost factor at Times 1 through 3. The standardized factor loadings for the items across all three time-points were larger than .56. The standardized factor loadings for the second-order factor were greater than .58. Further, the Cronbach's alpha reliabilities for the combined cost measure after removing the two problematic items were .84, .88, and .88 at Time 1 through Time 3, respectively.

Persistence in STEM. I conducted CFAs on the 3-item persistence measure at all three time-points. Since the models were just-identified, fits statistics were not available for the CFAs. However, the standardized factor loadings for the items (> .66 across all three time-points) and medium-sized correlations between the items (ranged between .47 and .56) suggested that the measure has good structural validity.

Table 3.3

Results of the Confirmatory Factor Analysis for the Study Variables at Each Time-Points

Variable	Time-Point	Fit Statistics			
		χ^2 (df)	CFI	RMSEA	SRMR
Stereotype Threat (two-dimensions)					
	T1	6.22 (8)	1.00	.00	.01
	T2	13.24 (8)	.99	.05	.01
	T3	13.11 (8)	.99	.05	.02
Self-Efficacy					
	T1	22.83** (5)	.94	.11	.04
Self-Efficacy (dropped one item)					
	T1	1.34 (2)	1.00	.00	.01
	T2	1.58 (2)	1.00	.00	.01
	T3	6.46* (2)	.99	.09	.02
Values (second order)					
	T1	268.17** (87)	.93	.08	.05
	T2	206.44** (87)	.94	.07	.05
	T3	245.70** (87)	.94	.08	.05

Table 3.3 Continued.

Variable	Time-Point	Fit Statistics			
		χ^2 (df)	CFI	RMSEA	SRMR
Cost (second order)					
	T1	180.88** (62)	.89	.08	.07
Cost (second order, dropped one effort cost item)					
	T1	129.43** (51)	.92	.07	.06
	T2	112.26** (51)	.95	.06	.06
	T3	145.20** (51)	.90	.08	.07
Cost (second order, dropped one effort cost and one psychological cost item)					
	T1	78.20** (41)	.96	.06	.05
	T2	85.77** (41)	.96	.06	.06
	T3	87.03** (41)	.94	.06	.05

Note. Model fit was considered acceptable if CFI > .90, RMSEA < .08, and SRMR <.08 (Hu & Bentler, 1999).
For self-efficacy, the 5-item measure yielded a RMSEA > .08. Therefore, based on modification indices one item was dropped which significantly improved the fit statistics. For second-order cost measure, CFI was smaller that .90. Modification indices suggested that an effort cost item and a psychological cost item were problematic. First, I dropped the effort cost item and CFI improved to .90. I suspected that this marginal CFI would not hold in the future measurement invariance models. Therefore, I also dropped the mentioned psychological item which significantly improved the fit statistics.
* $p < .05$; ** $p < .001$

Longitudinal Measurement Invariance

With any longitudinal design, measurement invariance should be tested to investigate whether each construct is psychometrically equivalent across time. Following guidelines by Bialosiewicz, Murphy, and Berry (2013), I first established configural invariance (baseline model). The configural invariance model indicates whether the model structure for each scale remains the same across the three time-points. Configural invariance is established if the same indicators load onto the same latent construct at each time-point. Next, I tested for metric invariance (weak invariance) to investigate whether factor loadings are the same across the three time points. Metric invariance is established if the change in fit indices, moving from configural to metric invariance models, is trivial. The change in model fit for the metric invariance is considered trivial if the change in CFI is $\leq .01$ for sample sizes $\geq$ 300 (Chen, 2007). Lastly, scalar invariance (strong) examines whether the intercepts are equal across the three time points. The change in model fit for the scalar invariance is considered trivial if the change in CFI is $\leq .01$ for sample sizes $\geq$ 300 (Chen, 2007).

Existing longitudinal research has shown that the more conservative tests of measurement invariance (i.e., scalar) are often not met. Little (2013) explains that the strictness of meeting the measurement invariance assumption should depend on the goals of the study. He argues that research questions that examine the behavior of a variable over time (e.g. growth curve models) require meeting more strict measurement invariance rules; whereas, research questions that address the effect of one variable on another over time (like the autoregressive mediation model for this study) may require less conservative statistical tests. Therefore, while I tested for up to scalar invariance, establishing weak measurement invariance was adequate for this study. See Table 3.4 for the measurement invariance results.

Stereotype threat. The two-dimensional measure of stereotype threat demonstrated measurement invariance as forcing factor loadings (metric invariance) and item intercepts (scalar invariance) to be equal across time did not lead to a significantly worse model fit.

Self-efficacy. The four-item self-efficacy measure demonstrated measurement invariance as forcing factor loadings (metric invariance) and item intercepts (scalar invariance) to be equal across time did not lead to a significantly worse model fit.

Task values. Results of the second-order configural model suggested adequate model fit, χ^2 = 1849.57 (888), CFI = .90, RMSEA = .06, SRMR = .06. Given the relatively low CFI (CFI = .90) for the configural model, I examined the modification indices. An examination of the modification indices suggested that the residuals for two intrinsic value items should be correlated to achieve better model fit. After reviewing the two items, which were, "I like this chemistry/biology course" and "I enjoy this chemistry/biology course", I concluded that the two items were similar in content and language and thus it was appropriate to correlate them. After correlating the residuals for the mentioned items, I conducted a second-order measurement invariance on the combined task value construct. Holding factor loadings (metric invariance) and item intercepts (scalar invariance) equal across time did not lead to a significantly worse model fit, suggesting that task values demonstrated longitudinal measurement invariance.

Costs. Results of the second-order configural model suggested poor model fit, χ^2 = 925.87 (450), CFI = .88, RMSEA = .05, SRMR = .08. Modification indices suggested that the residuals for two sets of opportunity cost items should be correlated. The two sets were: (1) "I am concerned that I have to give up a lot to do well in this chemistry/biology course" and "This chemistry/biology course takes a lot of time away from other activities that I want to pursue" as well as (2) "I am concerned success in this chemistry/biology course requires that I give up other

activities that I enjoy" and "I am concerned about losing track of some valuable relationships because of the work required for this chemistry/biology course." After correlating these sets of items, the configural model still did not demonstrate acceptable fit as the value for CFI was smaller than .90. Modification indices further suggested correlating the residuals for two sets of psychological cost items: (1) "I am concerned about being embarrassed if my work in this chemistry/biology course is inferior to that of my peers" and "I feel that I am not a good enough student to do well in this chemistry/biology course." After correlating the residuals for these items, the CFI for the configural model increased but was still slightly below the .90 acceptable level. Next, based on modification indices, I correlated the residuals for one set of effort cost items: "The hard work needed to get through this chemistry/biology course will not be worth it in the end" and "for me taking this chemistry/biology course is not worth the effort." These two items clearly tapped into the same construct as they both assessed students' perceptions of the worthiness of one's efforts. After correlating the residuals for this set of items I was able to achieve acceptable fit for the configural model. I then conducted the metric and scalar measurement invariance. Although the CFI values for the metric and scalar models were slightly lower than .90, the change in CFI moving from configural to metric and from metric to scalar models was smaller than .01. Therefore, I concluded that second-order longitudinal measurement invariance was achieved for the cost measure.

Table 3.4

Longitudinal Measurement Invariance for the Study Variables

Variable	χ^2 (df)	CFI	ΔCFI	RMSEA	SRMR
Stereotype threats					
Configural	155.80** (120)	.987	–	.03	.02
Metric	170.07** (128)	.985	-.002	.03	.03
Scalar	181.132** (136)	.984	-.001	.03	.03
Self-efficacy					
Configural	95.85** (51)	.964	–	.05	.04
Metric	103.94** (57)	.962	-.002	.05	.05
Scalar	120.72** (63)	.954	-.008	.05	.06
[1]Task values (second order)					
Configural	1771.31** (885)	.909	–	.05	.07
Metric	1839.98** (909)	.904	-.005	.05	.07
Scalar	1907.32** (933)	.900	-.004	.05	.07
[2]Costs (second order)					
Configural	839.97** (431)	.900	–	.05	.08
Metric	857.30** (447)	.899	-.001	.05	.08
Scalar	890.10** (463)	.895	-.004	.05	.08

Note. [1]Modification indices suggested that the residuals for two intrinsic value items should be correlated to achieve acceptable model fit. Since the two items were very similar, I correlated the residuals for the two items at all three time-points and achieved acceptable fit for the configural model.
[2]Modification indices suggested that one set of effort cost items, two sets of opportunity costs items, and two sets of psychological cost items should be correlated to achieve acceptable fit. I correlated the recommended residuals and achieved CFI > .90 for the configural model.
Note. * $p < .05$; ** $p < .001$

Testing the Clustering Effects of Instructors

Since students were nested within different biology and chemistry sections, I calculated intraclass correlations (ICC) to examine the percentage of the total variance in motivational beliefs, intentions to persist in STEM, and exam grades that was due to differences between instructors (one biology instructor and three chemistry instructors). To do this, I conducted a series of mixed models ANOVA where I indicated the instructor variables as the clustering variable and each of the motivation variables, STEM persistence, and final exam grades as the dependent variables. Next, I computed the ICCs by dividing the variance of the random intercept by the sum of the variance parameter estimates. A high ICC ($\rho > .05$; LeBreton & Senter, 2008) indicates that the differences between students on dependent variables (motivation and STEM outcomes) are at least partially explained by students' having different instructors. Results indicated that the ICCs for task values and costs were greater than .05 at all three time points (ICC reached .05 for self-efficacy at Time 2), which indicated significant clustering effects of instructors. See Table 3.5 for the ICC results. Therefore, in all of the path models, the instructor variable was entered as a stratification variable to adjust the standard errors for the non-independence of observations.

Table 3.5

Intraclass Correlations with Instructors as the Clustering Variable

	ICC		
Variable	Time 1	Time 2	Time 3
Self-Efficacy	.03	.05	.03
Task Values	.14	.12	.12
Costs	.12	.10	.05
Persistence Intentions	.02	.01	.01
Final Exam	–	–	.03

Descriptive Analyses

Using SPSS (version 27), I computed means and standard deviations for each variable and examined the Pearson correlations among the variables at each time-point. Investigating the bivariate associations among variables assisted in establishing the construct validity of the measures, as well as screening for issues such as multicollinearity and suppression effects. Results are presented in Chapter 4.

Data Analytic Strategy

I examined the relations between the predictors (self- and group- reputation stereotype threat) and the outcome variables (intentions to persist and STEM achievement) via the influence of the mediators (self-efficacy, values, and costs) using longitudinal mediation analysis. The three values variables were combined to create a composite task value scale and the three perceived costs were combined to create a composite perceived costs scale. This strategy has been employed in prior expectancy-value studies (e.g., Jiang et al., 2018). I used the composite

task values and perceived costs scales because the main purpose of this study was to understand the dynamics of the relationship between socio-cultural factors such as stereotype threat and African-American students' value and costs beliefs broadly. The specific relations between the different types of task values and perceived costs and stereotype threat were not the primary interest in this study. Furthermore, using composites of these variables allowed for more parsimonious models with fewer parameters to estimate, which was necessary to accommodate the anticipated sample size. Differences between men and women in outcome variables (grades and STEM persistence) were controlled for by including gender as a covariate in all models. This inclusion was grounded in existing literature that suggests meaningful differences between male and female students in STEM achievement and persistence favoring male students (Chen, 2013; Griffith, 2010).

The longitudinal mediation model allowed for examining the direct effects of stereotype threats on motivation after controlling for prior levels of motivation (path *a*), the direct effect of motivation on STEM outcomes after controlling for prior levels of STEM outcomes (path *b*), and the indirect effects of stereotype threats on STEM outcomes through motivation after controlling for prior levels of motivation and STEM outcomes (path *ab*). Due to the large number of parameters in autoregressive models and to retain the adequate power required for conducting the analyses, I tested 12 separate models with each model including only one predictor, one mediator, and one outcome variable. Figure 3.2 represents an example of the longitudinal mediational path model with stereotype threat as the predictor, motivation as the mediator, and STEM persistence as the outcome variable. Analyses were conducted in Mplus (version 7.3; Muthen & Muthen, 1998-2014).

Power analysis. Prior to data collection, I conducted a power analysis using Monte Carlo simulations. Using the existing data from a prior study, which included similar variables, I first computed the regression estimates for each path as well as the covariances between the variables. The regression estimates based on the existing data suggested that the effect size for each path is small ($B < .12$; Cohen, 1969). Then I used the obtained estimates and covariances to calculate the power for each path. Setting the sample size at 450 and using 10,000 bootstrap iterations, I achieved the desired power of .80 and above for most of the regression paths. Therefore, I concluded that conservatively, data from 450 participants should be collected to yield sufficient power to conduct each autoregressive path model. Unfortunately, I was able to collect data from only 362 participants. Using the current data and specifying the sample size to be 362 (current study's sample size), Monte Carlo simulation results indicated that power for three regression paths of interest were below .80. These paths included Time 1 stereotype threats → Time 3 persistence intentions (.25), Time 1 stereotype threats → Time 2 motivational variables (.67), and the indirect path from stereotype threats to persistence intentions through motivational variables (.58). Insufficient power might have resulted in some significant relations and effects remaining undetected. This possibility is discussed in the Limitations section in chapter 5.

Analyses to Address the Research Questions:

RQ 1-3) Relations Among Stereotype Threat, Self-Efficacy, Values, Costs, Intentions to Persist in STEM, and Grades Over the Course of a Semester

The study research questions were examined using a series of autoregressive longitudinal mediational path analyses (see Figure 3.2). The first research question, "do African-American students' perceptions of stereotype threat predict their expectancy and value beliefs in science courses after controlling for baseline expectancy and value beliefs?" was addressed by

examining path *a* in twelve longitudinal mediation models. Multiple paths from each predictor at Time 1 (self-reputation threat and group-reputation threat) to each mediator at Time 2 (self-efficacy, task values, and perceived costs) were examined while controlling for the mediators at Time 1.

The second research question: "do African-American students' expectancy and value beliefs in science courses predict their achievement and persistence in STEM after controlling for prior achievement and baseline intentions to persist?" was addressed by examining path *b* in the mediation model. Multiple paths from each mediator at Time 2 (self-efficacy, task values, perceived costs) to each outcome variable at Time 3 (intentions to persist in STEM and science exam grades) were examined after controlling for Time 2 intentions to persist in STEM and high school GPA.

Finally, the third research question: "do African-American students' expectancy and value beliefs in science courses mediate the relations between stereotype threat and academic outcomes?" was addressed by examining path *ab* in the mediation model. Multiple indirect paths from each predictor assessed at Time 1 to each outcome variable assessed at Time 3 through each mediator assessed at Time 2 were examined. When examining the indirect paths, the prior levels of mediators at Time 1 and the prior levels of outcome variables at Time 1 and 2 were controlled. The significance of the indirect effects was tested by using the INDIRECT command in Mplus. I requested bootstrapped confidence intervals in these analyses to indicate the significance of the indirect effect. The traditional null hypothesis significance test (*p* values) does not provide reliable results for indirect effects since null hypothesis significance tests are valid only when the assumption of normal distribution is met. Having two different paths involved in the indirect effect analysis, the assumption of normality is usually never met (Preacher & Hayes,

2008). Using the bootstrapping technique, Mplus calculates a range of confidence intervals. I used the 95% confidence interval to assess significance of indirect effects. I concluded that the indirect effect is significant at $\alpha = .05$ if the confidence intervals did not include a zero (see Figure 3.2 for the structural paths).

To investigate whether the data fit the hypothesized model, I examined the χ^2, CFI, RMSEA, and SRMR fit indices. Using Hu and Bentler's (1999) guidelines, a good fit is achieved if the χ^2 is non-significant, CFI is greater than .95, RMSEA is smaller than .06, and SRMR is smaller than .08. Since χ^2 is very sensitive to changes in sample size, many researchers including Little (2013) have recommended to examine other fit indices such as CFI when achieving a significant χ^2. Analyses were conducted in Mplus (version 7.3; Muthen & Muthen, 1998-2014).

CHAPTER IV

RESULTS

Descriptive Statistics

Descriptive statistics including the means, standard deviations, skewness, and kurtosis for variables at each wave of data are presented in Tables 4.1 through 4.3. At Time 1, students had relatively low self-reputation and group-reputation threat. Interestingly, students seemed to have higher group-reputation threat than self-reputation threat. Students reported average levels of self-efficacy and values, relatively low levels of cost, and high levels of persistence intentions.

Table 4.1

Descriptive Statistics for Variables at Time 1.

