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ORIGINAL ARTICLE

Implicit Science Stereotypes Mediate the Relationship between Gender and Academic Participation

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Abstract While the gender gap in mathematics and science has narrowed, men pursue these fields at a higher rate than women. In this study, 165 men and women at a university in the northeastern United States completed implicit and explicit measures of science stereotypes (association between male and science, relative to female and humanities), and gender identity (association between the concept "self" and one's own gender, relative to the concept "other" and the other gender), and reported plans to pursue science-oriented and humanities-oriented academic programs and careers. Although men were more likely than women to plan to pursue science, this gap in students' intentions was completely accounted for by implicit stereotypes. Moreover, implicit gender identity moderated the relationship between women's stereotypes and their academic plans, such that implicit stereotypes only predicted plans for women who strongly implicitly identified as female. These findings illustrate how an understanding of implicit cognitions can illuminate between-group disparities as well as within-group variability in science pursuit.

Keywords Gender stereotypes · Science and mathematics · Implicit stereotypes

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Introduction

Harvard University recently granted tenure to Sophie Morel, making her the university's first tenured female research professor in the mathematics department (Lewin, 2010). This "first" −374 years after the university's founding— is all the more notable given Harvard's position at the center of a spirited discussion several years before Morel earned tenure: In 2005, Harvard's then-president Lawrence Summers postulated that "issues of intrinsic aptitude" were the primary cause of the gender disparity in sciences, adding that while "no doubt there is some truth" to a "socialization" explanation, he "would be hesitant about assigning too much weight to that hypothesis" (Summers, 2005, para. 5–6).

Despite Summers' minimization of the effects of social factors, we review several ways in which contemporary social psychology suggests that socialization —in the form of situational cues in the local environment or learned attitudes and beliefs that develop over time— affects academic choices and behaviors. Notably, people can simultaneously hold both *explicit* and *implicit* evaluations or beliefs (Wilson et al., 2000). The former are generally self-reported or verbalized attitudes or beliefs, whereas the latter are relatively less conscious and must be assessed via indirect measures. These *implicit social cognitions* stem from "introspectively unidentified (or inaccurately identified) traces of past experience" (Greenwald & Banaji, 1995, p. 8). In turn, these implicit attitudes and beliefs influence behavior in ways distinct from their explicit counterparts (Greenwald et al., 2009).

The current research focuses on the role of implicit stereotypes of science as a male domain (operationalized here as the strength of association between *science* and *male* relative to *humanities* and *female*) in men and women's differential levels of scientific participation. We build on studies demonstrating such stereotypes' role in academic choices and performance among American women and men (e.g., Nosek et al., 2002). The first focus is on individual variability — we test whether the implicit stereotype associating *science* more with *male* (than *female*) predicts individuals' plans to continue in scientific fields. Next, we take a group-level perspective and directly test whether the disparity between the academic choices of men and women can be accounted for by implicit stereotypes. Finally, we look at variability within each gender to explore who is most affected by implicit stereotypes. In this vein, we expect that implicit gender stereotypes will be most relevant for people who are strongly implicitly identified with their gender. Thus, we expect that implicit stereotypes about gender and science will best predict behavior for people with particularly strong implicit ties between themselves and their gender. The current work was conducted in the United States, and unless otherwise noted, the literature reviewed draws on American or Canadian samples. We address the extent to which the processes observed in the current work may or may not generalize to other cultural contexts in the Discussion.

Gender and Science

Harvard's mathematics department is not unusual — women comprise only 17% of tenured or tenure-track mathematics professors in the United States (National Science Foundation, 2008a). While mathematics has a particular paucity of women compared to some scientific fields, and the gender gap becomes larger at successive stages of academic or career development, a similar pattern is seen at earlier levels of education and training, and in other science, technology, engineering, and mathematics (STEM) fields. Although the gender gap in the sciences has narrowed over the past several decades (Else-Quest et al., 2010; Hyde & Mertz, 2009), men continue to pursue science at greater rates than women at almost all levels of education and career stage. In 2008, women earned approximately 19% of undergraduate and 21% of doctoral degrees in engineering, 44% of undergraduate and 31% of doctoral degrees in mathematics, and 18% of undergraduate and 21% of doctoral degrees in computer science (Snyder et al., 2009; National Science Foundation, 2008b). Women remain a minority in post-high school STEM fields except for biology (in which they earned 60% of undergraduate degrees and approximately half of doctoral degrees in 2008; Snyder et al., 2009; National Science Foundation, 2008b).

When Allport (1954/1979) observed that stereotypes "are socially supported, continually revived and hammered in" (p. 200), he was capturing the reality that stereotypes reflect the world around us. Indeed, people quickly detect associations between social groups and particular traits (Gawronski & Bodenhausen, 2006; Mitchell et al., 2003; Olson & Fazio, 2001), but are slow to unlearn them, even when presented with contradictory evidence (Gregg et al., 2006). Given the preponderance of men in STEM fields, it is unsurprising that men and women tend to report that they associate science with male more than with female (Nosek, Smyth, et al., 2007).

These stereotypes both reflect and perpetuate women's underrepresentation in STEM fields. Highlighting the stereotype that women are not as mathematically or scientifically able as men causes women's interest and performance in STEM fields to suffer. For example, exposure to media coverage about gender differences in mathematical reasoning ability reduced mothers' estimates of their daughters' math abilities (Jacobs & Eccles, 1985), which is particularly notable since mothers' beliefs about daughters' (but not sons') abilities predicted their likelihood of pursuing a science career over a decade later (Bleeker & Jacobs, 2004). Research on stereotype threat (e.g., Logel et al., 2009; Spencer et al., 1999) makes clear that even subtle reminders of stereotypes alter academic performance and goals. Women's performance on quantitative tests was impaired after they were reminded about gender differences in performance (Spencer et al., 1999), were told that a measure was diagnostic of ability (Marx & Stapel, 2006), or watched gender-stereotyped advertisements (Davies et al., 2002; see Eriksson & Lindholm, 2007; Keller & Dauenheimer 2003; and Marx et al., 2005 for evidence of stereotype threat in Swedish, German, and Dutch samples, respectively). Cues about the gender disparity in STEM fields also incur costs. American women performed worse on a math test when they believed they were the sole woman completing it among a group of men, compared to when they thought they were completing it among other women (Sekaquaptewa & Thompson, 2003), and reminders of the disproportionately male nature of STEM fields decreased women's interest in participating in STEM activities and sense that they belong in such fields (Murphy et al., 2007).

The Role of Implicit Stereotypes in STEM Performance and Participation

Stereotypes' consequences seem all the more pernicious given that even people who repudiate them are vulnerable to their consequences. Although stereotypes that "men do science" are widespread, people report low personal endorsement for them (e.g., Schmader et al., 2004; cf Nosek et al., 2002 for a situation in which greater stereotype endorsement was observed). That is, people tend to report low levels of explicit stereotyping.

On the other hand, technologies that circumvent direct self-reports and measure implicit cognitions reveal that people can simultaneously hold implicit stereotypes and cognitions that diverge from their explicit ones. Implicit and explicit cognitions are frequently dissociated from one another (Cunningham et al., 2004; Hofmann et al., 2005) and appear to represent distinct, but related, constructs (Cunningham et al., 2001; Nosek & Smyth, 2007). A recent meta-analysis (Greenwald et al., 2009) of 184 independent samples representing over 14,000 subjects revealed that while both explicit and implicit attitudes and stereotypes (as assessed by the Implicit Association Test [IAT]; Greenwald et al., 1998) predicted behavior, they also explained unique variability in behavior. Moreover, implicit attitudes and stereotypes predicted behavior better than their explicit counterparts in socially sensitive domains such as those relating to stereotyping and prejudice.

Sincere and conscious beliefs that men and women are equally well-suited for STEM fields do not preclude internalization of these beliefs at a less conscious level. Even people who consciously disavow the notion that men are better-suited than women for STEM fields often exhibit strong implicit stereotypes of science as a male domain: 72% of nearly 300,000 visitors to a public website exhibited this stereotype (Nosek, Smyth, et al., 2007). Moreover, these implicit stereotypes predict individuals' academic performance and behaviors. While men with stronger *math* = *male* associations tended to perform better on the Math than the Verbal section of the Scholastic Aptitude Test (SAT), women with stronger such associations showed the opposite pattern (Nosek et al., 2002). Additionally, women with stronger implicit stereotypes of science as male were less engaged in science and believed themselves to be less capable in math. Men with stronger implicit stereotypes, in contrast, participated more in science and reported that they were more math-capable (Nosek & Smyth, 2011). Finally, women with more stereotype-consistent associations at the semester's start performed worse in a Calculus course than women with weaker such associations (Kiefer & Sekaquaptewa, 2007).

