



## Changes in race and sex stereotype threat among diverse STEM students: Relation to grades and retention in the majors



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### ABSTRACT

In laboratory studies, induced stereotype threat shows negative effects on academic performance and learning. Is the relation between stereotype threat and grades robust in naturalistic settings, specifically in introductory STEM courses? We gathered data on two new measures we term race and sex stereotype bias, which were administered four times over the course of introductory chemistry and biology courses for STEM majors ( $N = 1358$ ). Patterns of growth for all stereotype bias measures showed a discontinuous pattern, with increases during each semester (fall and spring) and decreases between semesters. For all stereotype bias measures, sophomores scored significantly higher than freshmen, and juniors scored in between. For the sex stereotype bias measure, females scored significantly higher than males. There were no race or sex differences on slopes of growth; though groups began at different levels, all grew at the same rate. There was little relation between grades and stereotype bias when analyzed by race; Asian students showed the largest number of significant – albeit small – correlations (3) and Black students the fewest (none). Correlations between grades and sex stereotype bias were significant and negative – but small – only for males. Results support a point made by Steele in 1997 but neglected since then; stereotype threat may affect only a small sub-portion within stereotyped groups. We argue that variables other than stereotype threat might be better targets for research attempting to explain gaps in STEM achievement and retention.

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### 1. Introduction

Stereotype threat in academic contexts has become a prominent line of educational research. Stereotype threat is defined as a person's perception that his or her performance on a test will confirm others' stereotypes about the abilities of a group the person belongs to (Steele & Aronson, 1995). Stereotype threat has been found to have robust, though small, effects with students of different races, sexes, elderly participants, people with disabilities, and a multitude of other stereotyped groups (Nguyen & Ryan, 2008). Different studies have considered outcomes such as academic achievement, scores on various performance tasks, self-confidence, and other dependent variables (Nguyen & Ryan). Most studies of academic stereotype threat among students of diverse races and both sexes have been conducted at a relatively small scale, in laboratory settings, and at academically-elite institutions. In the present research, we build on recent questionnaire ap-

proaches to first measure *changes* in stereotype threat over an academic year. However, we use a new measure we call stereotype bias that incorporates perceptions due to both low and high performance. Second, we analyze sex differences in sex stereotype bias and race differences in race stereotype bias. Third, we investigate the relation of race and sex stereotype bias to course grades and retention in STEM majors.

#### 1.1. Stereotype threat in academic domains

We review the stereotype threat literature in terms of sample sizes/research contexts, instruments used to measure stereotype threat, themes in findings from laboratory studies, and themes in classroom-based stereotype threat research.

#### 1.2. Small samples, laboratory studies

Most stereotype threat research in academic domains has been conducted on a small scale because the dominant research paradigm is to induce stereotype threat in a stereotyped group, give a

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test or task, make the stereotype salient to the task, and ensure that the stereotyped group is isolated in the testing environment (e.g., ensure that there are no role models in the room). It is difficult to marshal the resources to conduct such studies on a very large scale. For example, in the early and highly-cited experiment by Steele and Aronson (1995; Experiment 2), Black and White college students were given the same GRE-type verbal questions under one of two conditions: diagnostic of ability or non-diagnostic. After accounting for SAT verbal scores, Black students scored lower in the diagnostic condition than in the non-diagnostic condition, whereas there was no difference for White students. The majority of threat-inducing studies consist of a single laboratory session, and use tests of cognitive abilities such as practice SAT or GRE problems, other math problems, or vocabulary tests. In other words, most of these studies have not examined the effects of stereotype threat in authentic outcomes (e.g., grades or retention) in authentic learning environments. A second type of research has tested short-term and long-term effects of threat-reducing interventions such as posting images of role models (e.g., Blanton, Crocker, & Miller, 2000), salience-reducing interventions such as delaying collection of demographic information (e.g., Danaher & Crandall, 2008), and interventions designed to reduce related beliefs such as the belief in fixed ability (e.g., Aronson, Fried, & Good, 2002). In the present research, we examine sex and race stereotype bias in a large sample of students from gateway STEM courses and relate findings to both grades and retention, thereby addressing the problems of research with small samples, in laboratory settings, and using experimenter-developed tests of outcomes.