Variable	*N*	*M* (*SD*)	Skewness	Kurtosis
Self-Threat	291	1.96 (.89)	.48	-.74
Group-Threat	291	2.16 (1.03)	.45	-.81
Self-Efficacy	291	3.92 (.66)	-.25	-.64
Values	291	3.73 (.74)	-.52	.16
Cost	291	2.72 (.71)	-.09	-.48
Persistence Intentions	290	4.00 (.80)	-.28	-1.02
High School GPA	309	3.34 (.43)	.11	-.52

Note. Self-Threat = self-reputation threat; Group-Threat = group-reputation threat.

At Time 2, the patterns of means for the variables remained roughly the same; however, students' perceptions of self-reputation, group-reputation threat, and cost increased over time whereas their perceptions of self-efficacy, and values decreased. Based on the skewness and kurtosis results, variables appeared to be normally distributed.

Table 4.2

Descriptive Statistics for Variables at Time 2.

Variable	*N*	*M* (*SD*)	Skewness	Kurtosis
Self-Threat	274	2.00 (.91)	.61	-.10
Group-Threat	274	2.21 (1.06)	.44	-.73
Self-Efficacy	277	3.74 (.72)	-.22	-.15
Values	277	3.53 (.77)	-.33	-.28
Cost	277	2.80 (.71)	-.20	-.20
Persistence Intentions	276	3.77 (.86)	-.16	-.70

Note. Self-Threat = self-reputation threat; Group-Threat = group-reputation threat.

At Time 3, the patterns of means remained roughly the same as Time 1. Means also seemed to have decreased slightly for self-efficacy and values and increased slightly for group-reputation and cost since Time 2. These mean change patterns are also found in prior short-term longitudinal research that suggests expectancies and values decrease (Kosovich et al., 2017) while stereotype bias increases over a semester (Cromley et al., 2013). Additionally, results of repeated measures ANOVA suggested that there were significant mean differences across the three time-points for group-reputation threat, F (2, 404) = 3.69, p = .026, self-efficacy, F (2, 404) = 15.54, p < .001, task values, F (2, 408) = 23.00, p < .001, costs, F (2, 408) = 5.08, p = .007, and persistence intentions, F (2, 404) = 15.54, p < .001. However, self-reputation threat did not change significantly over the semester. These results suggest that motivational beliefs, group-reputation stereotype threat, and persistence intentions changed within a semester. The skewness and kurtosis results suggested that all of the variables at Time 3 were distributed normally.

Table 4.3

Descriptive for Variables at Time 3.

Variable	*N*	*M* (*SD*)	Skewness	Kurtosis
Self-Threat	271	2.00 (.91)	.67	-.14
Group-Threat	271	2.24 (1.08)	.58	-.42
Self-Efficacy	273	3.64 (.78)	-.21	-.32
Values	273	3.49 (.84)	-.40	-.11
Cost	273	2.82 (.74)	-.08	-.23
Persistence Intentions	272	3.72 (.89)	-.08	-.68
Final Exam	293	56.31 (16.41)	-.02	.38

Note. Self-Threat = self-reputation threat; Group-Threat = group-reputation threat. Final exam is on a 100-point scale.

Prior research suggests that women, compared to men, and first-generation students, compared to continuing generation students, report lower motivational beliefs in STEM disciplines. Specifically, male students indicate higher math self-efficacy (Nagy et al., 2008) and report higher interest in math (Frenzel et al., 2010, Watt, 2004) compared to female students. Similarly, first-generation students report lower self-efficacy (Hellman, 1996) and higher perceptions of costs (Goldman et al., 2020) compared to continuing generation students. Additionally, studies that have examined the intersectionality of gender and race have found that female, compared to male, students of color bear additional stereotype threat burdens (Ong et al., 2011) because they have two identities (gender and race) that are marginalized in STEM contexts. Similar to women, African-American first-generation, compared to continuing-generation, students may be more vulnerable to stereotypes because, besides being racially marginalized, they may also face financial and cultural challenges and may not have the same background and preparation (Bowen et al., 2005). Since these intersectional identities are important, Tables 4.4 through 4.6 include descriptive statistics for variables of interest for men, women, first-generation, and continuing-generation African-American students separately for times 1 through 3. However, I was unable to examine intersectionality in my primary analyses due to sample size restrictions.

Table 4.4

Time 1 Variable Descriptives for Female, Male, First-Generation, and Continuing-Generation Students Separately

	Female		Male		First-Gen		Cont-Gen		Fem/First-Gen		Male/Cont-Gen	
Variable	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)
Self-Threat	208	1.90 (.85)	82	2.14 (.95)	131	1.90 (.87)	160	2.01 (.90)	102	1.81 (.82)	29	2.21 (.97)
Group-Threat	208	2.07 (1.02)	82	2.38 (1.01)	131	2.15 (1.02)	160	2.16 (1.03)	102	2.01 (.99)	29	2.66 (1.00)
Self-Efficacy	208	3.92 (.68)	82	3.93 (.61)	131	3.93 (.63)	160	3.92 (.69)	102	3.95 (.63)	29	3.88 (.65)
Values	208	3.81 (.73)	82	3.53 (.74)	131	3.72 (.74)	160	3.74 (.74)	102	3.77 (.72)	29	3.53 (.76)
Cost	208	2.67 (.73)	82	2.86 (.64)	131	2.68 (.71)	160	2.76 (.70)	102	2.60 (.73)	29	2.96 (.57)
Persistence	207	3.98 (.80)	82	4.05 (.80)	131	4.03 (.79)	159	3.98 (.81)	102	4.03 (.76)	29	4.03 (.89)

Note. Self-Threat = self-reputation threat; Group-Threat = group-reputation threat. First-Gen = first-generation student; Cont-Gen = continuing-generation student.

Table 4.5

Time 2 Variable Descriptives for Female, Male, First-Generation, and Continuing-Generation Students Separately

	Female		Male		First-Gen		Cont-Gen		Fem/First-Gen		Male/Cont-Gen	
Variable	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)
Self-Threat	201	2.01 (.93)	71	1.99 (.88)	123	1.99 (.90)	151	2.00 (.92)	100	1.97 (.93)	23	2.12 (.80)
Group-Threat	201	2.17 (1.08)	71	2.35 (1.01)	123	2.21 (1.03)	151	2.20 (1.09)	100	2.16 (1.08)	23	2.42 (.73)
Self-Efficacy	204	3.76 (.73)	71	3.68 (.70)	123	3.71 (.75)	154	3.77 (.69)	100	3.75 (.76)	23	3.53 (.70)
Values	204	3.60 (.78)	71	3.33 (.73)	123	3.50 (.77)	154	3.56 (.77)	100	3.52 (.79)	23	3.41 (.69)
Cost	204	2.76 (.71)	71	2.92 (.72)	123	2.79 (.76)	154	2.81 (.67)	100	2.76 (.78)	23	2.91 (.70)
Persistence	203	3.75 (.86)	71	3.79 (.87)	123	3.78 (.88)	153	3.76 (.85)	100	3.76 (.85)	23	3.88 (1.01)

Note. Self-Threat = self-reputation threat; Group-Threat = group-reputation threat. First-Gen = first-generation student; Cont-Gen = continuing-generation student.

Table 4.6

Time 3 Variable Descriptives for Female, Male, First-Generation, and Continuing-Generation Students Separately

	Female		Male		First-Gen		Cont-Gen		Fem/First-Gen		Male/Cont-Gen	
Variable	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)
Self-Threat	194	1.95 (.86)	75	2.14 (1.05)	118	2.00 (.93)	153	2.01 (.91)	94	1.87 (.87)	24	2.51 (.96)
Group-Threat	194	2.17 (1.03)	75	2.46 (1.19)	118	2.17 (.99)	153	2.30 (1.15)	94	2.05 (.95)	24	2.67 (1.03)
Self-Efficacy	196	3.67 (.77)	75	3.60 (.81)	118	3.63 (.74)	155	3.66 (.81)	94	3.69 (.74)	24	3.41 (.75)
Values	196	3.56 (.85)	75	3.29 (.82)	118	3.49 (.84)	155	3.49 (.85)	94	3.53 (.85)	24	3.31 (.82)
Cost	196	2.81 (.78)	75	2.88 (.64)	118	2.79 (.81)	155	2.86 (.69)	94	2.77 (.86)	24	2.87 (.56)
Persistence	195	3.73 (.90)	75	3.67 (.87)	118	3.78 (.89)	154	3.66 (.89)	94	3.79 (.93)	24	3.76 (.71)
Final Exam	204	55.50 (16.61)	87	57.89 (15.92)	127	53.49 (17.16)	166	58.47 (15.53)	98	53.61 (16.60)	29	53.07 (19.22)

Note. Self-Threat = self-reputation threat; Group-Threat = group-reputation threat. First-Gen = first-generation student; Cont-Gen = continuing-generation student. Final exam is on a 100-point scale.

Correlations

Correlations within each time-point

Zero-order correlations among the variables within each time-point were in the expected direction and are presented in Table 4.7. Within each time-point, self-reputation and group-reputation threat correlated strongly. Also, within each time-point, self-efficacy and task values correlated positively and strongly. On the other hand, self-efficacy and costs correlated negatively and highly. Task values and costs correlated negatively and moderately. As anticipated, persistence intentions were positively correlated with task values and self-efficacy and negative correlated with perceived costs (these relations were moderate). Persistence was also moderately and negatively related to self-reputation and group-reputation threat across all three time-points. Final exam grades were positively related to Time 3 self-efficacy and task values and negatively related to Time 3 perceived costs.

Correlations between Time-Points

In this section, I discuss the correlations among stereotype threat indicators at Time 1, motivational variables (i.e., self-efficacy, task values, and perceived costs) at Time 2, and persistence intentions and final exam scores at Time 3. Both self-reputation and group reputation threat at Time 1 negatively and moderately related to Time 2 self-efficacy, negatively and weakly correlated with Time 2 task values, and positively and moderately correlated with Time 2 perceived costs. Additionally, self-reputation threat negatively and weakly correlated with Time 3 persistence intentions. Neither self-reputation threat nor group-reputation threat at Time 1 correlated with final exam grades.

The correlations between Time 2 motivational variables and Time 3 academic outcomes were in the expected direction. Time 2 self-efficacy and task values were positively and

moderately related to Time 3 persistence intentions and final exam grades. On the other hand, Time 2 perceived costs were negatively and moderately related to Time 3 persistence intentions and final exam grades. Across the three motivational variables, relations with persistence seemed to be stronger than relations with final exam grades.

Table 4.7

Correlations Among Variables at Each Time-Point

		1	2	3	4	5	6	7	8	9	10	11	12	13
T1	1. Self ST	–												
	2. Group ST	.64**	–											
	3. Efficacy	-.24**	-.25**	–										
	4. Values	-.15**	-.17**	.56**	–									
	5. Cost	.29**	.38**	-.47**	-.38**	–								
	6. Persist	-.23**	-.20**	.33**	.24**	-.34**	–							
	7. HS GPA	-.01	-.05	-.02	-.09	.01	.18**	–						
T2	8. Self ST	.53**	.51**	-.21**	-.12	.25**	-.19**	-.06	–					
	9. Group ST	.47**	.65**	-.21**	-.16*	.33**	-.13*	-.14*	.71**	–				
	10. Efficacy	-.24**	-.24**	.61**	.59**	-.48**	.44**	.06	-.21**	-.25**	–			
	11. Values	-.21**	-.18**	.49**	.85**	-.42**	.40**	-.004	-.11	-.10	.62**	–		
	12. Cost	.27**	.29**	-.37**	-.43**	.70**	-.27**	-.07	.26**	.32**	-.53	-.43**	–	
	13. Persist	-.15*	-.09	.31**	.39**	-.19**	.62**	.18**	-.16**	-.10	.45**	.40**	-.33**	–

Table 4.7 Continued.

		1	2	3	4	5	6	7	8	9	10	11	12	13
T3	14. Self ST	.40**	.43**	-.10	.03	.21**	-.15*	.01	.55**	.50**	-.19**	-.02	.24**	-.05
	15. Group ST	.37**	.64**	-.14*	-.08	.35**	-.17**	-.05	.42**	.64**	-.25**	-.13*	.37**	-.05
	16. Efficacy	-.18**	-.19**	.57**	.53**	-.42**	.36**	.10	-.03	-.14**	.63**	.48**	-.47**	.41**
	17. Values	-.09	-.05	.46**	.81**	-.35**	.24**	-.03	.03	-.03	.54**	.81**	.42**	.37**
	18. Cost	.19**	.22**	-.33**	-.36**	.61**	-.28**	-.15*	.17*	.29**	-.47**	-.36**	.74**	-.25**
	19. Persist	-.16*	-.06	.32**	.38**	-.18**	.54**	.28**	-.08	-.11	.44**	.37**	-.35**	.67**
	20. Fin Exam	-.04	-.01	.12	.14*	-.16*	.26**	.31**	.02	-.04	.31**	.22**	-.28**	.29**

Table 4.7 Continued.

		14	15	16	17	18	19	20
T3	14. Self ST	–						
	15. Group ST	.60**	–					
	16. Efficacy	-.21**	-.20**	–				
	17. Values	.02	-.02	.64**	–			
	18. Cost	.15*	.29**	-.47**	-.36**	–		
	19. Persist	-.09	-.13*	.49**	.45**	-.41**	–	
	20. Fin Exam	-.02	-.05	.34**	.23**	-.32**	.29**	–

Note. Self ST = Self-reputation threat; Group ST = Group-reputation threat; Efficacy = Self-efficacy; HS GPA = High school GPA; Persist = Persistence intentions; Fin Exam = Final Exam.
* $p < .05$; ** $p < .001$

Primary Analyses

In this section, I discuss the results of the analyses that were conducted to address the main research questions. Due to the large number of parameters per model and the relatively small sample size, 12 separate longitudinal mediation path models were conducted, each including one predictor, one mediator, and one outcome variable. Refer to Table 4.8 for a list of the mediation models examined in this study. Entering the variables in separate models led to some redundancy in the examined relations. For example, the relation between self-reputation and task values was tested in Models 3 and 9, the relation between self-reputation and persistence was tested in Models 1, 3, and 5, and the relation between task values and persistence was tested in Models 3 and 4 (see Figures 4.1 through 4.12). The fit statistics for each model are represented in Table 4.5.

Table 4.8
Relations Examined in each Mediation Model

Model #	Mediation Relation	Fit Statistics
1	Self-Reputation → Self-Efficacy →Persistence	$\chi^2 = 70.29^{**}$; CFI = .93, RMSEA = .08, SRMR = .07
2	Group-Reputation → Self-Efficacy →Persistence	$\chi^2 = 65.99^{**}$; CFI = .94, RMSEA = .08, SRMR = .07
3	Self-Reputation → Task Values →Persistence	$\chi^2 = 87.97^{**}$; CFI = .93, RMSEA = .09, SRMR = .06
4	Group-Reputation → Task Values →Persistence	$\chi^2 = 95.29^{**}$; CFI = .93, RMSEA = .10, SRMR = .06
5	Self-Reputation → Perceived Costs →Persistence	$\chi^2 = 45.01^{**}$; CFI = .97, RMSEA = .05, SRMR = .05
6	Group-Reputation → Perceived Costs →Persistence	$\chi^2 = 79.92^{**}$; CFI = .93, RMSEA = .08, SRMR = .07
7	Self-Reputation → Self-Efficacy →Final Exam	$\chi^2 = 52.07^{**}$; CFI = .93, RMSEA = .07, SRMR = .05
8	Group-Reputation → Self-Efficacy →Final Exam	$\chi^2 = 42.18^{**}$; CFI = .96, RMSEA = .06, SRMR = .05
9	Self-Reputation → Task Values →Final Exam	$\chi^2 = 65.78^{**}$; CFI = .94, RMSEA = .08, SRMR = .05
10	Group-Reputation → Task Values →Final Exam	$\chi^2 = 100.10^{**}$; CFI = .91, RMSEA = .11, SRMR = .06
11	Self-Reputation → Perceived Costs →Final Exam	$\chi^2 = 43.76^{**}$; CFI = .95, RMSEA = .06, SRMR = .05
12	Group-Reputation → Perceived Costs →Final Exam	$\chi^2 = 75.93^{**}$; CFI = .91, RMSEA = .09, SRMR = .07

Note. The RMSEA for models 3, 4, 10, and 12 were larger than the recommended .08 value (Hu & Bentler, 1999). However, in all of the models, including those with high RMSEA, at least two fit indices (CFI and SRMR) were within the acceptable range. For factor analyses, SRMR demonstrates higher power compared to RMSEA in rejecting the non-close fit models particularly when the sample size is not very large (Shi et al., 2020). Therefore, I concluded that all of the models demonstrated sufficient fit. $^{*}p < .05$; $^{**}p < .001$

RQ1) Do African-American Students' Perceptions of Stereotype Threat Predict Their Expectancy and Value Beliefs in Science Courses after Controlling for Baseline Expectancy and Value Beliefs?