Such findings led an NSF-sponsored report by the Association of American University Women on the gender gap in STEM to conclude that "the implications of this research for women in science and engineering are significant. Implicit biases against women in science may prevent girls and women from pursuing science from the beginning, play a role in evaluations of girls' and women's course work in STEM subjects, influence parents' decisions to encourage or discourage their daughters from pursuing science and engineering careers, and influence employers' hiring decisions and evaluations of female employees" (Hill et al., 2010, p. 78).

While existing research has demonstrated that implicit math or science stereotypes explain individual variability, the current research tests whether implicit stereotypes account for the large gender gap in STEM participation. An intriguing recent study suggests that this may be the case. Nosek and colleagues (2009) showed that these stereotypes explain *group*-level (rather than *individual*-level) variability in STEM performance. First, they found that implicit *science* = *male* associations were exhibited at the mean level in 34 countries from all six permanently inhabited continents (Nosek et al., 2009). The magnitude of this stereotype varied among nations, ranging from large (the lowest average IAT *D* score in Jordan of .26 translates to a Cohen's *d* score of approximately .74) to even larger (the average IAT *D* score in Tunisia of .65 translates to a *d* score of approximately 1.77). Crucially, countries with stronger average implicit stereotypes had larger gender gaps on standardized measures of scientific and mathematics performance. This finding suggests that implicit stereotypes account not just for some of the variability in peoples' individual choices, but also for some of the group-level difference between men and women's behavior. Additionally, these data reveal the robust nature of these stereotypes cross-nationally, and illustrate how their effects on men and women's academic and career choices operate across diverse nations.

Who is Most Susceptible to Stereotypes?

In addition to understanding variation between men and women, we examine within-gender variation to detect who is most susceptible to implicit stereotypes' effects. Implicit biases do not inevitably lead to behavior — the link between implicit bias and behavior is attenuated by factors such as motivation to be unbiased (Olson & Fazio, 2004) and ability to control the behavior (Dasgupta & Rivera, 2006). We explore whether a person's implicit self-concept can moderate the relationship between stereotypes and one's own behavior. We focus on the strength of ties to one's own gender as a potential moderator of the stereotype-behavior link.

People who are not very identified with their group may be less susceptible to group stereotypes. For example, if a person does not classify himself as a Star Trek fan, then reminders of "Trekkie" stereotypes may have relatively little impact on his behavior. In contrast, stereotypes would be highly applicable for a person strongly identified as a "Trekkie," and such a person might be more likely to be affected by "Trekkie" stereotypes. Several studies have shown this pattern. For example, compared to women low in gender identification, those who were highly gender-identified were more impaired by a threatening situation on a quantitative test. High (but not low) female-identified women performed worse than high male-identified men when they believed that their score would be used as an index of women's (or men's) math ability, and that test scores would be compared by gender (Schmader, 2002). Similarly, only women high in female identity completed fewer math problems after being told that a test would evaluate the performance of males and females. (In contrast, gender identification did not moderate performance when the threat was directed to the individual self rather than the gender as a whole [Wout et al., 2008]).

These findings are consistent with ideas predicted by Greenwald et al.'s (2002) reformulation of classic theories of cognitive consistency that explains relationships among triads of implicit cognitions (Festinger, 1957; Heider, 1958). Greenwald et al.'s theory suggests that self-related cognitions will tend toward a balanced state, such that the third in any of triad of cognitions is a function of the other two. In short, it predicts that the extent to which people self-stereotype is a function of both the strength of the group stereotype and their identification with the group, an idea succinctly summarized in Nosek et al.'s (2002) paper title *Math = Male, Me = Female, therefore Math ≠ Me* (p. 44). In this work, implicit math identity (*math = self* associations) was positively related to men's implicit gender identity (*male = self* associations) but negatively related to women's implicit gender identity (*female = self* associations). Additionally, implicit stereotypes most strongly covaried with prior performance among people with strong implicit links to their gender. In other words, people with strong ties to their gender seemed to be most affected by gender stereotypes.

Overview of the Current Research

The current research focuses on the role of implicit academic stereotypes and gender identity in students' academic choices. The first goal is to extend prior findings about the role of implicit stereotypes in math performance to the pursuit of science more broadly. Our first hypothesis therefore suggests that plans to pursue STEM and implicit science stereotypes will be gendered, such that men are more likely than women to intend to engage in STEM activities and to associate science with their group. Moreover, implicit STEM stereotypes will predict individuals' plans to pursue STEM. It has the following four components:

Hypothesis 1a We expect that both men and women will hold implicit stereotypes about gender and science. Specifically, we predict that people will find it easier to associate *male* with *science* and *female* with *humanities* than vice versa, reflecting the culturally prevalent belief that men, more than women, are tied to science.

Hypothesis 1b Similarly, we anticipate that participants will be implicitly identified with their own gender (that is, they will show a strong association between "own gender" and "self").

Hypothesis 1c Consistent with prior work, we predict that compared to women, men will be more likely to plan to participate in STEM activities and less likely to participate in humanities activities.

Hypothesis 1d Individual variability in implicit stereotypes will predict individuals' plans to persist in STEM. Specifically, men with stronger *science = male* stereotypes will be more likely to pursue STEM fields, whereas women with stronger such associations will be less likely to pursue STEM fields.

In addition, we take a different tack in this study by exploring implicit stereotypes' role in group-level differences in academic participation. This approach gives rise to our second hypothesis:

Hypothesis 2 Implicit science stereotypes will explain the *group* gender gap in science participation. In other words, implicit science stereotypes will mediate the relationship between gender and planned STEM participation.

Next, this research seeks to understand who is most likely to be affected by implicit stereotypes. The assumption that implicit stereotypes will be most self-relevant for people who are strongly identified with their gender leads to our final hypothesis:

Hypothesis 3 Implicit stereotypes will be most closely related to behavior for men and women who are high in *gender identity* (the extent to which people automatically associate their own gender with the concept "self," as measured by the IAT).

We also consider the role of explicit forms of each of the relevant constructs to allow for comparison of the effects of implicit and explicit cognitions.

Method

Participants

Two hundred and thirty-four first-year undergraduate students from a private university in the northeastern United States completed an online study in exchange for course credit or monetary compensation. Participants were also entered into a lottery to win an iPod. Participants were recruited through Introduction to Psychology courses, campus flyers, Facebook advertisements, and email solicitations. Advertising materials stated that the experiment was a study of academic attitudes and beliefs. Although all participants indicated they were 18 years of age or older at the study's onset, 18 participants who later reported that they were 17 years old were not included in data analysis. Of the remaining participants, 51 did not indicate their gender and were excluded from the analyses, yielding a total sample of 77 male and 88 female participants (98 Caucasian, 41 Asian or Pacific Islander, eight African-American, eight Hispanic, and 10 participants of other or unreported ethnic background). Participants' ages ranged from 18 to 22 years old (M=18.28, SD=.65). In all analyses, male was coded as 0 and female was coded as 1.

Materials

Implicit Measures As part of a larger, longitudinal study (Lane & Driver-Linn, 2008), participants completed IATs assessing academic stereotypes (*science* = *male* associations relative to *humanities* = *female* associations) and implicit gender identity (*self* = *female* associations relative to *self* = *male* associations). Although not of central interest in the current work, participants also completed IATs measuring implicit self-esteem and academic attitudes.

The IAT (for reviews, see Lane et al., 2007; Nosek, Greenwald and Banaji 2007) measures the relative strength of association between concepts. For example, to measure the extent to which people hold the implicit stereotype associating *male* with *science* relative to *female* with *humanities*, participants classify items related to *male* or *science* with one response and *female* or *humanities* with the other (denoted as the *male* + *science* block). In a second set of pairings, science and humanities switch, and participants classify items related to *male* or *humanities* with one response and *female* or *science* with the other (denoted as the *female* + *science* block). The task's logic rests on the assumptions that people will categorize items more easily when closely-associated categories share a response than when they do not, and that people complete cognitively easier tasks more quickly and accurately than they do difficult tasks. In this example, faster responses when *science* and *male* share one response (and *humanities* and *female* the other) than when *science* and *female* share one response (and *humanities* and *male* the other) would indicate a stronger association between *science* with *male* than with *female*. In other words, this pattern would reveal implicit stereotypes consistent with the belief that science is a male domain.

