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Implicit Gender–Science Stereotype Outperforms Math Scholastic Aptitude in Identifying Science Majors

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Abstract

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In the United States, women are less likely than men to pursue or complete a science major in college. Gender–science stereotyping, which can operate without intention or awareness, has been identified as a possible mediator of this disparity. In two studies with over 110,000 college students and graduates, women with relatively strong stereotypes associating male with science were least likely to major in science. Men with similarly strong stereotypes were most likely to be science majors. With science major as criterion, an indicator of the implicit gender–science stereotype out-predicted explicit stereotypic associations for both sexes. For women in both studies and men in one, implicit stereotype was a stronger correlate of science major than was math SAT. These effects confirm a potent link between implicit stereotyping and scientific self-concept and identify a psychological difference between men and women at advanced levels of scientific achievement.

Implicit Gender–Science Stereotype Outperforms Math Scholastic Aptitude in Identifying Science Majors

Women enrolling in top-tier U.S. universities in 1989 were only half as likely as men to declare a science, technology, engineering or math (STEM) major, and if they did, they were less likely than men to stay with it (Smyth & McArdle, 2004). More recent and representative graduation figures from 2006 (National Science Foundation, 2009), suggest a similar, ongoing disparity: Among female bachelor's degree recipients, just 11% were in STEM (social sciences excluded), while 23% of men earned STEM degrees. The causes of gender disparities in science education continue to be the focus of public debate and scholarly scrutiny (e.g., Ceci & Williams, 2007; Gallagher & Kaufman, 2005; Halpern, et al., 2007; Summers, 2005). Implicit gender stereotyping, operating without intention or awareness, has been identified as a possible mediator of such disparities (Kiefer & Sekaquaptewa, 2007; Nosek, Banaji & Greenwald, 2002a; Nosek et al., 2009; National Academies of Science, 2007; Steele, Reisz, Williams & Kawakami, 2007).

Studies that have included implicit measures of gender stereotypes indicate that these stereotypes relate to self-concepts that are likely important in shaping career choices. For example, women who strongly associate math with male are unlikely to associate math with self, while men with the same strong math–male association tend also to have a math–self association (Nosek et al., 2002a). These relations conform to Greenwald et al.'s (2002) unified theory of implicit social cognition, which uses a cognitive balance principle to predict development of associations between concepts (such as science and self) that are both associated to the same third concept (e.g., male). Application of this principle to choice of college major led us to predict that women with strong implicit science–male associations should be least likely to be science majors, while men with similarly strong stereotypes should be most likely to be science majors. We did not expect explicit, self-report measures of stereotyped associations to be as telling because they are subject to the constraints of limited introspective capability and to motivations to alter reports for personal or social purposes (Greenwald et al., 2002; Nisbett & Wilson, 1977; Orne, 1962; Tedeschi, Schlenker & Bonoma, 1971; Weber & Cook, 1972).

These predictions were tested with over 110,000 visitors to a publicly accessible educational website (*Project Implicit*, https://implicit.harvard.edu/) who reported U.S. citizenship, at least some college experience and an academic major. An indicator of math ability, which is a strong predictor in many models of STEM pursuit and attainment (e.g., Astin & Astin, 1993; Jagacinski, LeBold & Salvendy, 1988; Smyth & McArdle, 2004; Tai, Liu, Maltese & Fan, 2006), was available for substantial subsets of both samples in the form of self-reported Scholastic Assessment Test (SAT) math and verbal scores. According to Astin and Astin (1993), "The strongest and most consistent predictor of changes in students' interest in science majors or careers is the students' entering level of mathematical and academic competency" (p. 2). We could thus test the relation of stereotypes to majoring in STEM independent of this well-established predictor of STEM engagement and persistence.

Method Overview

A public website, now known as Project Implicit, was launched in September 1998 with the purpose of heightening public awareness of implicit social cognition, and alerting participants to the possibility that mental associations outside of their awareness or control might differ from their consciously held attitudes (Nosek, Banaji, & Greenwald, 2002b; Nosek et al., 2007). Visitors to the site are presented on the home page with two entry options, "*Demonstration*" and "*Research*." Upon choosing the *Demonstration* option, visitors may select any of about a dozen attitude and stereotype Implicit Association Tests (IAT; Greenwald, McGhee & Schwartz, 1998), whereas those choosing *Research* are asked to agree to be assigned to an experiment without foreknowledge of the topic. The "Gender–science" IAT, a long-standing option on the *Demonstration* site (for summary of the topics and data see Nosek et al., 2007), was added to the *Research* pool of studies in December, 2006. *Research* participants do not see a list of topics from which to choose and, unlike *Demonstration* visitors, cannot repeat a study. For these reasons, Gender–science participants through the *Research* portal are likely not as self-selected by topical interest as are *Demonstration* participants.