The results for this research question are organized based the relations between each pair of the predictors and mediators.

Self-reputation threat → self-efficacy (Models 1 and 7). Results of the path analyses revealed that in models 1 and 7 and after controlling for Time1 self-efficacy, Time 1 self-reputation threat negatively predicted Time 2 self-efficacy (β = -.10, p = .048 in Model 1; β = -.10, p = .049 in Model 7). Students who had higher perceptions of self-reputation threat early on in the semester had lower self-efficacy in the middle of the semester. Across models 1 and 7, Time 2 self-reputation threat did not significantly predict Time 3 self-efficacy after controlling for Time 1 self-reputation threat and Time 2 self-efficacy.

Group-reputation threat → self-efficacy (Models 2 and 8). Results of path analyses indicated that after controlling for Time 1 self-efficacy, Time 1 group-reputation threat negatively predicted Time 2 self-efficacy in Models 2 (β = -.12, p = .029) and 8 (β = -.11, p = .048). Students who had higher perceptions of group-reputation threat early in the semester reported lower self-efficacy in the middle of the semester. Across Models 2 and 8, Time 2 group-reputation threat did not significantly predict Time 3 self-efficacy after controlling for Time 2 self-efficacy.

Self-reputation threat → task values (Models 3 and 9). The results of path analyses indicated that after controlling for Time 1 task values, T1 self-reputation threat negatively predicted Time 2 task values in Models 3 (β = -.08, p = .019) and 9 (β = -.08, p = .019). Students who had higher perceptions of self-reputation threat early on in the semester had lower task

values in the middle of the semester. Across Models 3 and 9, Time 2 self-reputation threat did not significantly predict Time 3 values, after controlling for Time 2 task values.

Group-reputation threat → task values (Models 4 and 10). The results of path analyses indicated that across Models 4 and 10, after controlling for Time 1 task values, T1 group-reputation threat did not significantly predict Time 2 task values. It Additionally, Time 2 group-reputation threat did not significantly predict Time 3 task values, after controlling for Time 2 task values.

Self-reputation threat → perceived costs (Models 5 and 11). The results of the path analyses indicated that across Models 5 and 11, after controlling for Time 1 perceived costs, T1 self-reputation threat did not significantly predict Time 2 perceived costs. Additionally, Time 2 self-reputation threat did not significantly predict Time 3 perceived costs, after controlling for Time 2 perceived costs.

Group-reputation threat → perceived costs (Models 6 and 12). The results of the path analyses indicated that across Models 6 and 12, after controlling for Time 1 perceived costs, Time 1 group-reputation threat did not significantly predict Time 2 perceived costs. Additionally, Time 2 group-reputation threat did not significantly predict Time 3 perceived costs, after controlling for Time 2 perceived costs.

RQ2) Do African-American Students' Expectancy and Value Beliefs in Science Courses Predict Their Later Achievement and Persistence in STEM After Controlling for Prior Achievement and Intentions to Persist?

The results for this research question are organized based the relations between each pair of the mediators and outcomes.

Self-efficacy → persistence (Models 1 and 2). Results of the path analyses revealed that across models 1 and 2 and after controlling for T1 persistence intentions, Time 1 self-efficacy significantly predicted T2 persistence intentions ($\beta = .11$, $p = .042$ in Model 1; $\beta = .12$, $p = .037$ in Model 2). Additionally, in both models, Time 2 self-efficacy positively predicted Time 3 persistence intentions, after controlling for Time 2 persistence ($\beta = .21$, $p < .001$ in Model 1; $\beta = .22$, $p < .001$ in Model 2). These findings suggested that students who had higher self-efficacy at the beginning and in the middle of the semester, reported higher intentions to persist in STEM in the middle and at the end of the semester, respectively.

Task values → persistence (Models 3 and 4). Results of the path analyses revealed that across models 3 and 4 and after controlling for Time 1 persistence intentions, Time 1 task values significantly predicted T2 persistence intentions ($\beta = .20$, $p < .001$ in Model 3; $\beta = .21$, $p < .001$ in Model 4). Additionally, in both models, Time 2 task values positively predicted Time 3 persistence intentions ($\beta = .17$, $p = .003$ in Model 3; $\beta = .17$, $p = .002$ in Model 4) after controlling for Time 2 persistence. These findings suggested that students who had higher task values at the beginning and in the middle of the semester, reported higher intentions to persist in STEM in the middle and at the end of the semester, respectively.

Perceived costs → persistence (Models 5 and 6). Results of the path analyses revealed that across models 5 and 6, Time 1 costs did not significantly predict Time 2 persistence after

controlling for Time 1 persistence intentions. Additionally, across models 5 and 6 and after controlling for T2 persistence intentions, Time 2 costs negatively predicted Time 3 persistence intentions (β = -.14, p = .015 in Model 5; β = -.15, p = .008 in Model 6). This finding suggests that students who had higher perceived costs in the middle of the semester reported lower intentions to persist in STEM at the end of the semester.

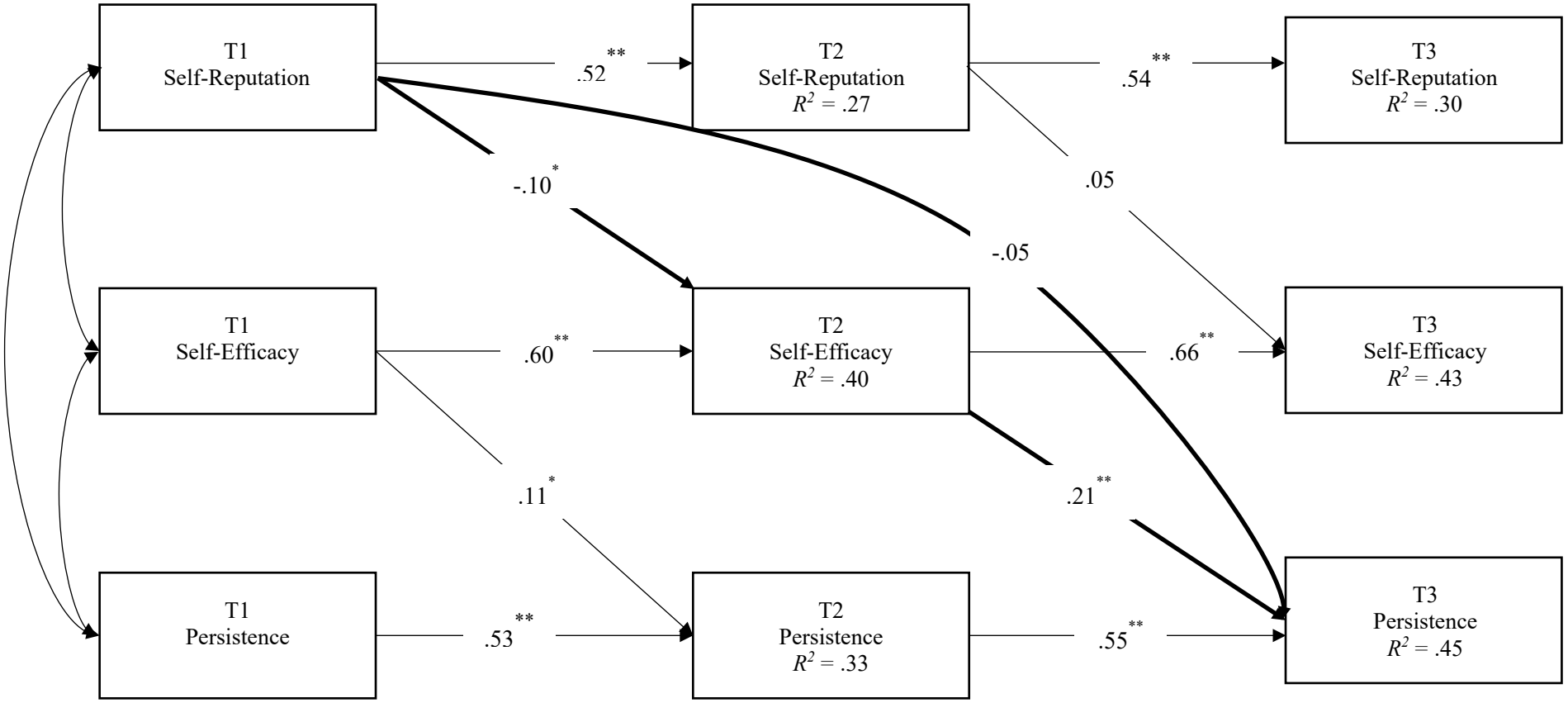
Self-efficacy → final exam grades (Models 7 and 8). Results of the path analyses revealed that across models 7 and 8 and after controlling for high school GPA, Time 2 self-efficacy positively predicted final exam grades (β = .29, p < .001 in Model 7; β = .30, p < .001 in Model 8). This finding suggests that students who reported higher self-efficacy in the middle of the semester earned higher exam grades at the end of the semester.

Task values → final exam grades (Models 9 and 10). Results of the path analyses revealed that across models 9 and 10 and after controlling for high school GPA, Time 2 task values positively predicted final exam grades (β = .18, p < .001 in Model 9; β = 18, p < .001 in Model 10). This finding suggests that students who reported higher costs in the middle of the semester earned higher exam grades at the end of the semester.

Perceived costs → final exam grades (Models 11 and 12). Results of the path analyses revealed that across models 11 and 12 and after controlling for high school GPA, Time 2 costs negatively predicted final exam grades (β = -.20, p < .001 in Model 11; β = -.22, p < .001 in Model 12). This finding suggests that students who reported higher self-efficacy in the middle of the semester earned lower exam grades at the end of the semester.

Figure 4.1

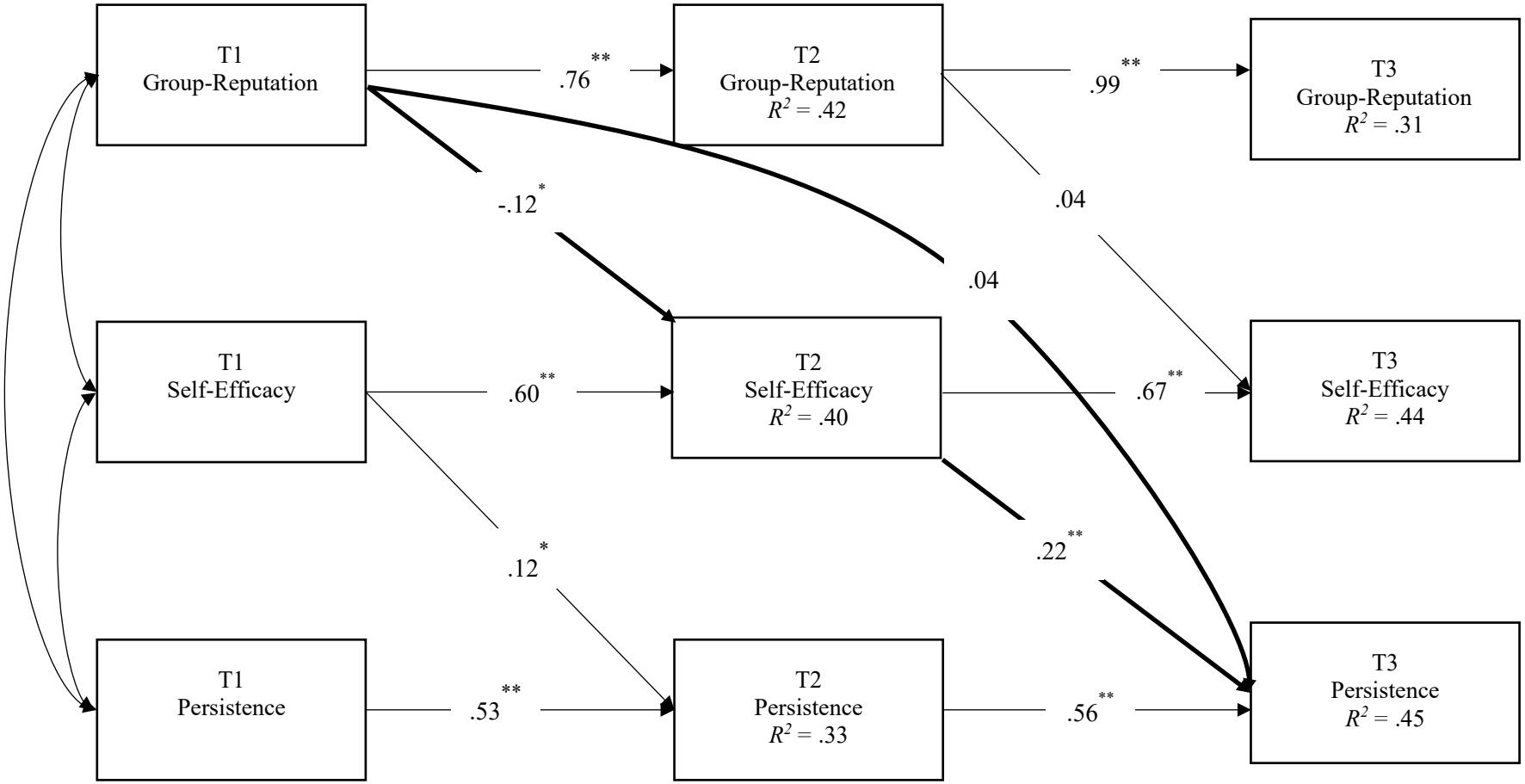
Model 1 Representing Relations Among Self-Reputation, Self-Efficacy, and Persistence



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on T3 persistence intentions were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.2

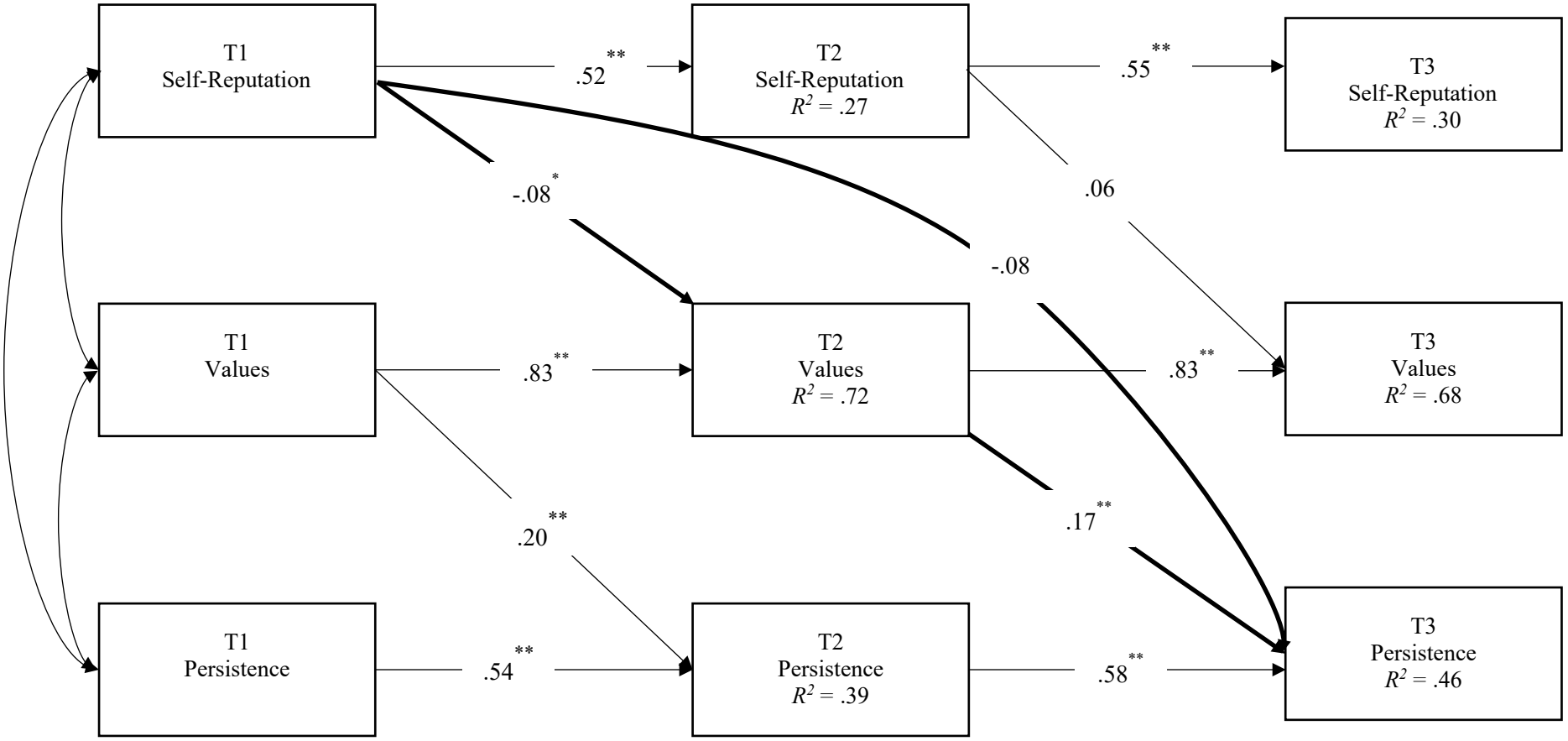
Model 2 Representing Relations Among Group-Reputation, Self-Efficacy, and Persistence