The *science stereotype* IAT assessed relative strength of associations between the categories *male* and *female* and the categories *science* and *humanities* as described above. *Male* stimuli included items such as "father" and "brother." *Female* stimuli included items such as "mother" and "sister." *Science* and *humanities* were represented by common academic fields, such as "chemistry" and "biology" for *science* and "classics" and "literature" for *humanities.*

The *gender identity* IAT assessed the relative strength of associations between the categories *male* and *female* and *self* and *other*. Gender categories were represented with the same stimuli used in the science stereotype IAT; *self* and *other* were represented with words such as "me," "my," and "mine" and "they," "them," and "theirs," respectively.

IAT stimuli appeared serially in the middle of the screen. Participants sorted items into their appropriate categories by pressing the "E" key for stimuli belonging to categories on the left and the "I" key for stimuli belonging to categories on the right. Whenever participants categorized a stimulus incorrectly, the letter "X" would appear and remain on the screen until the word was sorted correctly.

To calculate the IAT's reliability, we created five parcels of trials for each IAT that were then treated as individual items in calculating Cronbach's alpha. The science stereotype IAT (α=.80) and gender identity IAT (α=.86) showed strong internal consistency.

Explicit Measures Participants completed explicit measures that corresponded to the IATs. Explicit gender identity was assessed with three items adapted from the Identity subscale of Luhtanen and Crocker's (1992) Collective Self-Esteem Scale. Participants rated the extent to which they agreed or disagreed with the following statements: 1. Overall my gender has very little to do with who I am (reverse-coded); 2. My gender is unimportant to what kind of person I am (reverse-coded); and 3. In general, being a man or woman is an important part of my self-image, on a Likert-type scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). The average of these responses comprised the composite measure of explicit gender identity (α=.71).

Explicit science stereotypes were measured with four items. Participants indicated agreement with the following statements: "Men are just better at science than women" and "If I were having trouble with a math problem, I would go to a man instead of a woman for help" on the Likert-type scale described above. They also indicated the extent to which they thought the genders differed in skill at sciences and humanities on a scale from 1 (Men much better) to 5 (Women much better). The difference between responses to these questions provided an index of beliefs about the relative strengths of men and women. Standardized values of this difference score and the first two questions were averaged to provide an index of explicit stereotypes (α=.72), with higher scores reflecting more endorsement of the stereotype that men are better than women at science.

Behavioral Intentions Participants indicated their likelihood of pursuing STEM-related activities in college on three questions: 1. I will concentrate in math or a science-related subject; 2. I enjoy reading science literature or watching science programs even if they're not required; and 3. I doubt I will attend many science lectures out of those required for my courses (reverse-coded), α=.74. Participants also reported intentions to pursue humanities by agreeing or disagreeing with the items "I will concentrate in a humanities subject" and "I enjoy reading literature or watching programs related to the humanities even if they're not required." The use of only two items for this scale yielded a metric with relatively low reliability, α=.48. Importantly, this reduction in reliability would only work against our hypothesis, as it would make it more difficult to detect relationships between this variable and stereotypes.

Demographic Measures Participants also reported their gender, ethnicity, age, and year in school.

Procedure

Participants visited a secure website to begin the study at a time and location of their choosing during the first few weeks of the fall semester. After providing informed consent and indicating if they wished to receive payment or course credit, the study began. IATs were presented in random order, with the order of each IAT (e.g., whether the *science* + *self* or *science* + *other* block appeared first) also randomized. Participants next completed the explicit measures, reported their academic intentions, and provided demographic information.

Results

IAT Scoring

IAT scores were calculated according to procedures suggested by Greenwald et al. (2003). The *D* value (IAT effect) was obtained by first calculating mean response latencies for the combined blocks (e.g., *science* + *male, science* + *female*), and calculating the difference between these means. Mean differences were divided by the pooled standard deviations of response latencies. These calculations were performed separately for the first 24 and last 24 trials for each IAT—their average provides the *D* score, which is a standardized measure of the strength of association. Scores were coded such that higher scores indicated stronger associations between *science* and one's *own gender* (implicit stereotype) or between *self* and one's *own gender* (implicit gender identity). IATs where more than 10% of response latencies were less than 300*ms* were excluded from the analysis (three stereotype IATs and six gender identity IATs), as were any IATs that were not completed.

Gender Differences

We first conducted a multivariate analysis of variance (MANOVA) on the key variables to test for gender differences. A highly significant main effect of gender, $F(6, 145)=13.45$, $p<.0001$, emerged across the primary six variables (implicit and explicit stereotypes and gender identity; planned pursuit of science and humanities). Means and standard deviations by gender are presented in Table 1.

Gender Stereotypes and Identity Hypothesis 1a anticipated that men and women would exhibit strong implicit *science* = *male* stereotypes. Consistent with this prediction, both men and women exhibited robust stereotypic associations linking *male* and *science* relative to *female* and *humanities.* This effect was manifested in a large difference, partial η^2=.33, in the extent to which they associated academic domains and their own gender, such that men showed strong associations between science and their own gender, d=.68, whereas women showed associations in the opposite direction of a similar magnitude, $d=-.70$.

In contrast, men and women did not report differential associations between science and their own gender, partial η^2=.00. As in prior work, the correlation between implicit and explicit stereotypes was weak but positive (and marginally significant), $r(158)=.13$, $p=.10$, such that participants with stronger explicit academic stereotypes also tended to show stronger implicit stereotypes. Because the means presented in Table 1 represent standardized values, we report here the individual items to illustrate the relatively low (but mixed) levels of explicit stereotyping in the sample. Participants disagreed with the statement "Men are just better at science than women," (M=2.70, SD=1.75), $t(163)=-9.57$, $p<.0001$, $d=-.75$, although women (M=2.22, SD=1.56) disagreed more strongly with this statement than men (M=3.23, SD=1.80), $t(162)=3.87$, $p=.0002$, $d=.61$. Similarly, on average, participants disagreed with the statement "If I were having trouble with a math problem, I would go to a man instead of a woman for help," (M=3.48, SD=1.73), $t(164)=-3.82$, $p=.0002$, $d=.30$. Women also disagreed more strongly with this item, $t(163)=3.41$, $p=.0008$, $d=.63$. In contrast, the difference between responses to the questions "Do you think men or women are much better at science?" and "Do you think men or women are much better at the humanities?" revealed that participants reported that men were relatively better at science and women at humanities. Higher scores indicate a stronger belief that men are better at science and women

Table 1 Means and Standard Deviations by Gender

	Men		Women		Multivariate Analysis of Variance (MANOVA)		
	M	SD	M	SD	F-value	df	Partial η^2
Implicit Science Stereotype (Science and Own Gender Association)	.32	.47	−.32	.46	72.99****	(1,150)	.33
Implicit Gender Identity (Self and Own Gender Association)	.36	.44	.45	.40	1.72	(1,150)	.01
Explicit Science Stereotype	.18	.79	.15	.74	.07	(1,150)	.00
Explicit Gender Identity	4.77	1.47	4.59	1.43	.53	(1,150)	.00
Plans to Pursue Humanities	4.60	1.35	5.20	1.47	6.78**	(1,150)	.04
Plans to Pursue Science	4.43	1.78	3.85	2.06	3.44+	(1,150)	.02

Implicit scores are IAT D scores, ranging from −2 to +2; higher numbers reflect stronger associations as listed. Explicit stereotypes are the average of standardized values of individual items, and do not indicate absolute levels of stereotype endorsement. Higher values indicate stronger associations between science and one's gender. Explicit gender identity reflects the average of three explicit identity items on a 1 to 7 Likert-type scale; higher numbers indicate stronger identity with one's gender. Academic plans indicate stronger intentions to pursue humanities or sciences on 1 to 7 Likert-type scales; higher numbers indicate greater intent to pursue the relevant discipline. Differences between men and women were tested with a MANOVA, which revealed a significant main effect of gender, F (6, 145)=13.45, p<.0001

+p<.10. *p<.05. **p<.01. ***p<.001. ****p<.0001

are better at humanities. People responded in stereotype-consistent ways (M=.62, SD=.87), t (163)=9.11, p<.0001, d=.71. Men and women reported similarly strong endorsement of these stereotypes, t (162)=−.16, *ns*, d=.03. Analysis of the individual items indicated that participants believed that men were better at science (M=2.59, SD=.62), t (164)=−8.48, d=.66 and women were better at humanities (M=3.20, SD=.61), t (163)=4.23, d=.33. Men and women endorsed these beliefs equally, both ts≤.90, *ns*.