### 1.3. Measures of stereotype threat

A growing number of researchers have developed questionnaires to measure stereotype threat in an effort to assess it in authentic educational settings, with more statistical power, and with larger samples of sub-populations. For example, Picho and Brown (2011) developed a measure they called the *Social Identities and Attitudes Scale (SIAS)* to test susceptibility to stereotype threat (e.g., “My gender influences how teachers interpret my behavior,” p. 398). The SIAS showed excellent reliability and validity with undergraduate students using Confirmatory Factor Analysis approaches, but the relation of SIAS scores to achievement was not tested, and the scale is not specific to STEM. In this study, we investigate stereotype bias longitudinally in an authentic learning environment with a large sample; however, we investigate stereotype bias in STEM specifically and relate this to achievement and retention.

### 1.4. Themes in findings from the laboratory-based stereotype threat literature

Overall, the findings from stereotype threat research are extremely robust, and while the effect sizes are small (Nguyen & Ryan, 2008 report  $d = .26$  in a meta-analysis), it has been argued that small effects early in education can have large cumulative effects over time (Yeager & Walton, 2011). Effects are found when tasks are difficult (but not when they are easy), when participants are identified with the domain (e.g., math majors completing a math task), and when participants are identified with the “threatened” group (e.g., female engineers for whom being female is a very important part of their identity; Aronson et al., 1999). A wide range of moderators of the effects of stereotype threat have also been investigated, including anxiety (e.g., Osborne, 2007), identification with the domain (Keller, 2007), identification with the group (e.g., Morgan & Mehta, 2004), working memory load of the task (e.g., Beilock, Rydell, & McConnell, 2007), and stereotype salience (e.g., Nguyen & Ryan, 2008).

### 1.5. Themes in findings from classroom-based longitudinal and intervention stereotype threat literature

Based on findings from laboratory studies, a few researchers have conducted stereotype-threat-based research in intact classrooms. In the present research, we did not implement an intervention, but a handful of intervention studies have examined the effect of manipulating stereotype-threat-related-variables on achievement/retention outcomes, so we review them here. Using data from the National Longitudinal Survey of Freshmen, Massey and Fischer (2005) found no relation between “performance burden” (e.g., “If I excel academically it reflects positively on my own group” p. 53) and end-of-freshman-year GPA. In a reanalysis of the same data, Fischer (2010) found a statistically significant but extremely small ( $b = -.001$ ) effect of performance burden on freshman GPA, and no effect on graduation after accounting for GPA. Using an undergraduate calculus sample at an elite institution, Good, Rattan, and Dweck (2012) found that sense of belonging in math settings fully mediated effects of perceived sex stereotyping on intention to take math courses, but this was true for both males and females equally. That is, hearing messages that women do not belong in math reduced sense of belonging for both male and female math students, and this reduced sense of belonging was associated with a lower intention to continue with math courses ( $\beta = -.17$  for the indirect effect). In addition to the mediated main effect of perceptions of stereotyping, this variable interacted with perceptions of entity (i.e., non-malleable math ability) messages from faculty, but only for females.

### 1.6. Interventions based on stereotype threat theory

A small number of non-laboratory studies have tested interventions to ameliorate effects of stereotype threat. One early experiment by Steele and colleagues (Steele, 1997) was a complex 10-week intervention for University of Michigan freshmen. Participants were sampled from admitted students, but underrepresented minorities were oversampled. Students lived together in a dormitory wing and participated in targeted academic “challenge” workshops in STEM or writing, together with weekly discussion groups that normalized the challenges of adjusting to college. There was a prior-achievement  $\times$  program interaction for Black participants: participating students with lower incoming SAT/ACT scores had first-semester GPAs that were similar to control students, but participating students with higher incoming scores had much higher first-semester GPAs compared to control students. Black program participants with high incoming scores showed no GPA difference from White program participants with high incoming scores, effectively eliminating expected effects of stereotype threat.

A second focus for interventions to reduce effects of stereotype threat is incremental-ability-beliefs treatments: inducing a belief that ability is malleable, and that a student can become more able in a subject. Aronson et al. (2002) had Stanford undergraduate participants write a ‘pen pal’ letter to a putative struggling middle-school student. Letters were either focused on malleable abilities or a control ‘multifaceted nature of intelligence’ condition. The malleable abilities intervention increased enjoyment of education and valuing of academics more for Black than White undergraduates, although the intervention did not affect stereotype threat scores. The intervention was associated with significantly higher GPA for Black undergraduates, but not for White undergraduates. In a follow-up study with University of Texas students (Good, Aronson, & Inzlicht, 2003), undergraduates engaged in e-mail-based and in-person mentoring of Black and Hispanic 7th graders from a rural school district. The year-long mentoring program included incremental-beliefs messages (as in Aronson et al., 2002),

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