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on T3 persistence intentions were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.3

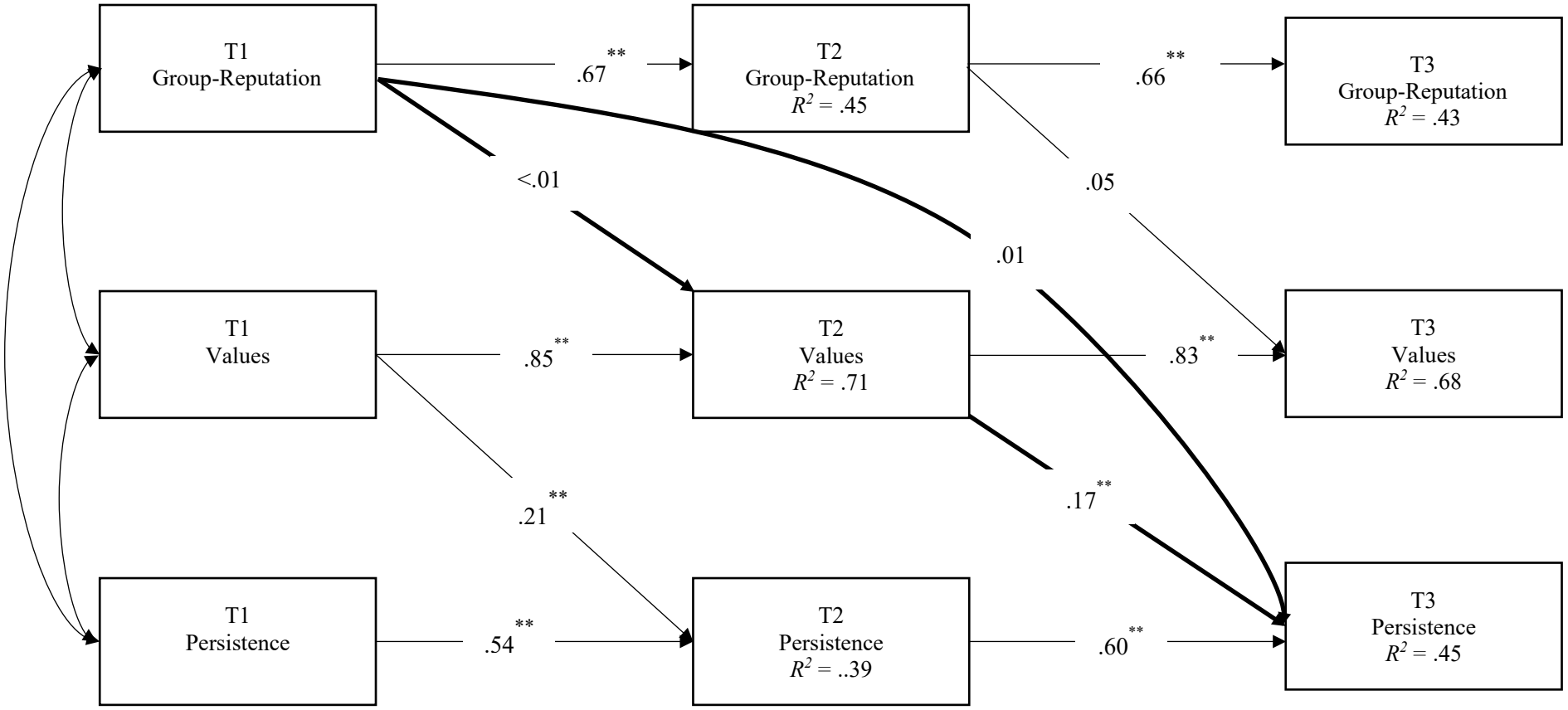
Model 3 Representing Relations Among Self-Reputation, Values, and Persistence



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on T3 persistence intentions were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.4

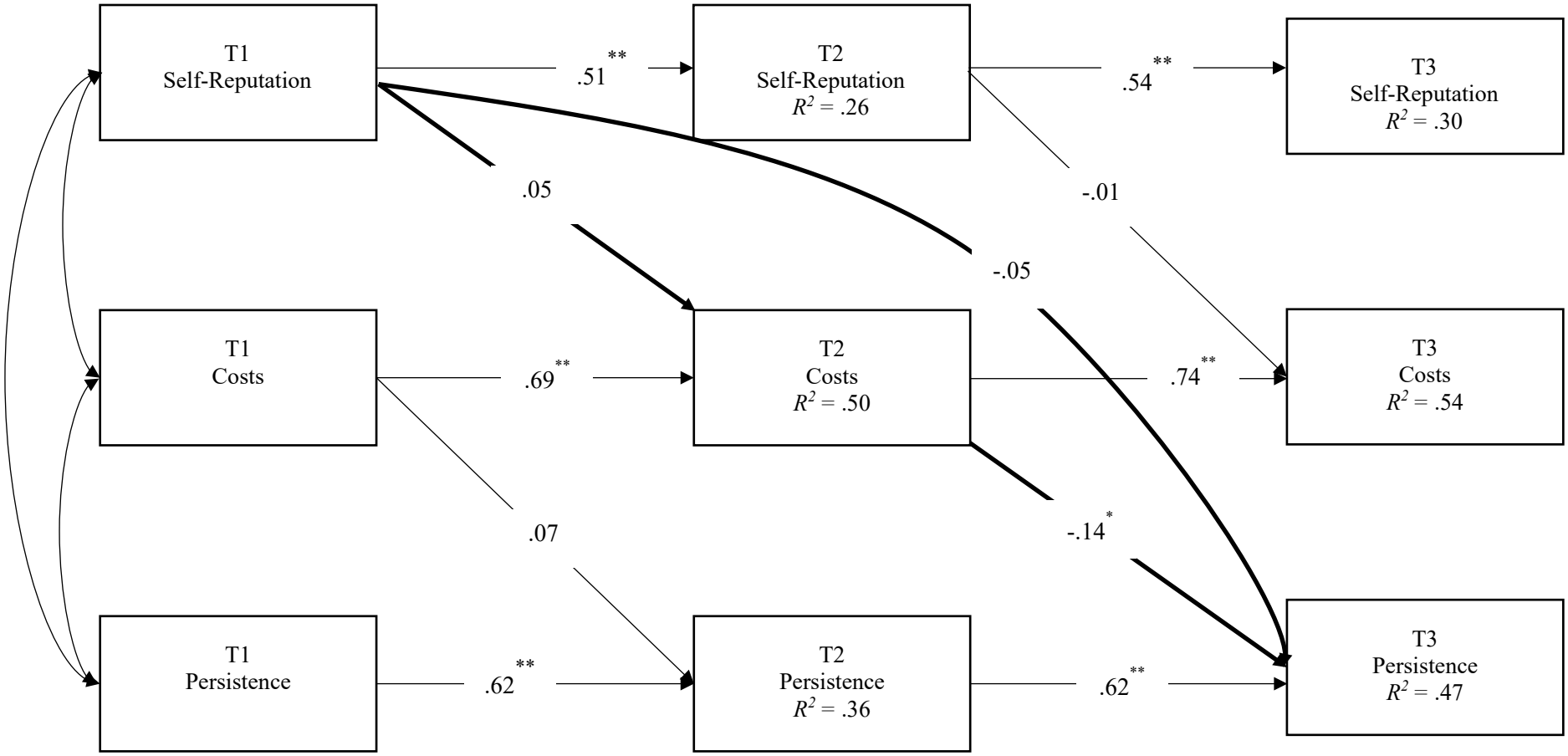
Model 4 Representing Relations Among Group-Reputation, Values, and Persistence



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on T3 persistence intentions were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.5

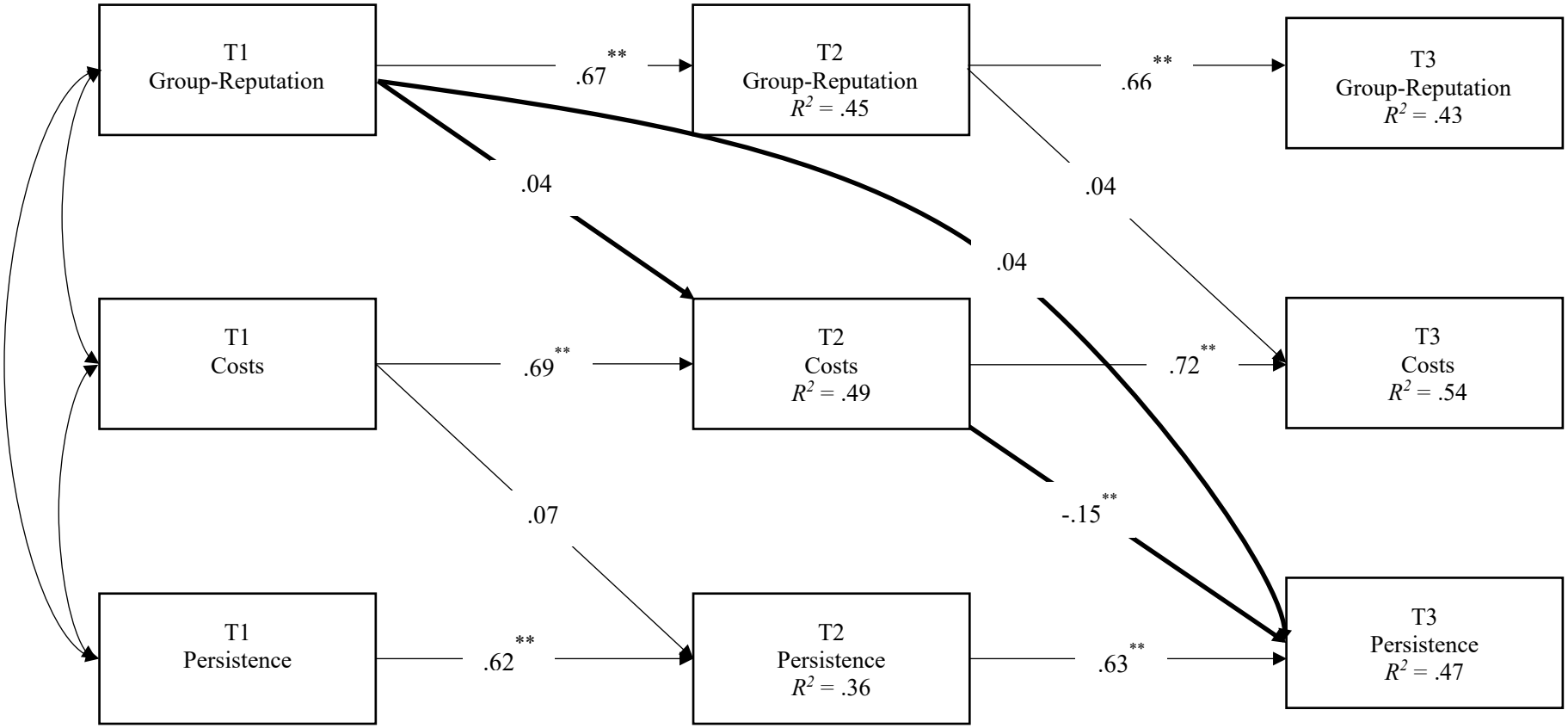
Model 5 Representing Relations Among Self-Reputation, Costs, and Persistence



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on T3 persistence intentions were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.6

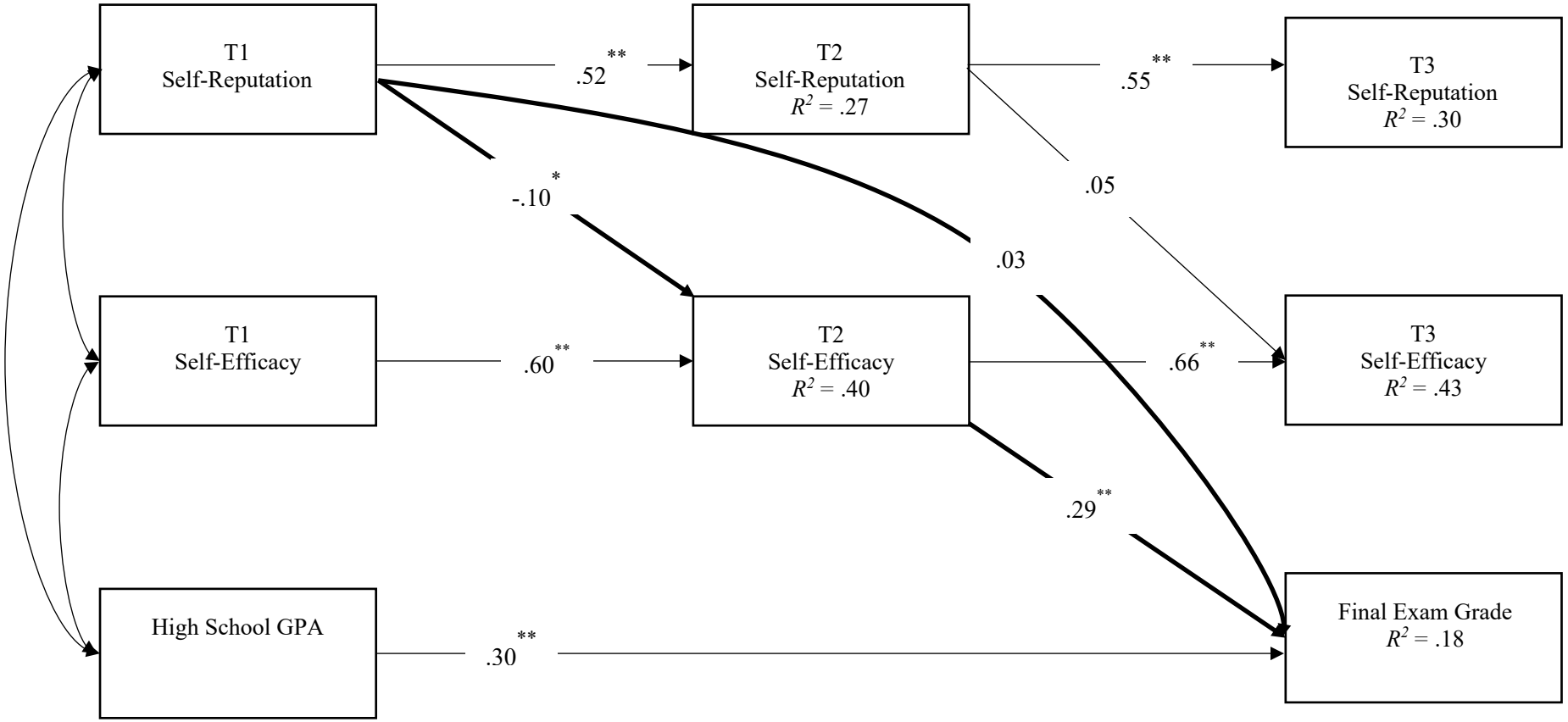
Model 6 Representing Relations Among Group-Reputation, Costs, and Persistence



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on T3 persistence intentions were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.7