As predicted by Hypothesis 1b, men ($M_{implicit}$=.36; $M_{explicit}$=4.77) and women ($M_{implicit}$=.45; $M_{explicit}$=4.59) strongly identified with their own gender implicitly and explicitly. Neither effect varied by gender, partial η^2s<.01. Implicit and explicit gender identity were generally unrelated to each other, r (154)=.09, *ns*.

Behavioral Intentions Hypothesis 1c predicted that students' academic plans would mirror the distributions in these fields. Indeed, men (M=4.43) were marginally more likely than women (M=3.85) to report plans to pursue science, partial η^2=.02, whereas women (M=5.20) were more likely than men to plan to pursue the humanities (M=4.60), partial η^2=.04.

Individual Variation in Plans to Pursue STEM

Hypothesis 1d stated that variability in implicit stereotypes would predict students' academic plans. As seen in Table 2, implicit stereotypes predicted students' behavioral intentions, such that stronger associations between science and one's own gender (relative to humanities and the other gender) were positively related to students' plans to pursue STEM, r=.28, but negatively related to students' plans to pursue humanities, r=−.31. Inspection of the relationship between stereotypes and behavioral intentions by gender (Table 3) revealed that stronger associations between science and one's own gender predicted both men and women's plans to pursue science (r_{men}=.27, r_{women}=.20), but only men's plans to pursue humanities (r_{men}=−.31, r_{women}=−.15)

In contrast, explicit stereotypes were less tied to students' plans: They were dissociated from plans to pursue science in the overall sample, r=.07, as well as among men (r=.15) and women (r=.01). Overall, stronger explicit beliefs that one's gender was associated with science were negatively related with plans to pursue the humanities, r=−.16, although inspection of these relationships by gender revealed that explicit stereotypes predicted plans for men (r=−.31) but not women (r=−.04).

Implicit Stereotypes Account for Between-Group Differences in Academic Plans

Thus far, we have focused on *individual-level* variability. We now consider *group-level* differences in stereotypes and academic plans. We focus on implicit stereotypes, which were a more robust predictor of students' academic plans than their explicit counterparts. The central analysis tested Hypothesis 2, which stated that implicit stereotypes would account for the group-level difference in students' academic choices. To simplify the analyses, we calculated the difference between plans to pursue sciences and plans to pursue humanities for each student, such that higher values indicated greater intention to pursue science than humanities. Given that the choice of one academic major over another often (although not always) precludes study of

Table 2 Relationships among Implicit and Explicit Measures of Stereotyping, Gender Identity, and Students' Academic Plans for All Participants

	Implicit stereotype	Implicit gender identity	Explicit stereotype	Explicit gender identity	Science pursuit	Humanities pursuit	Science-humanities pursuit
Implicit stereotype	1.00						
Implicit gender identity	−.09	1.00					
Explicit stereotype	.13+	−.03	1.00				
Explicit gender identity	−.11	.09	.06	1.00			
Science pursuit	.28***	−.04	.07	−.02	1.00		
Humanities pursuit	−.31****	.16*	−.16*	.12	−.47****	1.00	
Science-humanities pursuit	.34****	−.11	.12	−.07	.90****	−.81****	1.00

Ns ranged from 153 to 165. Higher numbers on the stereotyping measures reflect stronger associations between science and one's own gender; higher numbers on the gender identity measures reflect stronger identity with one's gender. Science-humanities pursuit represents the relative intention to pursue science more than the humanities

+p<.10. *p<.05. **p<.01. ***p<.001. ****p<.0001

another, it is not surprising that these items were negatively related, r (161)=−.47, $p<.0001$. Analyses on individual constructs of "plans to pursue science" and "plans to pursue humanities" showed the same pattern as those on the difference scores.

A series of regressions tested whether implicit stereotypes explained men and women's differential plans to pursue science rather than the humanities (see Fig. 1; Baron & Kenny, 1986). As expected, the first regression showed that men were significantly more likely than women to pursue science rather than humanities, $\beta=-.22$, $F\,(1, 154)=7.91$, $p=.01$. As indicated above, the second regression revealed that men were far more likely than women to associate their gender with science, $\beta=-.58$, $F\,(1, 154)=77.42$, $p<.0001$. Additionally, students with higher scores on this potential mediating variable—*own gender=science* associations—were more likely to plan to pursue science rather than humanities, $\beta=.34$, $F\,(1, 154)=20.11$, $p=.0004$. The final stage of the mediational analysis tested for the effects of the original predictor (gender) on behavior (students' academic plans) after controlling for the mediator (implicit stereotypes). Remarkably, this analysis revealed that the robust effect of gender on students' intended academic pursuits completely dissipated, $\beta=-.04$, *ns*, after controlling for implicit stereotypes, Sobel $z=3.19$, $p=.001$. In other words, on a group level, if the effect of implicit stereotypes were removed, women and men were equally likely to plan to pursue science over humanities.

The relationship between stereotypes and behavior is likely bidirectional: While stereotypes can shape behaviors, behaviors in turn can shape stereotypes. Because it is plausible that students' implicit stereotypes change in a way congruent with their future plans, we next tested whether students' academic plans mediated the relationship between gender and implicit stereotypes. The first two requirements for mediation—demonstrating the relationships between a. gender and

Table 3 Relationships among Implicit and Explicit Measures of Stereotyping, Gender Identity, and Academic Plans for Women (Above the Diagonal) and Men (Below the Diagonal)

	Implicit stereotype	Implicit gender identity	Explicit stereotype	Explicit gender identity	Science pursuit	Humanities pursuit	Science-humanities pursuit
Implicit stereotype		−.05	−.19+	−.26*	.20+	−.15	.22*
Implicit gender identity	.00		.04	.21+	−.10	.19+	.17
Explicit stereotype	.10	−.02		.10	−.01	.04	−.03
Explicit gender identity	−.07	−.02	.22*		−.01	.20+	−.1
Science pursuit	.27*	.06	.15	−.08		−.37***	.89****
Humanities pursuit	−.31**	.09	−.31**	.06	−.58****		−.75****
Science-humanities pursuit	.32**	.00	.25*	−.08	.92****	−.86****	

Correlations for women are presented above the diagonal; correlations for men are below the diagonal. *N*s ranged from 82 to 88 for women and 74 to 77 for men. Higher values on the stereotyping measures reflect stronger associations between science and one's gender; higher values on the gender identity measures reflect stronger identity with one's gender. Science-humanities pursuit represents the relative intention to pursue science more than the humanities.

+p<.10. *p<.05. **p<.01. ***p<.001. ****p<.0001.

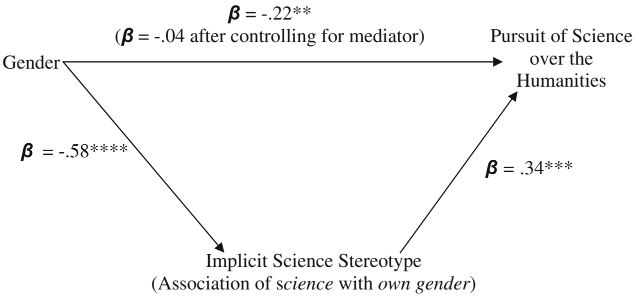

Fig. 1 Implicit stereotypes mediate the relationship between gender and students' plans to pursue science or humanities. After controlling for implicit stereotypes, gender no longer predicted students' academic plans. * p<.05 ** p<.01 *** p<.001 **** p<.0001

implicit science stereotypes; and b. plans to pursue science and implicit science stereotypes, have been established. The final and critical regression found that students' gender ($\beta = -.53$, $p < .0001$) and academic plans ($\beta = .22$, $p = .001$) continued to predict implicit stereotypes even when controlling for behavioral intentions. Although the decrease in the effect of gender on implicit stereotypes appears slight (from −.58 to −.53) after controlling for students' plans, this reduction represents partial mediation (Sobel $z = 2.17$, $p = .03$), suggesting, as might be expected, that some portion of the relationship between gender and implicit stereotypes is accounted for by students' own academic behaviors.

Who is Most Affected by Implicit Stereotypes?

The preceding mediational analyses showed that the between-group difference in academic participation are explained by men's and women's implicit stereotypes. We now ask whether within-group individual differences predict which men and which women are more likely to behave consistently with their implicit stereotypes. Drawing on cognitive consistency theories, Hypothesis 3 predicted that gender stereotypes will best predict behavior for people who are strongly identified with their gender.

To test this hypothesis, we regressed gender, gender identity, implicit stereotypes, and all of their two- and three-way interactions onto students' academic plans. This model explained a significant amount of variance in students' plans, *Adjusted* $R^2 = .12$, $F\,(7, 144) = 3.85$, $p = .001$. Science stereotypes were a significant predictor of students' plans, $\beta = .49$, $p = .003$, such that people with stronger associations between science and their own gender (compared to humanities and the other gender) were more likely to plan to pursue science rather than the humanities. This main effect was qualified by a two-way interaction between implicit stereotypes and gender, $\beta = -.37$, $p = .03$, and a three-way interaction between gender, implicit stereotypes, and implicit gender identity, $\beta = .47$, $p = .02$. No other main effects or interactions were significant. To better understand the nature of these interactions, we next examined the effects of implicit gender identity, stereotypes and their interaction on behavior separately for men and women.

First, we considered the main effects of implicit stereotypes and gender identity on women's academic plans (Table 4). Taken together, these variables explained a marginally significant amount of variance in students' plans, *Adjusted* $R^2 = .04$, and implicit stereotypes were a marginally significant predictor of students' plans, $\beta = .20$. Adding the interaction to the model explained significantly more variance, *Change in Adjusted* $R^2 = .04$. While the main effects of implicit stereotypes and gender identity no longer predicted students' plans (absolute values of both βs<.06), their interaction did, $\beta = .39$, $p = .05$. As seen in Fig. 2, simple slope analyses (Aiken & West, 1991) revealed that, among women relatively weakly implicitly identified with female, implicit stereotypes were unrelated to academic plans, $\beta = -.03$, *ns*. In contrast, among women strongly implicitly identified as female, stronger associations between *female* and *science* predicted greater intent to pursue science over humanities, $\beta = .40$, $p = .01$.

On the other hand, analogous analyses for men revealed that their gender identity did not attenuate the relationship between implicit stereotypes and academic plans (Fig. 2). The first regression included the main effects of academic stereotypes and gender identity. As was observed among women, stronger associations between science and one's own gender predicted greater likelihood of pursuing science rather than the humanities, $\beta = .33$, *Adjusted* $R^2 = .08$, $F\,(2, 68) = 4.13$, $p = .02$. Inclusion of the interac-

Table 4 Beta Weights from Hierarchical Regression Predicting Academic Plans (Greater Planned Pursuit of Science than Humanities) as a Function of Implicit Stereotypes and Gender Identity

	Step 1			Step 2				
	Adj. R^2	Implicit Stereotype	Implicit Gender Identity	Adj. R^2	Change, Adjusted R^2	Implicit Stereotype	Implicit Gender Identity	Implicit Stereotype x Gender Identity Interaction
Women	.04	.20+	−.16	.08	.04*	−.06	.04	.39*
Men	.08	.33**	−.02	.09	.01	.43**	.09	−.22

+p<.10. *p<.05. **p<.01. ***p<.001. ****p<.0001

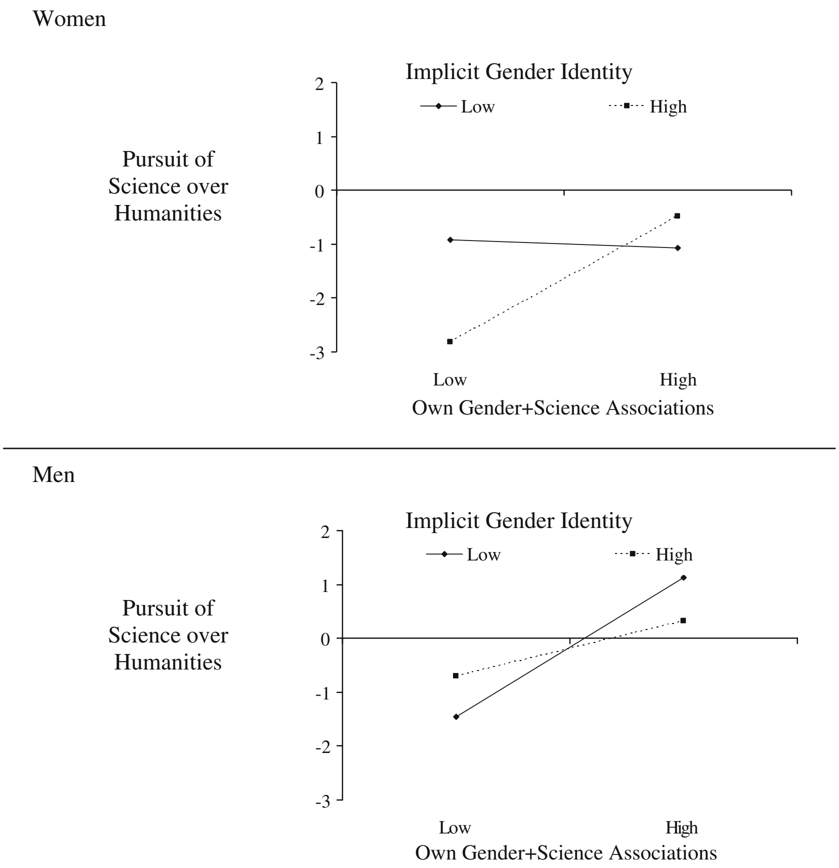

Fig. 2 Implicit gender identity moderates the relationship between implicit stereotypes among women (*top panel*), such that implicit stereotypes predicted plans among women strongly (but not weakly) identified with female. In contrast, implicit gender identity did not moderate the relationship between men's implicit stereotypes and behavior (*bottom panel*)

tion between implicit science stereotypes and gender identity did not explain significantly more variance than the main effects alone, *Change in Adjusted* $R^2 = .01$, $F(1, 67) = 1.96$, *ns.* Even when considering the interaction between implicit stereotypes and gender identity, the significant effect of implicit stereotypes on behavioral plans persisted, $\beta = .44$.

Discussion

In this study, male and female college students planned to pursue different academic fields – men were more likely to pursue science, and women were more likely to pursue humanities. Both men and women showed robust associations between *male* and *science*, with the result that men associated science with their own gender, while women did not. As predicted, these differential associations completely accounted for the gap in men and women's academic plans — after controlling for implicit stereotypes, gender itself was no longer related to students' planned behaviors. In contrast, explicit, or self-reported, stereotypes were less consistently related to students' academic plans. While prior work has demonstrated that implicit stereotypes predict individuals' academic choices and performance (e.g., Kiefer and Sekaquaptewa 2007; Nosek et al., 2002; Nosek & Smyth, 2011), these data demonstrate that they can also account for average differences between groups. The current study, coupled with recent work showing that national-level implicit stereotypes covary with national gender gaps in science participation and performance (Nosek et al., 2009), illustrates how individual differences in implicit stereotypes can translate into group-level disparities.

Additionally, the effects of implicit stereotypes on women's behavior varied by the strength of women's gender identity. Among women, implicit stereotypes predicted behavior only for those who were highly implicitly identified as female. In contrast, implicit stereotypes predicted men's academic plans regardless of their level of gender identity.

The Path from Gender to Implicit Stereotypes

Although the current work shows how implicit stereotypes account for the relationship between gender and participation in sciences and humanities, the route from gender to implicit stereotypes is certainly not a direct one. Young boys and girls are not born with differential associations between their own group and math or science, but rather learn them over time. Such associations appear to form early in students' educational experiences. American boys and girls in second grade showed associations between boys and math (Cvencek et al., 2011), and German fourth grade girls (but not boys) showed similar implicit stereotypes (Steffens et al., 2010). In the latter study, implicit stereotypes were absent in seventh grade but reemerged in ninth grade. In a large Internet-based sample, the *science=male* association was stronger in older participants than younger participants (Nosek, Smyth, et al., 2007). While the cross-sectional nature of these data precludes an understanding of whether differences across groups were due to generational differences or intra-individual development, they highlight the fact that implicit stereotypes are not a *fait accompli*. These studies illustrate the early appearance of the implicit stereotype that science is a male field, but also demonstrate its variability across the lifespan.