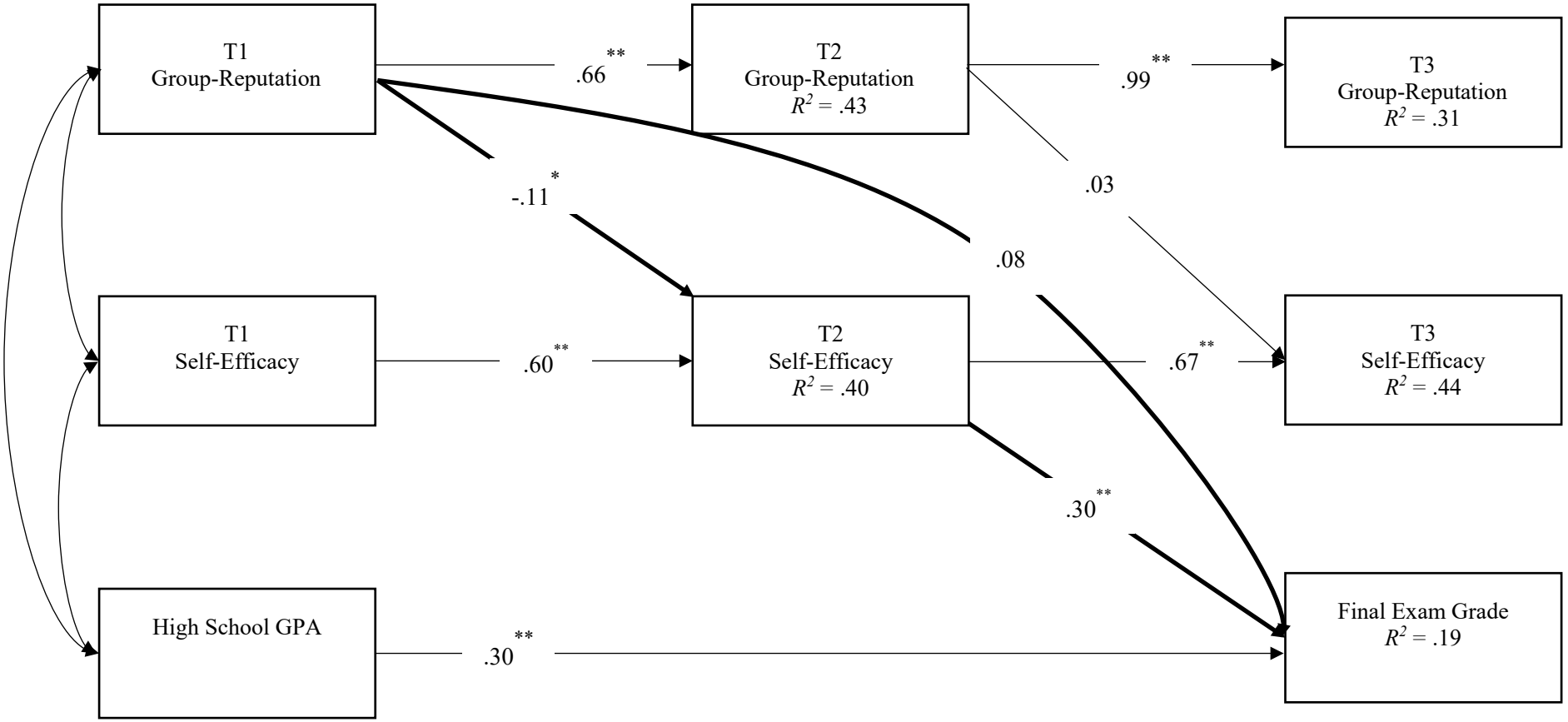
Model 7 Representing Relations Among Self-Reputation, Self-Efficacy, and Final Exam Grades



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on final exam grades were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.8

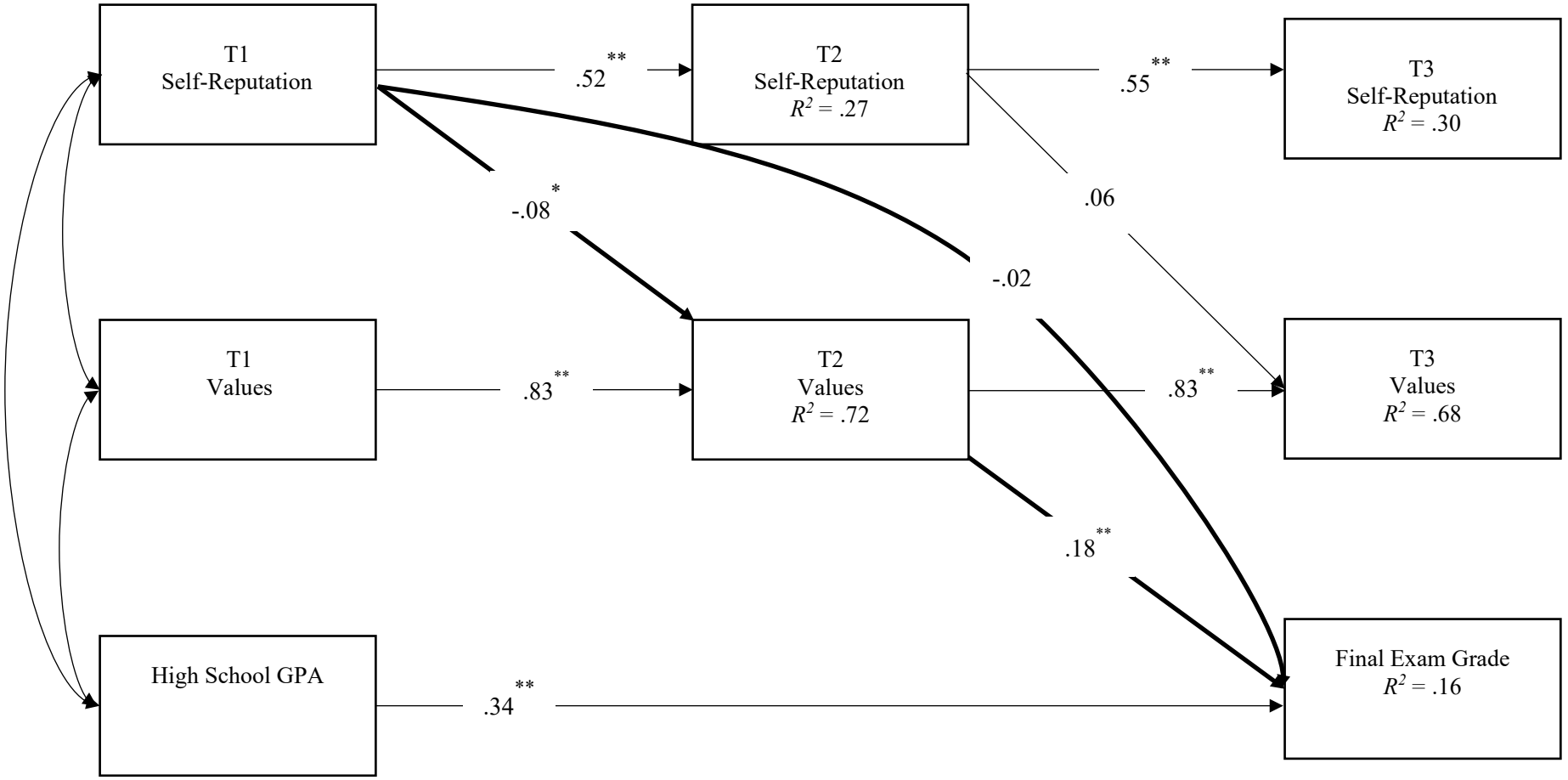
Model 8 *Representing Relations Among Group-Reputation, Self-Efficacy, and Final Exam Grades*



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on final exam grades were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.9

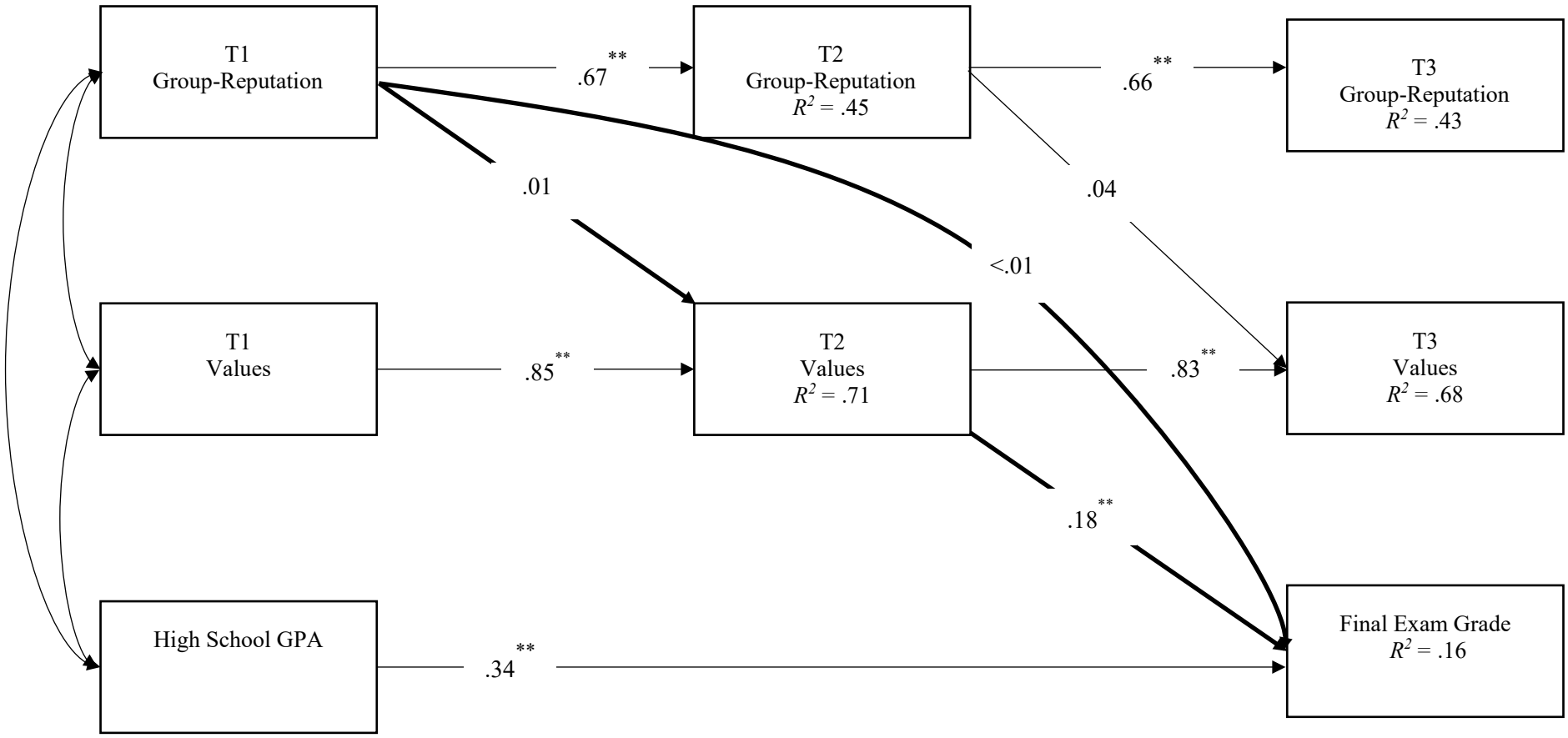
Model 9 *Representing Relations Among Self-Reputation, Values, and Final Exam Grades*



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on final exam grades were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.10

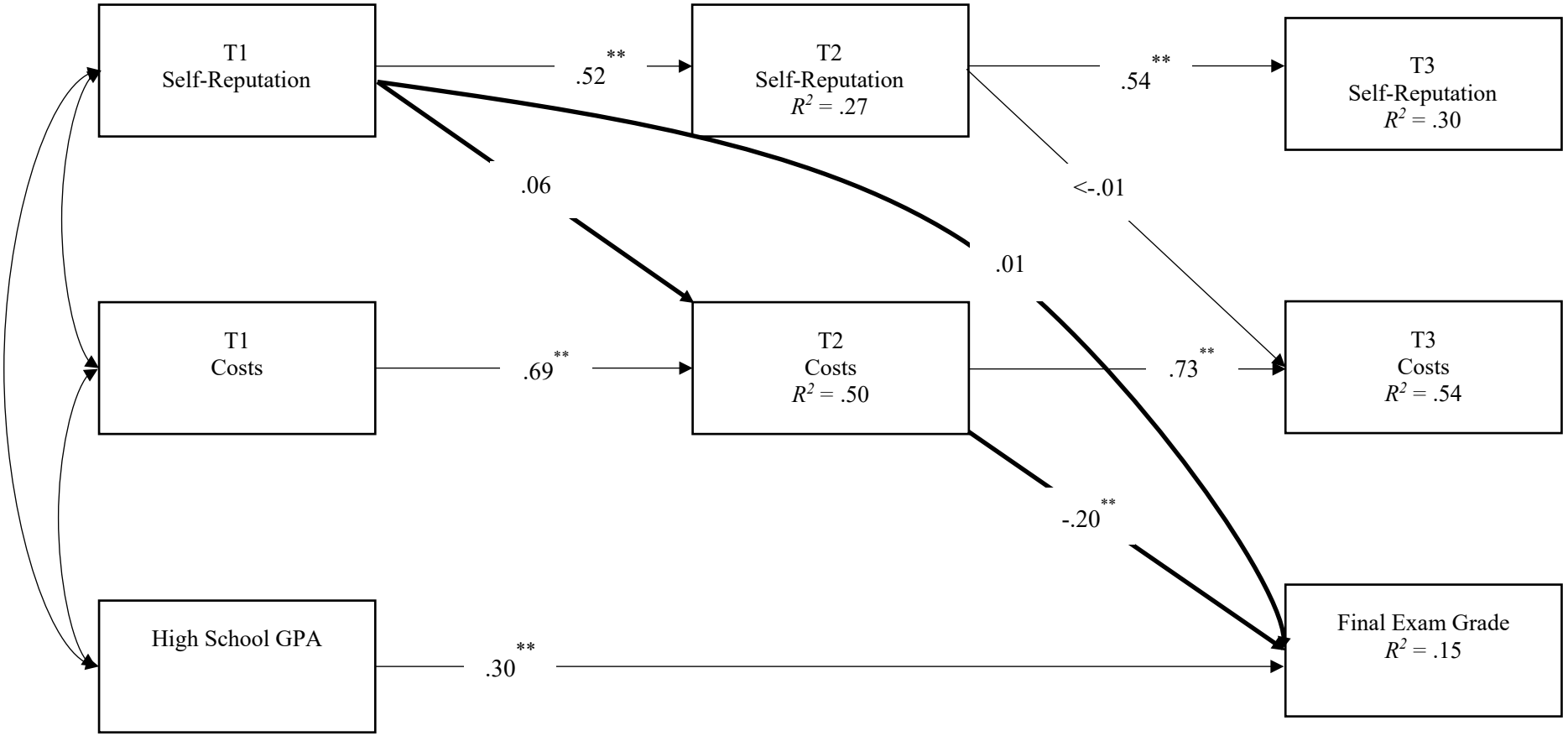
Model 10, *Representing Relations Among Group-Reputation, Values, and Final Exam Grades*



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on final exam grades were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.11

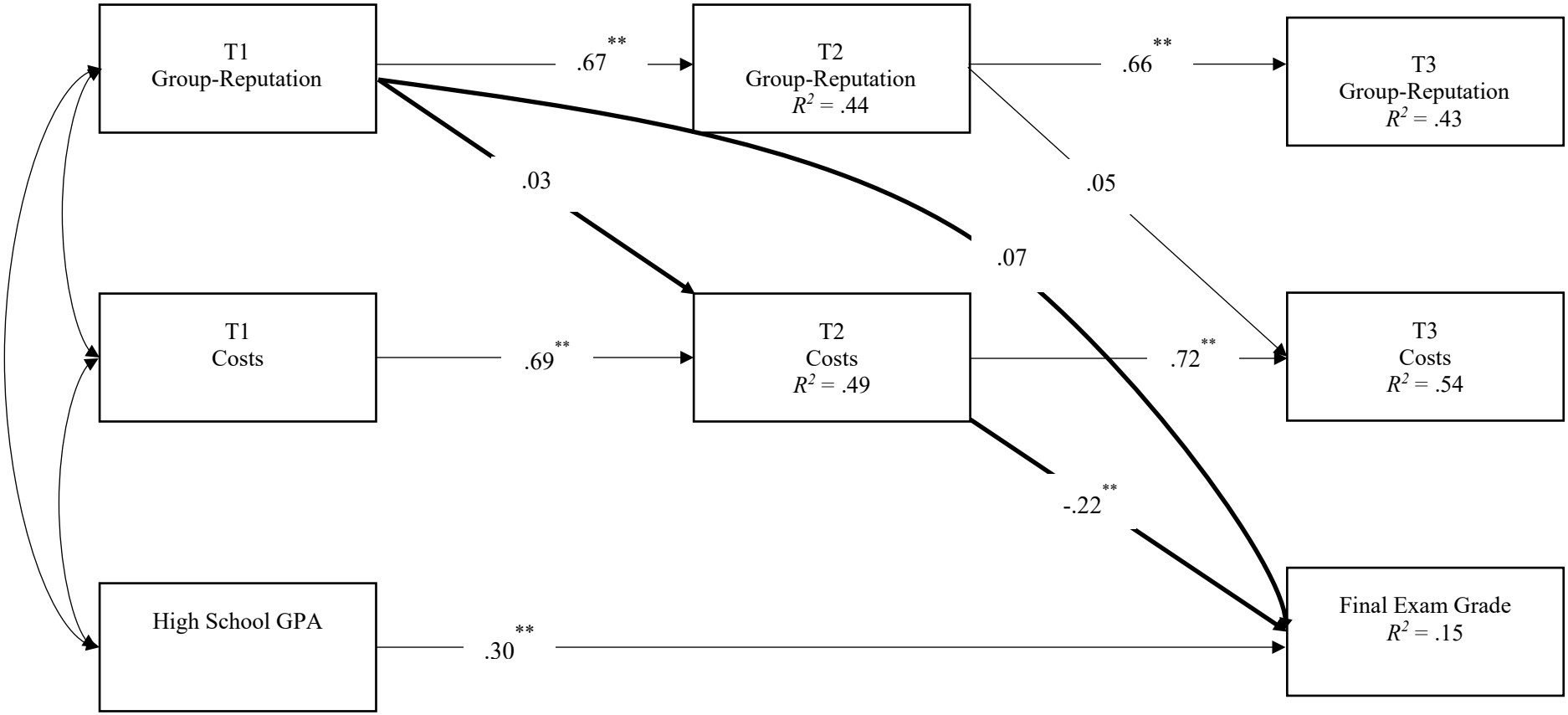
Model 11, *Representing Relations Among Self-Reputation, Costs, and Final Exam Grades*



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on final exam grades were controlled for.
$^{*}p < .05$; $^{**}p < .01$

Figure 4.12

Model 12, *Representing Relations Among Group-Reputation, Costs, and Final Exam Grades*



Note. Path coefficients are standardized. T1 = Time 1; T2 = Time 2; T3 = Time 3. Although not displayed in the figure, the effects of gender on final exam grades were controlled for.
$^{*}p < .05$; $^{**}p < .01$

RQ3: Do African-American Students' Expectancy and Value Beliefs in Science Courses Mediate the Relations between Stereotype Threats and Academic Outcomes?