Even if implicit stereotypes are in place, they are not invariant (Blair, 2002; Gawronski & Bodenhausen, 2006). A recent meta-analysis (Lenton et al., 2009) showed that implicit gender stereotypes are susceptible to interventions designed to alter them. For example, although women at a coeducational and a single-sex college began first year with similarly strong *male=leader* (compared to *female=supporter*) associations, their stereotypes moved in different directions. In the second year, women at the coeducational college held stronger implicit stereotypes of male as leader than women at the single-sex school. Mediational analyses revealed that contact with women faculty explained the difference in attitudes in the sophomore year (Dasgupta & Asgari, 2004). However, two laboratory studies and a field study found that exposure to female scientists or math professors did *not* change implicit stereotypes about math and gender (Stout et al., 2011). These findings demonstrate both the possibility and challenge of altering long-entrenched stereotypes. Having a female calculus professor was associated with development of more positive implicit attitudes toward science and stronger implicit identity with the field. These shifts may provide what the researchers term "inoculation" against implicit stereotypes' consequences. Indeed, women with a female calculus professor engaged in the kinds of agentic academic behaviors that could serve to counter a negative stereotype, such as visiting office hours, asking questions in class, or exerting effort on a difficult test.

The Moderating Role of Gender Identity

We hypothesized that implicit stereotypes' effects would depend on gender identity, and that students with the strongest implicit ties to their own gender would be most susceptible to them. This prediction was supported for women, but not men.

Because of the correlational nature of our results, it is unclear whether lower levels of female identity protect women from the application of the *science=male* stereotype, or whether counter-stereotypic engagement with the sciences leads to lower levels of female identity. Findings suggest that the process is bidirectional. On one hand, women who are weakly gender-identified see science stereotypes as less self-relevant and do not apply them to themselves, as illustrated in findings that women who were most strongly gender-identified were most susceptible to threatening cues (Schmader, 2002; Wout et al., 2008). To the extent that women who are most weakly gender-identified are less affected by stereotypes about women in science, they may be less constrained by structural impediments to science pursuit. On the other hand, women who are engaged with STEM fields may, at least when situationally relevant, identify less with their gender. For example, women with a heavy load of math classes or who were placed under situational threat distanced themselves from feminine characteristics or behaviors such as being emotional, flirting, or wearing make-up that were believed to be negatively associated with scientific achievement (Pronin et al., 2004). While this kind of *identity bifurcation* may occur spontaneously in the face of threat, strategic compartmentalization of one's gender identity may also affect science performance. For example, making a positively-stereotyped social identity salient boosted both women's (Shih et al., 1999) and girls' (Ambady et al., 2001) performance on a math test.

Why did gender identity moderate the relationship between stereotypes and behavior among women but not men? This finding is puzzling, as both men and women tend toward consistency among their cognitions related to the self, math, and gender (Greenwald et al., 2002; Nosek et al., 2002). Members of positively-stereotyped groups (in this case, men) may rely less on strategies for distancing themselves from cultural beliefs than members of negatively-stereotyped groups (in this case women). College STEM majors in a physics class wrote about a value that was most or least important to them twice during the semester (thus affirming their global identity, which may reduce "the fear of being devalued based on a group identity" [Miyake et al., 2010, p. 1235]). This slight intervention reduced the gender gap in performance on exams and final grades—an effect "based more robustly on the affirmation's positive impact on women than on its [slight, and inconsistent] negative impact on men" (p. 1236). A similar approach mitigated the race gap in academic achievement by affecting Black, but not White, middle schoolers (Cohen et al., 2006). Taken together, these studies suggest that the consequences of positive self-stereotypes may be less fungible than negative self-stereotypes (see also Walton & Cohen, 2007, for a case in which an intervention affected the performance of Black, but not White, students).

Moreover, although much of the literature (and the current paper) discusses the stereotype as “science as a male domain,” the stereotype may be described with the less-palatable phrase “women are bad at science.” This latter statement may more accurately capture the folk psychology of stereotypes: When people were asked to list stereotypes about social groups, they were more likely to list the “intellectual weaknesses of females” (Aronson et al., 1999, p. 40). If men’s self-stereotypes about science are a function of women’s perceived deficiencies rather than their abilities, then their gender identification may not be relevant for their application.

Much of the first generation of research on implicit attitudes and stereotypes focused on the “if” question of whether implicit cognitions predict behavior (Greenwald et al., 2009). With that question answered in the affirmative, the current study joins a growing second generation of research showing that behavior is not destined solely as a function of implicit bias. The relationship between implicit cognitions and behavior is moderated by individual and situational differences in explicit (Dasgupta & Rivera, 2006; Olson & Fazio, 2004) and implicit (Glaser & Knowles, 2008) motivation to be non-biased, working memory capacity (Hofmann et al., 2008), and executive control (Wiers et al., 2009). Nosek et al. (2002) noted “that wanting and choosing can be firmly shaped by membership in social groups” (p. 58). The current study extends this conclusion by noting that “wanting and choosing” to travel one academic path or another are not simply products of group membership. Rather, individuals’ own particularly weak or strong ties with their groups —in conjunction with implicit beliefs about those groups— can mold and alter desires and plans.

Caveats

There are at least two caveats to this research. First, participants were predominantly European-American students enrolled at a private American university. The underlying process at the core of our findings —that implicit biases can influence behavior— has been demonstrated in several different nations, including Italy (voting behavior, Arcuri et al., 2008; Galdi et al., 2008), the Netherlands (mental health; Glashouwer & de Jong, 2010; Thush et al., 2007), Sweden (hiring behavior; Rooth, 2010), and Australia (job persistence, von Hippel et al., 2008; risk-taking behaviors, Molesworth & Chang, 2009). These data, coupled with findings that the *science = male* stereotype appears cross-nationally and correlates with nation-level gender gaps in science achievement (Nosek et al., 2009), offer reason to anticipate that implicit science stereotypes’ consequences are not limited to the cultural context or moment of the current study. At the same time, the burgeoning literature on moderators of the relationship between implicit cognitions and behavior makes clear that this process can be disrupted. To the extent that characteristics that countervail implicit stereotypes’ effects are embedded within particular cultures (or subcultures), their impact may be muted. Indeed, although tentative due to the sample size, Asian and Asian-American participants in the current work showed no relationship between *own gender= science* beliefs and plans to pursue science rather than the humanities (r=.03), whereas this relationship was robust for non-Asian participants (r=.42).

While the current research extends prior work that focused specifically on the *math = male* stereotype by measuring cognitions about science more broadly, this wider perspective may obscure important differences among scientific fields. Given the importance of stereotypes on math persistence (Nosek et al., 2002) and performance (Kiefer & Sekaquaptewa, 2007), the influence of stereotypes on engagement with particular scientific subfields may be moderated by the degree to which a field is (or is perceived as) quantitatively or computationally intensive. Finer grains of measurement of stereotypes may illuminate important differences among different scientific subfields. For example, people may not stereotype biology as a male field given the relatively equal distribution of men and women in these fields (National Science Foundation, 2008b), whereas the quintessential stereotype of a computer scientist is a nerdy male (Cheryan et al., 2009). We might expect, therefore, that implicit stereotypes of science as male may have greater influence on pursuit of computer science than biology.

Conclusion

The gender gap in scientific participation has received intense scrutiny (see Halpern et al., 2007 for a review), and discussions about the role of stereotyping and discrimination in this gap have sometimes been contentious. The longstanding focus on explicit stereotypes may have been a search for wrongs in all the wrong places. Even among people who disavow such stereotypes, implicit stereotypes are learned early and reinforced often. These individual stereotypes do not operate in a vacuum—the current work shows how, summed over large populations, individuals’ stereotypes can give rise to large group differences.

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References

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks: Sage.

Allport, G. W. (1979). *The nature of prejudice* (25th ed.). Cambridge, MA: Perseus Books.