To answer this research question, I examined the indirect relations between stereotype threats (self-reputation and group-reputation threat) and academic outcomes (persistence intentions and exam grades) via expectancy value beliefs (self-efficacy, task values, and perceived costs). Significance of the effects were inferred based on the bootstrapped confidence intervals. Results of the indirect effects are reported in Table 4.9.

Self-reputation → motivation → persistence. Results of the indirect path analyses suggested that Time 1 self-reputation threat indirectly and negatively predicted Time 3 persistence intentions through Time 2 task values (b = -.01, 95% BC CI [-.033, -.001]). This finding suggested that higher self-reputation threat early in the semester led to lower task values in the middle of the semester which, in turn, resulted in diminished intentions to persist in STEM at the end of the semester. The indirect relation between Time 1 self-reputation threat and Time 3 persistence intentions was not significant through Time 2 self-efficacy (b = -.02, 95% BC CI [-.046, .000]) and Time 2 perceived costs (b = -.01, 95% BC CI [-.021, .005]). That is, Time 2 self-efficacy and perceived costs did not mediate the relation between Time 1 self-reputation threat and Time 3 persistence intentions.

Group-reputation threat → motivation → persistence. Results of the indirect path analyses suggested that Time 1 group-reputation threat indirectly and negatively predicted Time 3 persistence intentions through Time 2 self-efficacy (b = -.02, 95% BC CI [-.048, -.002]). This finding suggested that higher group-reputation threat early in the semester led to lower self-efficacy in the middle of the semester which, in turn, resulted in diminished intentions to persist in STEM at the end of the semester. The indirect relation between Time 1 group-reputation threat

and Time 3 persistence intentions was not significant through Time 2 task values ($b < .01$, 95% BC CI [-.011, .012]) or perceived costs ($b < -.01$, 95% BC CI [-.017, .008]). That is, Time 2 task values and perceived costs did not mediate the relation between Time 1 group-reputation threat and Time 3 persistence intentions.

Self-reputation → motivation → final exam grades. Results of the indirect path analyses suggested that Time 1 self-reputation threat indirectly and negatively predicted final exam grades through Time 2 task values ($b = -.02$, 95% BC CI [-.038, -.002]). This finding suggested that higher self-reputation threat early in the semester led to declined task values in the middle of the semester which, in turn, resulted in lower exam grades at the end of the semester. The indirect relation between Time 1 self-reputation threat and final exam grades was not significant through Time 2 self-efficacy ($b = -.03$, 95% BC CI [-.069, .001]) and Time 2 perceived costs ($b = -.01$, 95% BC CI [-.038, .006]). That is, Time 2 self-efficacy and perceived costs did not mediate the relation between Time 1 self-reputation threat and final exam grades.

Group-reputation → motivation → final exam grades. Results of the indirect path analyses suggested that Time 1 group-reputation threat indirectly and negatively predicted final exam grades through Time 2 self-efficacy ($b = -.03$, 95% BC CI [-.067, -.006]). These findings suggested that higher group-reputation threat early in the semester led to lower self-efficacy in the middle of the semester which, in turn, resulted in lower exam grades at the end of the semester. The indirect relation between Time 1 group-reputation threat and final exam grades was not significant through Time 2 task values ($b < .01$, 95% BC CI [-.012, .014]) or perceived costs ($b = -.01$, 95% BC CI [-.030, .014]). That is, Time 2 task values and perceived costs did not mediate the relation between Time 1 group-reputation threat and final exam grades.

Table 4.9

Indirect Effects of Stereotype Threat on Academic Outcomes through Expectancy Value Beliefs

Model		*b*	*SE (b)*	β	*p*	95% *BC CI*
1	Self-Reputation → Self-Efficacy →Persistence	-.02	.01	-.02	.105	[-.046, .000]
2	**Group-Reputation → Self-Efficacy →Persistence**	**-.02**	**.01**	**-.03**	**.065**	**[-.048, -.002]**
3	**Self-Reputation → Task Values →Persistence**	**-.01**	**.01**	**-.01**	**.085**	**[-.033, -.001]**
4	Group-Reputation → Task Values →Persistence	<.01	.01	<.01	.963	[-.011, .012]
5	Self-Reputation → Perceived Costs →Persistence	-.01	.01	-.01	.312	[-.021, .005]
6	Group-Reputation → Perceived Costs →Persistence	<-.01	.01	-.01	.465	[-.017, .008]
7	Self-Reputation → Self-Efficacy →Final Exam	-.03	.02	-.03	.066	[-.069, .001]
8	**Group-Reputation → Self-Efficacy →Final Exam**	**-.03**	**.02**	**-.03**	**.058**	**[-.067, -.006]**
9	**Self-Reputation → Task Values →Final Exam**	**-.02**	**.01**	**-.02**	**.065**	**[-.038, -.002]**
10	Group-Reputation → Task Values →Final Exam	<.01	.01	<.01	.180	[-.012, .014]
11	Self-Reputation → Perceived Costs →Final Exam	-.01	.01	-.01	.242	[-.038, .006]
12	Group-Reputation → Perceived Costs →Final Exam	-.01	.01	-.01	.547	[-.030, .014]

Note. Significant indirect paths are presented in bold. Significance was inferred based on the bootstrapped 95% confidence intervals. Indirect paths were marked as significant if the confidence intervals did not contain zero.

CHAPTER V

DISCUSSION

The main aims of this study were threefold. Drawing from stereotype threat and expectancy-value theories, the first aim addressed the relations between stereotype threats and STEM motivation in African-American undergraduate science students. Existing expectancy-value research is limited in examining socio-cultural factors, such as stereotypes, that could shape these motivational beliefs (Eccles & Wigfield, 2020). This study contributed to the expectancy-value literature by shedding light on socio-cultural factors that could influence expectancy and value beliefs in STEM contexts.

The second aim of the study was to understand the associations between African-Americans' motivational beliefs and STEM outcomes. Although extant research has examined the relations between expectancy-value constructs and academic outcomes (e.g., see Rosenzweig et al., 2019 for a review), most of these studies are conducted with majority White and Asian samples and the motivational beliefs of racial underrepresented minority students are studied less commonly. Additionally, perceived costs, an important component of the expectancy-value framework and an important determinant of achievement behavior (e.g., Flake et al. 2015; Perez et al., 2014), has received less attention in existing research. The present study addressed these gaps by examining the relations between academic outcomes and all three components of the expectancy value framework including self-efficacy, task values, and perceived costs in a sample of African-American science students.

The third aim of the study was to examine the role of expectancy-value beliefs in mediating the relations between stereotype threats and academic outcomes. Most studies that have examined motivation as a mediator of stereotype threat-academic performance relations are

cross-sectional. Longitudinal designs allow for a more rigorous examination of mediation relations than cross-sectional designs and also facilitate making stronger causal inferences (Cole & Maxwell, 2003; Sobel, 1990). Accordingly, in this study, I employed a rigorous short-term longitudinal mediation design and examined the role of expectancy-value beliefs in mediating the relations between stereotype threat and academic outcomes. Additionally, most researchers have conceptualized stereotype threat as a unidimensional construct in prior research. However, stereotype threat may be a multidimensional construct in which individuals may experience different types of stereotype threat depending on the focus of the threat (self vs. group). The different types of stereotype threat, in turn, may have distinct psychological mechanisms and consequences (Shapiro & Neuberg, 2007; Shapiro, 2011). Therefore, in this study, I examined two different types of stereotype threat (self-reputation and group-reputation) and investigated whether these distinct threats differentially related to academic outcomes through distinct motivational beliefs.

Three research questions guided this study: 1) Do African-American students' perceptions of stereotype threat predict their expectancy and value beliefs in science courses after controlling for baseline expectancy and value beliefs? 2) Do African-American students' expectancy and value beliefs in science courses predict their achievement and persistence in STEM after controlling for prior achievement and baseline intentions to persist? 3) Do African-American students' expectancy and value beliefs in science courses mediate the relations between stereotype threat and academic outcomes? In this chapter, I discuss the results for each research question in detail.

RQ1: Do African-American Students' Perceptions of Stereotype Threat Predict Their Expectancy and Value Beliefs in Science Courses After Controlling for Baseline Expectancy and Value Beliefs?

Based on existing cross-sectional correlational and experimental literature (Steele & Aronson, 1995; Cadinu et al., 2003; Smith et al., 2015), I had hypothesized that perceptions of stereotype threats early in the semester would negatively relate to self-efficacy and task values and positively relate to perceived costs later in the semester. Results of the path analyses partially supported my hypotheses. Higher self-reported self-reputation threat early in the semester was related to lower self-efficacy in science and lower values for science but self-reputation threat was not related to perceptions of cost in the science course. In other words, African-American students who were more concerned about being judged or treated stereotypically due to their race had lower confidence in their abilities to succeed in their science courses and found their science courses less valuable. These concerns, however, did not lead students to perceive their science courses to be more costly. Additionally, higher perceptions of group-reputation threat early in the semester was related to lower self-efficacy in science courses but was not related to values or perceptions of cost about the science course. In other words, African-American students who, early in the semester, were more concerned about performing poorly and confirming the negative stereotypes about their racial group had lower confidence in their abilities to succeed in their science courses later on. These concerns, however, did not lead students to devalue their science courses or perceive them to be more costly. Next, I discuss the results of each tested path in greater detail and situate the findings in relation to previous research.

Stereotype Threats and Self-Efficacy

Results indicated that both self-reputation and group reputation threat negatively predicted self-efficacy. These findings lend some empirical support to the hypothesis that socio-cultural factors such as stereotypes influence individuals' expectations to succeed (Eccles & Wigfield, 2002, 2020). Expectancy-value theory posits that individuals shape ability beliefs based on important others' expectations of them. Therefore, perceiving that important others (e.g., teachers and peers) question the competence and intelligence of members of a particular racial group could negatively impact ability beliefs in the members of that group (Wigfield & Eccles, 2002) and thus result in diminished perceived competence.

Theory and prior empirical research, however, has not provided insights into why and how the different types of stereotypes threat may impact self-efficacy differentially. It is possible that students who are more concerned about being treated stereotypically (those with higher self-reputation threat), might have experienced more racism and stereotypes in the past and/or in similar settings compared to students with lower self-reputation threat. Thus, exposure to discrimination might have caused a sense of chronic vigilance about experiencing future discrimination and racial stereotyping in these students. Experiencing discrimination or being vigilant about it may, in turn, negatively impact students' beliefs in their abilities to succeed academically (Totonchi et al., 2021; Wong et al., 2003) Additionally, being more conscious about stereotypes might lead students to gradually develop negative feelings about themselves (low self-esteem) and their competence, which, in turn, diminishes their academic engagement and performance (Pinel, Warner, & Chua, 2005).

With regards to group-reputation threat, students who were more concerned about confirming negative race-based competence-related stereotypes about their group reported lower

perceived competence as well. One explanation for this effect may be that students who experience higher group-reputation threat generally have a stronger bond with the members of their minority group compared to students with lower group-reputation threat (Shapiro, 2011). Therefore, these students may feel more anxious and apprehensive about performing poorly, tainting the image of their group, and disappointing their group members. Performance anxiety, in turn, is closely tied to self-efficacy (Bandura, 1988). That is, students who are more anxious about performing poorly or failing academically may generally have doubts in their abilities to succeed and lower self-efficacy. Therefore, students who perceived higher group-reputation threat in this study, perhaps experienced more performance anxiety and hence reported lower self-efficacy. Importantly, these self-doubts and anxieties about poor performance might have been triggered by environments where students receive messages that suggest academic inferiority of students from certain racial groups (Wong et al., 2003). This hypothesis, however, was not tested in this study. A direction for future research could be examining students' exposure to race-based stereotypes in academic environments and controlling for its effects on motivation and academic outcomes.

The established negative relationship between group-reputation threat and perceived competence was also consistent with findings from experimental studies that examined stereotype threat as a unidimensional construct (Cadinu et al., 2003; Steele & Aronson, 1995). In studies where stereotype threat was manipulated by exposing participants to racial minority-intellectual inferiority stereotypes, individuals demonstrated lower outcome expectations. For instance, across two studies, African-American participants in the stereotype threat conditions read passages that suggested that members of their racial group have inferior intelligence and competence compared to members of other racial groups (Steele & Aronson, 1995; Cadinu et al.,

2003). The participants were then asked to predict their performance on an upcoming test that was diagnostic of their intelligence. The idea behind this manipulation was that participants who read such degrading messages would fear that if they performed poorly on the test, they would inadvertently confirm the negative stereotypes about their racial group. This psychological predicament is aligned with the group-reputation threat concept. Results of these experimental studies suggested that students in the stereotype threat conditions reported lower expectations to succeed on the tests.

Results from this study not only confirmed the negative association between stereotype threat and expectancy-value beliefs that were established in prior research but also complemented prior findings by directly assessing the psychological beliefs that lead to such negative motivational outcomes. Identifying the relations between specific threats and motivational beliefs could be fruitful when designing interventions to mitigate the effects of stereotype threats on achievement motivation and academic outcomes. The rigorous longitudinal mediation methodology employed in this study facilitated making stronger inferences about the antecedent effects of stereotype threats on motivation. In other words, the effects that were found in this study (even though small) were over and above the effects of baseline motivational beliefs.

Stereotype Threats and Task Values

The results suggested that students who were more concerned about other's stereotypic judgements (i.e., reported higher self-reputation threat) held lower values for their science courses. This finding is consistent with expectancy-value theory, which suggests cultural stereotypes could distally impact individuals' values for tasks or domains (Wigfield & Eccles, 2002). Individuals who experience or anticipate experiencing stereotypes may gradually

disidentify from the domain to protect their self-esteem (Spencer, 1999). Such disidentification may result in devaluing the domain, disengaging from it, and eventually completely withdrawing from the domain (Spencer, 1999; Woodcock et al., 2012).

The findings of this study are also consistent with some prior empirical research. For instance, there is empirical evidence to suggest that exposure to stereotype threat diminishes individuals' interest in the stereotyped domain (Davies et al., 2002; Shapiro & Williams, 2012). For example, an experimental study by Davies and colleagues (2002) revealed that women for whom female-math inability stereotype was activated reported lower interest in quantitative domains. The authors concluded that individuals tend to lose interest in domains in which the risk of being stereotyped is high (similar to self-reputation threat; i.e., concerns about being judged stereotypically). For the same reason, targeted individuals might disidentify from the stereotyped domain which would result in devaluing the domain. Relatedly, a longitudinal study with racial minority students in science fields revealed that students who perceived more stereotype threat in their first year of college reported lower identification with science in the second year, which, in turn, led to diminished intentions to persist in science (Woodcock et al., 2012). The findings from this study were in line with results from these prior studies and also complemented them by highlighting that self-reputation threat specifically leads to lower values in science courses.