Ambady, N., Shih, M., Kim, A., & Pittinsky, T. L. (2001). Stereotype susceptibility in children: Effects of identity activation on quantitative performance. *Psychological Science, 12*, 385–390. doi:10.1111/1467-9280.00371.

Arcuri, L., Castelli, L., Galdi, S., Zogmaister, C., & Amadori, A. (2008). Predicting the vote: Implicit attitudes as predictors of the future behavior of decided and undecided voters. *Political Psychology, 29*, 369–387. doi:10.1111/j.1467-9221.2008.00635.x.

Aronson, J., Lustina, M. J., Good, C., Keough, K., Steele, C. M., & Brown, J. (1999) When white men can't do math: Necessary and sufficient factors in stereotype threat. *Journal of Experimental Social Psychology, 35*, 29–46. doi:10.1006/jesp.1998.1371.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173–1182. doi:10.1037/0022-3514.51.6.1173.

Blair, I. V. (2002). The malleability of automatic stereotypes and prejudice. *Personality and Social Psychology Review, 6*, 242–261. doi:10.1207/S15327957PSPR0603_8.

Bleeker, M. M., & Jacobs, J. E. (2004). Achievement in math and science: Do mothers' beliefs matter 12 years later? *Journal of Educational Psychology, 96*, 97–109. doi:10.1037/0022-0663.96.1.97.

Cheryan, S., Plaut, V. C., Davies, P., & Steele, C. M. (2009). Ambient belonging: How stereotypical cues impact gender participation in computer science. *Journal of Personality and Social Psychology, 97*, 1045–1060. doi:10.1037/a0016239.

Cohen, G. L., Garcia, J., Apfel, N., & Master, A. (2006). Reducing the racial achievement gap: A social-psychological intervention. *Science, 313*, 1307–1310. doi:10.1126/science.1128317.

Cunningham, W. A., Nezlek, J. B., & Banaji, M. R. (2004). Implicit and explicit ethnocentrism: Revisiting the ideologies of prejudice. *Personality and Social Psychology Bulletin, 30*, 1332–1346. doi:10.1177/0146167204264654.

Cunningham, W. A., Preacher, K. J., & Banaji, M. R. (2001). Implicit attitude measures: Consistency, stability, and convergent validity. *Psychological Science, 12*, 163–170. doi:10.1111/1467-9280.00328.

Cvencek, D., Meltzoff, A. N., & Greenwald, A. G. (2011). Math-gender stereotypes in elementary-school children. *Child Development, 82*, 766–779. doi:10.1111/j.1467-8624.2010.01529.x.

Dasgupta, N., & Asgari, S. (2004). Seeing is believing: Exposure to counterstereotypic women leaders and its effect on automatic gender stereotyping. *Journal of Experimental Social Psychology, 40*, 642–658. doi:10.1016/j.jesp.2004.02.003.

Dasgupta, N., & Rivera, L. M. (2006). From automatic antigay prejudice to behavior: The moderating role of conscious beliefs about gender and behavioral control. *Journal of Personality and Social Psychology, 91*, 268–280. doi:10.1037/0022-3514.91.2.268.

Davies, P. G., Spencer, S. J., Quinn, D. M., & Gerhardstein, R. (2002). Consuming images: How television commercials that elicit stereotype threat can restrain women academically and professionally. *Personality and Social Psychology Bulletin, 28*, 1615–1628. doi:10.1177/014616702237644.

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*, 103–127. doi:10.1037/a0018053.

Eriksson, K., & Lindholm, T. (2007). Making gender matter: The role of gender-based expectancies and gender identification on women's and men's math performance in Sweden. *Scandinavian Journal of Psychology, 48*, 329–338. doi:10.1111/j.1467-9450.2007.00588.x.

Festinger, L. (1957). *A theory of cognitive dissonance*. Palo Alto, CA: Stanford University Press.

Galdi, S., Arcuri, L., & Gawronski, B. (2008). Automatic mental associations predict future choices of undecided decision-makers. *Science, 321*, 1100–1102. doi:10.1126/science.1160769.

Gawronski, B., & Bodenhausen, G. V. (2006). Associative and propositional processes in evaluation: An integrative review of implicit and explicit attitude change. *Psychological Bulletin, 132*, 692–731. doi:10.1037/0033-2909.132.5.692.

Glaser, J., & Knowles, E. D. (2008). Implicit motivation to control prejudice. *Journal of Experimental Social Psychology, 44*, 164–172. doi:10.1016/j.jesp.2007.01.002.

Glashouwer, K. A., & de Jong, P. J. (2010). Disorder-specific automatic self-associations in depression and anxiety: Results of The Netherlands Study of Depression and Anxiety. *Psychological Medicine: A Journal of Research in Psychiatry and the Allied Sciences, 40*, 1101–1111. doi:10.1017/S0033291709991371.

Greenwald, A. G., & Banaji, M. R. (1995). Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Psychological Review, 102*, 4–27. doi:10.1037/0033-295X.102.1.4.

Greenwald, A. G., Banaji, M. R., Rudman, L. A., Farnham, S. D., Nosek, B. A., & Mellott, D. S. (2002). A unified theory of implicit attitudes, stereotypes, self-esteem, and self-concept. *Psychological Review, 109*, 3–25. doi:10.1037/0033-295X.109.1.3.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. K. L. (1998). Measuring individual differences in implicit cognition: The Implicit Association Test. *Journal of Personality and Social Psychology, 74*, 1464–1480. doi:10.1037/0022-3514.74.6.1464.

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the Implicit Association Test: I. An improved scoring algorithm. *Journal of Personality and Social Psychology, 85*, 197–216. doi:10.1037/0022-3514.85.2.197.

Greenwald, A. G., Poehlman, T. A., Uhlmann, E., & Banaji, M. R. (2009). Understanding and using the Implicit Association Test: III. Meta-analysis of predictive validity. *Journal of Personality and Social Psychology, 97*, 17–41. doi:10.1037/a0015575.

Gregg, A. P., Seibt, B., & Banaji, M. R. (2006). Easier done than undone: Asymmetry in the malleability of implicit preferences. *Journal of Personality and Social Psychology, 90*, 1–20. doi:10.1037/0022-3514.90.1.1.

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S., & Gernsbacher, M. A. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest, 8*, 51. doi:10.1111/j.1529-1006.2007.00032.x.

Heider, F. (1958). *The psychology of interpersonal relations*. New York: Wiley.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. Washington, DC: American Association of University Women.

Hofmann, W., Gawronski, B., Gschwender, T., Le, H., & Schmitt, M. (2005). A meta-analysis on the correlation between the Implicit Association Test and explicit self-report measures. *Personality and Social Psychology Bulletin, 31*, 1369–1385. doi:10.1177/0146167205275613.

Hofmann, W., Gschwender, T., Friese, M., Wiers, R. W., & Schmitt, M. (2008). Working memory capacity and self-regulatory behavior: Toward an individual differences perspective on behavior determination by automatic versus controlled processes. *Journal of Personality and Social Psychology, 95*, 962–977. doi:10.1037/a0012705.

Hyde, J. S., & Mertz, J. E. (2009). Gender, culture, and mathematics performance. *Proceedings of the National Academy of Sciences, 106*, 8801–8807. doi:10.1073/pnas.0901265106.

Jacobs, J. E., & Eccles, J. S. (1985). Gender differences in math ability: The impact of media reports on parents. *Education Researcher, 14*, 20–25. doi:10.3102/0013189X014003020.

Keller, J., & Dauenheimer, D. (2003). Stereotype threat in the classroom: Dejection mediates the disrupting threat effect on women's math performance. *Personality and Social Psychology Bulletin, 29*, 371–381. doi:10.1177/0146167202250218.

Kiefer, A. K., & Sekaquaptewa, D. (2007). Implicit stereotypes, gender identification, and math-related outcomes: A prospective study of female college students. *Psychological Science, 18*, 13–18. doi:10.1111/j.1467-9280.2007.01841.x.

Lane, K. A., Banaji, M. R., Nosek, B. A., & Greenwald, A. G. (2007). Understanding and using the Implicit Association Test: IV: What we know (so far) about the method. In B. Wittenbrink & N. S. Schwarz (Eds.), *Implicit measures of attitudes: Procedures and controversies* (pp. 59–102). New York: Guilford Press.