Results suggested that there are differences between the effects of self-reputation threat and group-reputation threat on task values. Although the correlation results suggested a negative but relatively weak relation between group-reputation threat and task values, this relation was non-significant in the regression path models. That is, students' concerns about performing poorly and confirming the negative stereotypes about their racial group did impact their values

for science courses. It could be that the negative emotions associated with perceiving group-reputation threat such as the fear and anxiety related to inadvertently confirming the negative stereotypes (e.g., Bosson et al., 2004; Osborne, 2001; Spencer et al., 1999) might have led some students to feel slightly disinterested in the stereotyped science domain. This impact, however, was not large enough in the regression model after controlling for prior levels of task values.

It is also possible that high self-reputation threat, perhaps more that group-reputation threat, may be indicative of an unwelcoming environment. Science students who are concerned about others' stereotypic judgements, likely perceive the science course environments as threatening. These perceptions could, in turn, make them uninterested in the course and lead them to disidentify from it. On the other hand, group-reputation threat is more indicative of students' strong ties with their minority group and the anxiety related to disappointing their group members (Shapiro, 2011), which potentially has less direct effects on students' values for the course.

Stereotype Threats and Costs

With regards to perceived costs, the non-significant path coefficients between stereotype threats and this motivational variable were unexpected. Based on prior literature, students who anticipate being stereotyped tend to invest less effort into tasks (Keller, 2002; Stone, 2002). Following this argument, I expected that students with high self-reputation threat would find spending time and effort in a stereotyped domain costly (i.e., effort cost). In addition, the anxiety associated with confirming the negative stereotypes (e.g., Bosson, et al., 2004; Osborne, 2001; Spencer et al., 1999) could have implications for perceived costs. This fear and anxiety may be tied to individual's anticipation of failure, which is a psychological drawback associated with engaging in the task (i.e. psychological cost). Therefore, I expected that group-reputation threat

also be positively associated with perceived costs. The moderate sized correlations between perceived costs and stereotype threats lend some merit to these expectations. However, path analysis results indicated that the unique impact of stereotype threats on perceived costs were not meaningful, controlling for prior costs. Thus, based on the findings, stereotype threats do not predict perceived costs over and above prior cost beliefs. It is possible that combining the three types of costs (effort, opportunity, and psychological) into one general cost variable masked the expected effects of stereotype threats on effort cost and psychological cost. I have further elaborated on this in the Limitations section.

While expectancy-value theory provides a mechanism via which cultural stereotypes affect students' academic outcomes, stereotype threat theory provides a framework for understanding why some students are affected more than others by these negative socio-cultural factors. In this study, I adopted an integrative approach and merged expectancy-value framework with psycho-social stereotype threat theory to address the mechanisms through which stereotypes affect African-American students' STEM achievement. As described above, the results of the present study expanded expectancy-value theory by providing empirical evidence for at least two socio-cultural threats (self-reputation and group-reputation threat) that negatively impact students' achievement motivation. Additionally, these results expanded stereotype threat theory by providing insight into the distinct motivational consequences of two different, yet related, stereotype concerns.

RQ2: Do African-American Students' Expectancy and Value Beliefs in Science Courses Predict Their Later Achievement and Persistence in STEM After Controlling for Prior Achievement and Intentions to Persist?

Based on extant cross-sectional and longitudinal expectancy-value research, which typically includes a majority White- and Asian-American samples (e.g., Eccles et al., 1983; Perez et al., 2014; Perez et al., 2019; Robinson et al., 2019; Wigfield et al., 2016), I had hypothesized that African-American students' self-efficacy and task values in the middle of the semester would positively predict their intentions to persist in a STEM major and grades on a science course final exam. On the other hand, I had expected that their perceived costs would be negatively associated with these academic outcomes.

Results suggested that African-American students who had more confidence in their abilities to succeed in their science course in the middle of the semester and those who more highly valued their science course reported higher intentions to persist in their STEM major and they also received higher grades on their final exam. As expected, the relations were in the opposite direction for perceived costs. African-American students who perceived more drawbacks associated with their science courses reported lower intentions to persist in their STEM majors and they also received lower grades in their science course at the end of the semester.

Results of this study lend further support to expectancy-value theory, which posits that expectations for success as well as subjective task values and relative costs directly relate to individuals' achievement-related choices, engagement, and persistence (e.g., Eccles et al., 1983; Wigfield & Eccles, 2002). These findings are also in line with extant empirical research that highlights the significant effects of expectancy-value motivational variables on academic

outcomes (e.g., Perez et al., 2014; Perez et al., 2019; Robinson et al., 2019; Wigfield et al., 2016). This prior research suggests that competence beliefs are typically stronger predictors of performance-related outcomes such as grades and academic achievement whereas task values are usually more strongly linked to individuals' choice behaviors such as intentions to persist (Eccles, 1984, 2005; Wigfield & Eccles, 2000). The stronger expectancy-performance and values-choice relations, although have been demonstrated in some prior studies (e.g., Meece et al., 1990; Perez et al., 2014), these relations have not been detected in all expectancy-value research (e.g., Wang & Eccles, 2013). Similarly, in this study, a brief look at the magnitude of the coefficients for the relations between expectancy-value beliefs and academic outcomes did not suggest that self-efficacy is more strongly related to grades than to persistence intentions. Similarly, results did not indicate that task values are more strongly related to persistence intentions than to grades. On the contrary, all three of the expectancy-value variables appeared to modestly relate to both achievement and persistence. When interpreting these findings, the reader should bear in mind that self-efficacy and task values were entered in separate models. It is possible that if these motivational variables were entered in the same models, the effects of task values on achievement would no longer be significant after controlling for the effects of self-efficacy. This speculation is aligned with the empirical findings reported by Trautwein and colleagues (Trautwein et al., 2012). These authors reported that both expectancies and values predicted achievement when they were entered in separate models. However, when these variables were entered in the same model, task values did not significantly predict achievement. The inability to model self-efficacy and task values together is a limitation of the present study and is further discussed at the end of this chapter.

Existing longitudinal studies with majority White- and Asian-American STEM students has revealed that perceived competence and task values positively relate to students' end-of-semester achievement in STEM courses and their likelihood of graduation from STEM courses (e.g., Robinson et al., 2019; Totonchi et al., 2020). However, there are few studies that focus on racial/ethnic minority students. The findings from this study complement the existing literature by providing insights into the impact of expectancy-value beliefs on STEM achievement and persistence in a sample of African-American students. Examining the motivational beliefs of African-American students and its relations to academic outcomes is crucial as national reports suggest that these students drop out of STEM majors at higher rates even though they start their STEM degrees with higher levels of interest (Riegle-Crumb et al., 2019; Shim et al., 2008).

RQ3: Do African-American Students' Expectancy and Value Beliefs in Science Courses Mediate the Relations Between Stereotype Threats and Academic Outcomes?

The final research question of this study examined the role of expectancy-value beliefs in mediating the relations between the two stereotype threats and academic outcomes. Partially supporting my hypotheses, the results indicated that group reputation stereotype threat early in the semester predicted intentions to persistence in STEM at the end of the semester through self-efficacy. Specifically, the results suggest perceiving higher group-reputation threat led to lower self-efficacy, which in turn led to lower intentions to persist. Self-reputation threat, on the other hand, negatively predicted intentions to persistence in STEM through task values. Additionally, both self-reputation and group-reputation threat early in the semester indirectly related to final exam grades. For self-reputation threat, this relation was mediated by task values and for group-reputation threat this relation was mediated by self-efficacy. These findings are consistent with expectancy-value theory (Eccles at al., 1983; Wigfield and Eccles, 2002) that posits ability

beliefs (e.g., self-efficacy) and task values are influenced by cultural stereotypes. These self-beliefs and values, in turn, are direct determinants of individuals' choice behaviors and performance outcomes (see Figure 2.1).

The findings from this study are also in line with the results of a few empirical studies that have examined expectancies and values as mediators of the relationship between stereotype threat and academic outcomes. This prior research has demonstrated that induced stereotype threats that target the competence of the group (what Shapiro would call as group-reputation threat) reduce math performance through diminished performance expectancies (Cadinue et al., 2003). Additionally, in a cross-sectional study that assessed stereotype threat with a combination of self-reputation and group-reputation items, stereotype threat was found to relate to lower persistence intentions through reduced success expectancies and values (Smith et al., 2015; von Hippel, 2011).

Contributing to the existing literature, results of this study suggested that concerns about being stereotypically judged and the anxiety of confirming the race-based stereotypes about one's group negatively impacted African American students' STEM outcomes by diminishing their ability beliefs and values for science courses. The meaning of the relations between stereotype threat and expectancy-value beliefs are already discussed under research question 2. What is particularly interesting, however, is that although both self-reputation and group-reputation threats were negatively correlated with STEM persistence intentions, neither directly related to this outcome. That is, the stereotypes threat variables only indirectly, through self-efficacy and task values, related to STEM persistence and achievement.

While existing studies have documented the partial mediation role of expectancy and value beliefs in the stereotype threat-academic outcomes relations (e.g., Cadinu et al., 2003;

Smith et al., 2015; Steele & Aronson, 1995; von Hippel et al., 2011), these studies were either experimental or cross-sectional correlational. Although experimental studies allow for examination of causal effects, they are limited in that they are conducted in controlled conditions making the generalizability of the results to authentic real-world contexts difficult. On the other hand, cross-sectional correlational studies are typically conducted in authentic contexts. However, the design of the study does not permit making causal inferences. Longitudinal mediation designs can be conducted in authentic contexts and facilitate making strong causal inferences than cross-sectional studies by allowing time passages between predictors, mediators, and outcomes and by controlling for extraneous confounding variables (Cole & Maxwell, 2003). Using this rigorous methodology, this study provides stronger evidence for the causal effects of stereotype threats on motivation and that of motivation on academic outcomes than other cross-sectional studies. More importantly, this methodology allowed for a rigorous examination of the motivational processes through which stereotype threats affect academic outcomes in authentic settings.

Results of this study indicated that these motivational processes differed for self-reputation threat versus group-reputation threat. Self-reputation threat impacted persistence intentions and final exam grades through task values; however, group-reputation threat impacted these outcomes through self-efficacy. As discussed under research questions 1 and 2, African-American students with higher group-reputation threat may have had a stronger bond with members of their racial group, which may have made them more anxious and apprehensive about performing poorly and tainting the image of their group in others' eyes (Shapiro, 2011; Shapiro & Neuberg, 2007). This performance anxiety, in turn, reduced students' confidence in their abilities to succeed –manifested by diminished self-efficacy– and negatively impacted their

actual academic outcomes. On the other hand, students with higher self-reputation threat may have been more vigilant about experiencing discrimination in the context of science courses and potentially found the environment more threatening and less welcoming. Such perceptions, in turn, may have led to reduced values for their science course. The findings from this study shed light on the distinct mechanisms and consequences of different types of stereotype threats. The implications of these findings for practice and future research are discussed next.

A Note on the Intersectionality of Multiple Marginalized Identities

As noted in Chapter III, the majority of the sample (71%) were women. Being racially underrepresented and also female, students may experience additional stereotype threat burdens that may be due to a combination of marginalized identities in STEM. Such experiences are best understood using an intersectional approach. Intersectionality provides an analytical lens for understanding how different aspect of one's identities (e.g., race, gender, class, sexuality, physical appearance, religion, and disability) intersect and overlap to create various modes of privilege or discrimination (Crenshaw, 1991). Research that has explored the intersection of various identities suggests that for students who have multiple stigmatized identities (women, racial minority, low socio-economic status), compared to those with one or two stigmatized identities, the effects of stereotype threat on STEM achievement is more detrimental (Tine & Gotlieb, 2013).

One statistical approach to examining intersectionality could be adding gender and first-generation status as moderators into the models to see whether men and women as well as first-generation and continuing-generation students are differentially affected by stereotype threat. Unfortunately, I was not able to examine the moderating effects of gender and first-generation status on vulnerability to stereotype threat due to the small sample size (also see limitations).

However, a brief look at the stereotype threat means for students with various marginalized identities suggested that contrary to what I expected, male, compared to female, students seemed to have higher self- and group-reputation threat perceptions.

While female racial minority and majority students frequently experience gender stereotype threat in STEM settings (e.g., Johns et al., 2005; Schamder, 2002), male African-American students experience pervasive racism and discrimination in educational contexts and the larger society that is well-documented in research (e.g., Graham & Anderson, 2008; Lynn et al, 2010). In the U.S., Black men are frequently stereotyped as problems and prone to violence (Howard, 2013). Subsequently, Black men are 5.9 times more likely to be incarcerated (U.S. Bureau of Justice Statistics, 2018) and 3.2 times more likely to be killed by a police officer (Schwartz & Jahn, 2020), than White men. Being threatened by the law enforcement, African-American men are vulnerable to a variety of adverse mental health outcomes including depression and anxiety (Sheehan et al., 2021). The experiences of African-American men in the larger society is directly connected to their academic experiences and exposures to education inequality. Black males often perceive their university campuses as being more hostile and unfriendly toward Black men compared to toward students of other races (Smith et al., 2007). Also, Black male students, even those who are high-achieving, report that they are often met with suspicion from faculty who often question their intelligence and competence (e.g., Cokley, 2003). Similar experiences may have led African-American male students in this study to experience more stereotype threat compared to African-American female students. An intersectional approach to understanding students' experiences with discrimination in STEM could shed light on how gender and race intersect to shape students' pathways in and out of STEM.

Implications

This study has implications for theory and practice. First, while recent theoretical and empirical advancements suggest individuals of marginalized groups perceive multiple threats (e.g., Shapiro, 2011; Shapiro & Neuberg, 2007), prior studies have mostly taken a unidimensional approach to understanding stereotype threat. Addressing this gap in the literature and advancing stereotype threat theory, I distinguished between two different types of stereotype threats and examined the distinct mechanisms for the effects of each stereotype threat on academic outcomes. Understanding the unique mechanisms and consequences of distinct stereotype threats is important particularly when designing interventions to mitigate the negative effects of stereotype threat on academic outcomes. For example, results of this study suggest that boosting students' self-efficacy could potentially mitigate the negative effects of group-reputation threat on science outcomes whereas improving their values could potentially attenuate the effects of self-reputation threat.

Second, unlike most studies that have examined the associations among stereotype threats, motivation, and academic outcomes cross-sectionally, I examined these relations longitudinally over a semester, allowing for stronger inferences about the direction of effects among these variables. The findings of this dissertation provided support for the antecedent effects of stereotype threat perceptions on motivation. Although expectancy-value theory suggests that socio-cultural factors including stereotypes influence individuals' motivational beliefs, little research has examined the relations among stereotype threats and expectancy-value beliefs. The results of the present study extended expectancy-value literature by providing support for the contextual nature of motivation and by shedding more light on how socio-cultural factors impact African-American students' motivational beliefs. These finding facilitate

understandings of factors that contribute to the achievement and persistence disparities between African-American and majority students in STEM.

Third, while a handful of studies have examined the mediating role of one (or at the most two) components of the expectancy-value theory (mainly performance expectancies and interest or utility value; Cadinu et al., 2003; Smith et al., 2015; von Hippel et al., 2011), I explored the relations between stereotype threat and all three motivational beliefs in expectancy-value theory, including self-efficacy, task values, and costs. To my knowledge, no other study has examined perceived costs as a mechanism for the effects of stereotype threat on academic outcomes. Investigating the role of perceived costs is important because this variable is a key component of expectancy-value theory and is found to have detrimental effects on achievement and persistence outcomes (e.g., Flake et al., 2015; Perez et al., 2014; Perez et al., 2019). Additionally, one longitudinal study that looked at the relations between perceived costs and stereotype threat has reported a positive relation between effort cost and stereotype threat (Totonchi et al., 2020). Although, the regression results in the present study did not indicate a significant relation between stereotype threats and cost, the correlations demonstrated moderate positive associations among both types of stereotype threat and perceived costs. Future research is needed to examine the role of different types of perceived costs, perhaps effort and psychological costs in particular, in mediating the relations between stereotype threats and academic outcomes. These two types of cost are expected to be more closely related to stereotype threat since prior research suggests that unidimensional stereotype threat decreases individuals' willingness to invest effort in a task (Keller, 2002; Stone, 2002) and increases their anxiety while performing on a task (psychological drawback associated with the task; Bosson, et al., 2004; Osborne, 2001; Spencer et al., 1999).