Lane, K. A., & Driver-Linn, E. (2008). *Change in implicit cognitions predicts change in behavioral intentions*. Poster presented at Society of Personality and Social Psychology Annual Conference, Albuquerque, NM.

Lenton, A. P., Bruder, M., & Sedikides, C. (2009). A meta-analysis on the malleability of automatic gender stereotypes. *Psychology of Women Quarterly, 33*, 183–196. doi:10.1111/j.1471-6402.2009.01488.x.

Lewin, T. (2010). The female factor: After Harvard controversy, conditions change but reputation lingers. *New York Times*. Retrieved from http://www.nytimes.com

Logel, C., Walton, G. M., Spencer, S. J., Iserman, E. C., & von Hippel, W. (2009). Interacting with sexist men triggers social identity threat among female engineers. *Journal of Personality and Social Psychology, 96*, 1089–1103. doi:10.1037/a0015703.

Luhtanen, R., & Crocker, J. (1992). A collective self-esteem scale: Self-evaluation of one's social identity. *Personality and Social Psychology Bulletin, 18*, 302–318. doi:10.1177/0146167292183006.

Marx, D. M., Stapel, D. A., & Muller, D. (2005). We can do it: The interplay of construal orientation and social comparisons under threat. *Journal of Personality and Social Psychology, 88*, 432–446. doi:10.1037/0022-3514.88.3.432.

Marx, D. M., & Stapel, D. A. (2006). Distinguishing stereotype threat from priming effects: On the role of the social self and threat-based concerns. *Journal of Personality and Social Psychology, 91*, 243–254. doi:10.1037/0022-3514.91.2.243.

Mitchell, C. J., Anderson, N. E., & Lovibond, P. F. (2003). Measuring evaluative conditioning using the Implicit Association Test. *Learning and Motivation, 34*, 203–217. doi:10.1016/S0023-9690(03)00003-1.

Miyake, A., Kost-Smith, L. E., Finkelstein, N. D., Pollock, S. J., Cohen, G. L., & Ito, T. A. (2010). Reducing the gender achievement gap in college science: A classroom study of values affirmation. *Science, 330*, 1234–123. doi:10.1126/science.1195996.

Molesworth, B. C., & Chang, B. (2009). Predicting pilots' risk-taking behavior through an Implicit Association Test. *Human Factors, 51*, 845–857. doi:10.1177/0018720809357756.

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science, 18*, 879–885. doi:10.1111/j.1467-9280.2007.01995.x.

National Science Foundation. (2008a). Thirty-three years of women in S&E faculty positions. Retrieved from http://www.nsf.gov/statistics/infbrief/nsf08308/

National Science Foundation. (2008b). Women, minorities, and persons with disabilities in science and engineering. Retrieved from http://www.nsf.gov/statistics/wmpd/pdf/tabc-4.pdf

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math = Male, Me = Female, therefore Math ≠ Me. *Journal of Personality and Social Psychology, 83*, 44–59. doi:10.1037/0022-3514.83.1.44.

Nosek, B. A., Greenwald, A. G., & Banaji, M. R. (2007). The Implicit Association Test at age 7: A methodological and conceptual review. In J. A. Bargh (Ed.), *Automatic processes in social thinking and behavior* (pp. 265–292). Psychology Press.

Nosek, B. A., & Smyth, F. L. (2007). A multitrait-multimethod validation of the Implicit Association Test: Implicit and explicit attitudes are related but distinct constructs. *Experimental Psychology, 54*, 14–29. doi:10.1027/1618-3169.54.1.14.

Nosek, B. A., & Smyth, F. L. (2011). Implicit social cognitions predict sex differences in math engagement and achievement. *American Educational Research Journal*. doi:10.3102/0002831211410683. Advance online publication.

Nosek, B. A., Smyth, F. L., Hansen, J. J., Devos, T., Lindner, N. M., Ranganath, K. A., et al. (2007). Pervasiveness and correlates of implicit attitudes and stereotypes. *European Review of Social Psychology, 18*, 36–88. doi:10.1080/10463280701489053.

Nosek, B. A., Smyth, F. L., Sriram, N., Lindner, N. M., Devos, T., Ayala, A., et al. (2009). National differences in gender-science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Sciences, USA, 106*, 10593–10597. doi:10.1073/pnas.0809921106.

Olson, M. A., & Fazio, R. H. (2001). Implicit attitude formation through classical conditioning. *Psychological Science, 12*, 413–147. doi:10.1111/1467-9280.00376.

Olson, M. A., & Fazio, R. H. (2004). Trait inferences as a function of automatically-activated racial attitudes and motivation to control prejudiced reactions. *Basic and Applied Social Psychology, 26*, 1–11. doi:10.1207/s15324834basp2601_1.

Pronin, E., Steele, C. M., & Ross, L. (2004). Identity bifurcation in response to stereotype threat: Women and mathematics. *Journal of Experimental Social Psychology, 40*, 152–168. doi:10.1016/S0022-1031(03)00088-X.

Rooth, D. (2010). Automatic associations and discrimination in hiring: Real world evidence. *Labour Economics., 17*, 523–534. doi:10.1016/j.labeco.2009.04.005.

Schmader, T. (2002). Gender identification moderates the effects of stereotype threat on women's math performance. *Journal of Experimental Social Psychology, 38*, 194–201. doi:10.1006/jesp.2001.1500.

Schmader, T., Johns, M., & Barquissau, M. (2004). The costs of accepting gender differences: The role of stereotype endorsement in women's experience in the math domain. *Sex Roles, 50*, 835–850. doi:10.1023/B:SERS.0000029101.74557.a0.

Sekaquaptewa, D., & Thompson, M. (2003). Solo status, stereotype threat, and performance expectancies: Their effects on women's performance. *Journal of Experimental Social Psychology, 39*, 68–74. doi:10.1016/S0022-1031(02)00508-5.

Shih, M., Pittinsky, T. L., & Ambady, N. (1999). Stereotype susceptibility: Identity salience and shifts in quantitative performance. *Psychological Science, 10*, 80–83. doi:10.1111/1467-9280.00111.

Snyder, T. D., Dillow, S. S., & Hoffman, C. M. (2009). *Digest of education statistics, 2008 (NCES 2009–020)*. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Institute of Education Sciences.

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35*, 4–28. doi:10.1006/jesp.1998.1373.

Steffens, M. C., Jelenec, P., & Noack, P. (2010). On the leaky math pipeline: Comparing implicit math-gender stereotypes and math withdrawal in female and male children and adolescents. *Journal of Educational Psychology, 102*, 947–963. doi:10.1037/a0019920.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of Personality and Social Psychology, 100*, 255–270. doi:10.1037/a0021385.

Summers, L. (2005). Remarks at NBER conference on diversifying the science and engineering workforce. Retrieved from http://president.harvard.edu/speeches/summers_2005/nber.php

Thush, C., Wiers, R. W., Ames, S. L., Grenard, J. L., Sussman, S., & Stacy, A. W. (2007). Apples and oranges? Comparing indirect measures of alcohol-related cognition predicting alcohol use in at-risk adolescents. *Psychology of Addictive Behaviors, 21*, 587–591. doi:10.1037/0893-164X.21.4.587.

von Hippel, W., Brener, L., & von Hippel, C. (2008). Implicit prejudice toward injecting drug users predicts intentions to change jobs among drug and alcohol nurses. *Psychological Science, 19*, 7–11. doi:10.1111/j.1467-9280.2008.02037.x.

Walton, G. M., & Cohen, G. L. (2007). A question of belonging: Race, social fit, and achievement. *Journal of Personality and Social Psychology, 92*, 82–96. doi:10.1037/0022-3514.92.1.82.

Wiers, R. W., Beckers, L., Houben, K., & Hofmann, W. (2009). A short fuse after alcohol: Implicit power associations predict aggressiveness after alcohol consumption in young heavy drinkers with limited executive control. *Pharmacology Biochemistry and Behavior, 93*, 300–305. doi:10.1016/j.pbb.2009.02.003.

Wilson, T. D., Lindsey, S., & Schooler, T. (2000). A model of dual attitudes. *Psychological Review, 107*, 101–126. doi:10.1037/0033-295X.107.1.101.

Wout, D., Danso, H., Jackson, J., & Spencer, S. (2008). The many faces of stereotype threat: Group- and self-threat. *Journal of Experimental Social Psychology, 44*, 792–799. doi:10.1016/j.jesp.2007.07.005.