Fourth, the present study has implications for educational practice and policy making. Given the demonstrated effects of stereotype threats on African-American students' motivation, achievement, and persistence, attention should be paid to designing and implementing interventions that reduce these effects. For instance, re-construal interventions that lead students to perceive a lower level of threat (e.g., informing students that tests do not show gender/race differences; Good et al., 2008), coping mechanisms that help students suppress anxious thoughts related to performing on tests and confirming the negative stereotypes (Logel et al., 2009), and educating students about stereotype threat and the illegitimacy of race-based stereotypes (Johns et al., 2005) have been found to be effective in reducing the effects of stereotype threat on academic performance. These interventions may restore students' confidence in their abilities to succeed in science courses and thus improve their achievement and interest in pursuing science.

Findings from this study may also inform practitioners about the importance of developing more inclusive and diverse educational environments to support minority students,' and particularly African-American students,' motivation, persistence, and achievement. This can be achieved by facilitating positive interactions among members of the minoritized groups (Abrams et al., 2006), providing access to successful role models from the minoritized groups (Marx & Goff, 2005), and educating the members of the majority group about the stereotypes and latent ability of individuals from minoritized groups (Walton et al., 2014). For example, researchers have evaluated the efficacy of workshops that address the issues of equity and racism in educational settings (e.g., Abramovitz & Blitz, 2015; White-Davis et al., 2018). These workshops exposed teachers to videos, articles, books, podcasts, websites, and activities in which issues of racism, privilege, implicit bias, and intersectionality of marginalized identities were explored. Educating teachers about the history of American racism and its substantive effects on

students of color contributes to increasing the public's knowledge about the structural inequities in the society. The educators participating in these workshops, also learned that they are institutional gatekeepers who play significant roles in either maintaining or undoing racism. Participating in these workshops contributed to teachers' knowledge about strategies to address racism in education and other settings and encouraged them to apply their newly gained knowledge to promote equity in their workplaces. Participating in workshops also increased teacher's confidence in their abilities to improve the racial climate in their institutions. Similar training could be developed for post-secondary faculty to improve the racial climate in STEM courses and programs.

The pervasiveness of racism persists even when teachers and practitioners address their own racial biases and participate in diversity and equity trainings (Evans, 2007). Structural changes in educational institutions need to take place to reduce racism and prejudice targeted at students of minority groups and provide environments that are supportive of students with different marginalized identities. Educational leaders should recognize and covey to their staff that course curriculum, the school culture, and educational practices are not race-neutral, and they often portray White culture (Valles & Muller, 2010). The leaders, thus, should work towards developing curriculum, culture, and policies that promote racial diversity in universities and schools and at the same time challenge rules and processes that are institutionalized in schools that sustain exclusion. Creating identity-safe environments could, in turn, reduce perceptions of stereotype threat and help students develop more adaptive motivational beliefs, which could result in improved achievement and persistence outcomes.

Limitations and Future Directions

There are limitations to this study that need to be considered when interpreting the findings. First, the participants in this study were sampled from a minority serving public university where approximately 40% of the undergraduate students were from underrepresented racial groups. Therefore, it is possible that these students experience less racial discrimination and perceive less stereotype threat compared to students at predominantly White institutions (PWI). Thus, the results from this study may not be generalizable to students who attend PWIs or institutions with a smaller ratio of racial minority to racial majority students. Future studies should test these mediation models with African-American students in PWIs to see whether the same motivational mechanisms explain the negative effects of stereotype threats on academic outcomes. Given the extant literature that suggests African-American students at PWIs experience more isolation and racial discrimination (e.g., Caldwell & Obasi, 2010; Stevens et al., 2018), I would expect that the negative effects of stereotype threats on academic outcomes would be stronger for African-American students at PWIs compared to minority serving institutions. Thus, improving motivational beliefs may play an even more critical role in attenuating the negative effects of stereotype threat on academic outcomes for students in PWIs.

Second, although I controlled for the effects of gender on STEM outcomes (achievement and persistence intentions), I was unable to examine the moderating role of gender or first-generation status on the relations between vulnerability to stereotype threat and the STEM outcomes. Future research with a larger sample could include gender and first-generation status as moderators in the analytical models and examine whether male and female students as well as first-generation and continuing-generation students are differentially affected by perceptions of self- and group-reputation threat.

Third, a broader limitation of the present study is the use of self-report measures for assessing a wide-range of psychological and behavioral constructs. Students may hide or alter their true attitudes and beliefs and instead report what they perceive to be socially desirable. Relying exclusively on self-report measures could pose a threat to internal validity of the measures and could provide biased results. However, the results indicated effects of these variables indicated effects on exam performance, which has real world, direct consequences for students.

Fourth, as reported in the methods section, the perceived cost measure demonstrated poor psychometric properties, therefore, I used a variety of modification indices to achieve acceptable fit for the measurement models. This could pose a threat to the internal validity of the findings and provide inaccurate results. Given that cost has been rarely examined with African-American student populations, it may be that this measure does not assess cost perceptions with African-American student samples as well as it does with majority White students. Future psychometric research could further examine the measurement properties of perceived cost measures with racial minority students.

Fifth, the sample collected for this study was not sufficient to ensure power of .80 for some of the tested paths. The significant, though generally small, effects as well as the non-significant marginal effects found for the direct and indirect paths in this study might be direct consequences of the low power. Therefore, the significant and non-significant results of this study should be interpreted with caution. In future studies, researchers should replicate these analyses with a larger sample.

Lastly, due to the large number of parameters relative to the sample size, I specified separate models for each predictor, mediator, and outcome variable. While this approach helped

avoid potential multicollinearity between the variables, it limited my ability to examine the unique effects of each predictor on motivation and academic outcomes, controlling for the effects of other predictors. For instance, the inability to include both types of stereotype threat in the same mediation model prevented an understanding of the unique effects of each type of stereotype threat on motivation over and above the effects of the other stereotype threat variable. Future studies with larger sample sizes could include both types of stereotype threat in the same model and more accurately examine the unique mechanisms via which each stereotype threat affects academic outcomes.

Also, relatedly, due to the large number of parameters, I combined intrinsic, attainment, and utility values into one single task value construct and also combined effort, opportunity, and psychological costs into one single perceived cost construct. The different task values and costs, although usually highly correlated, tap into different psychological beliefs (Eccles et al., 1983; Flake et al., 2015). It is possible that combining the different types of values and costs may have hidden the relations between specific value or cost beliefs and stereotype threats. In fact, prior research that examined the relations between stereotype threats and different types of values suggests that only attainment value (and not intrinsic or utility value) and effort cost related to stereotype threat (Totonchi et al., 2020). Therefore, it is possible that in this study, intrinsic and utility value were not individually related to stereotype threat and combining them with attainment value in a general task value variable may have attenuated the effects of stereotype threats on value. Future research with larger sample sizes could model the different types of values and costs separately to provide a more nuanced picture of the relations between expectancy-value beliefs and stereotype threats.

Summary

In this study, I integrated stereotype threat theory with expectancy-value theory to examine the motivational mechanisms through which two stereotype threats affect achievement and persistence of African-American students in science courses. I tested 12 longitudinal mediation models to examine the roles of self-efficacy, task values, and perceived costs in mediating the relations between two types of stereotype threat and STEM outcomes. Results suggested that both self-reputation threat and group-reputation threat early in the semester were negatively related to self-efficacy in the middle of the semester. Self-reputation threat (but not group-reputation threat) early on was also significantly related to task values in the middle of the semester. Neither of the two stereotype threats were related to perceived costs. On the other hand, as expected, all three expectancy-value motivational beliefs were significantly related to persistence intentions and final exam grades. To be more specific, self-efficacy and task values in the middle of the semester positively related to persistence intentions and final exam grades at the end of the semester whereas perceived costs in the middle of the semester was negatively related to these outcomes. Lastly, results of indirect effects analyses suggested that self-efficacy mediated the association between group-reputation threat and STEM outcomes, but task values mediated the relation between self-reputation threat and STEM outcomes.

The results of this study contribute to the existing literature in three ways: (1) The findings advance expectancy-value theory by providing empirical evidence for two socio-cultural factors that impact students' self-efficacy and task values and indirectly affect their STEM achievement and choice behaviors. (2) Findings expand stereotype threat theory by examining two different types of stereotype threat and exploring their distinct psychological mechanisms and consequences on academic outcome. (3) The longitudinal nature of this study allowed for

making stronger inferences about the direction of the relations among stereotype threat, motivation, and STEM outcomes. Taken together, these results suggest that African-American students who are concerned about being judged stereotypically and are fearful that they would confirm the negative stereotypes about their racial group report lower confidence in their abilities to succeed in science and hold lower values for science. These beliefs, in turn, lead them to achieve lower grades in their science courses and result in lower intentions to persist in STEM. Findings from this study shed light on factors that may explain the achievement and persistence gap between African-American and majority students in STEM.

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APPENDIX

Survey Items

All of the above self-report measures are scored on a 5-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Self-Efficacy (Midgley et al., 2000)

1. *I'm certain I can master the skills taught in this chemistry/biology course.
2. I'm certain I can figure out how to do the most difficult class work in this chemistry/biology course.
3. I can do almost all the work in this chemistry/biology course if I don't give up.
4. Even if the work in this chemistry/biology course is hard, I can learn it.
5. I can do even the hardest work in this chemistry/biology course if I try.

Task Values (Conley, 2012)

Intrinsic value

1. I enjoy this chemistry/biology course.
2. What I am learning in this chemistry/biology course is exciting to me.
3. I am fascinated by what I am learning in this chemistry/biology course.
4. I enjoy what I am learning in this chemistry/biology course.
5. I like this chemistry/biology course.

Attainment value

1. It is important for me to be a person who can reason with the concepts in this chemistry/biology course
2. Learning the science concepts in this chemistry/biology course is an important part of who I am.
3. It is important for me to be someone who is good at solving problems in this chemistry/biology course.
4. Being someone who is good at the science taught in this chemistry/biology course is important to me.
5. Being good at the science I am learning in this chemistry/biology course is an important part of who I am.

Utility value

1. The things I learn in this chemistry/biology course are practical for me to know.
2. What I learn in this chemistry/biology course helps me in my daily life outside of school.
3. This chemistry/biology course will be useful for me later in life.
4. This chemistry/biology course is valuable because it will help me in the future.
5. Doing well in this chemistry/biology course will be important for my future.

Perceived Costs (Perez et al., 2014)

Effort cost

1. This chemistry/biology course requires more effort than I am willing to put into it.

2. The hard work needed to get through this chemistry/biology course will not to be worth it in the end.
3. For me, taking this chemistry/biology course is not worth the effort.
4. *I am not sure I've got the energy to do well in this chemistry/biology course.

Opportunity cost

1. I am concerned success in this chemistry/biology course requires that I give up other activities I enjoy.
2. I am concerned about losing track of some valuable relationships because of the work required for this chemistry/biology course.
3. This chemistry/biology course takes a lot of time away from other activities that I want to pursue.
4. I am concerned that I have to give up a lot to do well in this chemistry/biology course.

Psychological cost

1. I am concerned about being embarrassed if my work in this chemistry/biology course is inferior to that of my peers.
2. *I worry that others will think I am a failure if I do not do well in this chemistry/biology course.
3. I fear that I am not a good enough student to do well in this chemistry/biology course.
4. I am concerned that my self-esteem will suffer if I am unsuccessful in this chemistry/biology course.
5. I am anxious that I won't be able to handle this chemistry/biology course.

Stereotype Threat (Shapiro et al., 2011)

Self-reputation threat

I am concerned that my race,

1. will influence the way other people in this chemistry/biology course interact with me.
2. could lead me to be judged negatively by others in this chemistry/biology course.
3. could lead others in this chemistry/biology course to judge me based on the stereotypes about the people of my race.

Group-reputation threat

I am concerned that my actions in this chemistry/biology course,

1. will reinforce the negative stereotypes others have about people of my race.
2. might poorly represent people of my race to others.
3. might confirm the negative stereotypes others have about people of my race.

Intentions to Persist in STEM (Perez et al., 2014)

1. I am likely to leave my STEM major or STEM-related track. (Reversed)
2. I am likely to remain in my STEM-related major through to graduation or completion of my program of study.
3. I intend to switch to a major in the social sciences, arts, or humanities and/or leave my STEM-related track before I graduate or complete my program of study. (Reversed)

Demographic Questions

1. Please list your current or intended major (s).

2. What year are you in college?

☐Freshman
☐Sophomore
☐Junior
☐Senior

3. How old are you? (insert number in years)

4. Are you a first-generation college student (i.e., neither of your parents/guardians went to college)?

☐Yes
☐No

5. Are you a full-time or part-time student?

☐Full-time
☐Part-time

6. What is your gender?

☐Female
☐Male
☐Other (please specify)

7. Are you of Hispanic/Latino descent?

☐Yes
☐No

8. What is your race? (Please mark all that apply)

☐African American or Black
☐Asian, Pacific Islander, or Asian American
☐European American or White
☐Native American
☐Other (please list)

*Item was dropped after conducting confirmatory factor analysis.

VITA

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EDUCATION

Ph.D. Educational Psychology and Program Evaluation 2021
Old Dominion University, Norfolk, VA

M.S. Experimental Psychology 2015
Old Dominion University, Norfolk, VA

B.S. Clinical Psychology 2012
Allameh Tabataba'i University, Tehran, Iran

PROFESSIONAL EXPERIENCE

Research Scientist *2021 - Present*
Center for Advanced Study of Teaching and Learning, University of Virginia

Graduate Research Assistant 2015 - 2020
Darden College of Education and Professional Studies, Old Dominion University

Graduate Teaching Assistant 2014 - 2015
Psychology Department, Old Dominion University

HONORS AND AWARDS

Nominated for the APA Division 15 Poster Award. The Annual Meeting of the American Psychological Association, Chicago, IL (August 2019)

Outstanding Student Award. Old Dominion University, Darden College of Education and Professional Studies, Department of Educational Psychology and Program Evaluation, Norfolk, VA (April 2019)

AERA Division C Outstanding Poster Award. The Annual Meeting of the American Educational Research Association, New York, NY (April 2018)

APS Student Research Award. The Annual Convention of the Association for Psychological Sciences, Chicago, IL (May 2016).

PUBLICATIONS

Totonchi D. A., Derlega, V. J., & Janda, L. H. (2019). Implicit Sex Guilt Predicts Sexual Behaviors: Evidence for the Validity of the Sex-Guilt Implicit Association Test. Journal of Sex & Marital Therapy, 45(1), 50-59. https://doi.org/10.1080/0092623X.2018.1474409

Maduro, R. S., Derlega, V. J., Peterkin, A., Totonchi, D. A., Winstead, B. A., & Braitman, A. L. (2018). HIV nondisclosure and harm to sexual partners predict social evaluations and HIV stigma: Moral outrage and threat to self/others as mediators. Stigma and Health, 3(3), 265-274. https://doi.org/10.1037/sah0000097

Totonchi, D. A., & Glass, C. R. (2017). Inside Graduate Admissions: Merit, Diversity, and Faculty Gatekeeping by Julie R. Posselt. The Review of Higher Education, 40(4), 627- 630. https://doi.org/10.1353/rhe.2017.0026.

CONFERENCE PRESENTATIONS

Totonchi, D. A., Perez, T., Hall, K., & Braitman, A. (under review). Distinct stereotype threat perceptions: Longitudinal validation of a two-dimensional measure across two undergraduate science samples. Paper to be presented at the annual meeting of the American Educational Research Association, Virtual Conference, April 2021.

✢Totonchi, D. A., Lee, A. A., & Perez, T. (August, 2019). Is the relationship between stereotype threat and achievement goals reciprocal? Poster accepted to be presented at the annual meeting of the American Psychological Association, Chicago, IL. ✢APA Division 15 Poster Award Nominee.

✢Totonchi D. A., Perez, T., Lee, Y., & Linnenbrink-Garcia, L. (April, 2018). The Role of Stereotype Vulnerability in Minorities' Declining Science Motivation: A Parallel Growth Curve Analysis. Poster presented at the annual meeting of American Educational Research Association, New York, NY. ✢AERA Division C Best Graduate Student Poster Award.

Totonchi, D. A., Yue, Y., Perez, T., & Linnenbrink-Garcia, L. (August, 2018). The Impact of Undergraduate Research Experiences on STEM Motivation: A Qualitative Study. Poster presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

✢Totonchi, D. A., Janda, L. H., & Derlega, V. J. (May, 2016). Does Implicit Sex Guilt Predict Sexual Behaviors? Evidence for the Convergent Validity of the Sex Guilt Implicit Association Test. Association for Psychological Sciences, Paper presented at the 28th APS Annual Convention, Chicago, IL. ✢APS Student Research Award.