Even though the participants were not representative of a definable population other than that of visitors to the Project Implicit site, the samples reflect greater age and education variation than samples of college students.

Experiment 1

Method

Participants

Between January 2004 and July 2008, 104,296 *Demonstration* site volunteers who reported U.S. citizenship, at least some college experience and an academic major (see Table 1 for demographic details) completed the gender–science IAT. Seventy percent were female and two racial groups, whites (81%) and blacks (5%) comprised 86% of this sample. The median age was 25 ($M = 30$, $SD = 11.7$), with 62% outside the typical college age range of 18-22. Highest educational level was listed as "some college" by 50% (most of whom were aged 18-22), a bachelor's degree by 31%, and some graduate schooling or degree by 19%.

Procedure and measures

Upon entering the *Demonstration* portal, participants were presented with a list of topics from which to choose, each including a brief description of the typical IAT result (e.g., "*This IAT often reveals a relative link between liberal arts and females and between science and males*."). Having selected gender–science, participants completed, in randomized order, implicit and explicit gender–science measures, and finished with a brief demographic questionnaire.

STEM majors

Participants could select from the following list of 13 categories of majors for both a first and a second major. Underlined categories were coded as STEM majors in our analyses.

<u>Biological sciences/life sciences</u>
Business

Communications
<u>Computer and information sciences</u>
Education
<u>Engineering, mathematics, or physical sciences/science technologies</u>
<u>Health professions or related sciences</u>
Humanities/liberal arts
Law or legal studies
Psychology
Social sciences or history
Visual or performing arts
Other

Following other researchers in the STEM achievement literature (e.g., Elliott, Strenta, Adair, Matier & Scott, 1995; Smyth & McArdle, 2004; Tai, Liu, Maltese & Fan, 2006; Xie & Shauman, 2003), we defined STEM majors as those in biological, physical, computer or health sciences (those choosing for their first major a nonspecific "Other" option, about 6% of respondents, were excluded from analyses). Participants were classified as STEM majors if either their first or second major was in a STEM category. By these criteria, 32% of women and 43% of men were classified as STEM majors[1]. For descriptive and display purposes, we obtained 19 independent rankings of the twelve major categories by the perceived amount of scientific course work required (Cronbach's $\alpha = .985$; see online supplement for details).

Explicit academic gender stereotypes

Explicit academic gender stereotypes were assessed by asking participants to rate the strength of their associations of gender with each of the terms "Liberal Arts" and "Science." The specific instruction, "*Please rate how much you associate the following domains with males or females*" was followed in the first two years of the survey by a 5-point response scale (strongly male, somewhat male, neither male nor female, somewhat female, strongly female) and by a 7-point scale in the later years (slightly male and slightly female added on either side of the "neither male nor female" option). Sixty-nine percent of participants answered with the 5-point scale and 31% used the 7-point scale. Ratings were standardized within scale format prior to use in analyses.

Implicit academic gender stereotypes

The IAT assesses the *relative* strengths of associations and was administered according to recommendations of Nosek, Greenwald, and Banaji (2005). The gender–science IAT required quickly sorting words into *female*, *male*, *liberal arts* or *science* categories using two computer keys (see online supplement for words). In separate trial blocks that were presented in a random order, either *science* and *male* were categorized with one key, *liberal arts* and *female* with the other, or *science* and *female* were categorized with one key, *liberal arts* and *male* with the other. Faster correct responding in the first condition compared to the second indicates greater strength of science–male (and arts–female) associations relative to science–female (and arts–male) associations. IAT *D* scores (Greenwald, Nosek & Banaji, 2003) were computed for each individual. These individually calibrated gender–science IAT scores index a participant's difference in mean response latency between the conditions, scaled by the overall variation (*SD*) of the participant's response latencies.

For simplicity and with respect to our substantive focus on science, we refer to this as the "gender–science" IAT and to positive scores as indicative of science–male stereotyping, though note that arts–female associations are an integral, inseparable component of the measurement (Nosek et al., 2005).

Mathematical and verbal ability

Requests for self-reports of college admission test scores, SAT-math, SAT-verbal, and ACT-composite, were added to the gender–science task on the *Demonstration* site in December, 2006, nearly three years after the start date for the overall sample. Since then, 56% of participants (54% of women and 61% of men) who reported being U.S. citizens with some college and an academic major also reported SAT math and verbal scores. Another 20% reported ACT composite scores, but not SAT scores. ACT subtest scores, e.g., English and math, were not requested, so our analyses involving academic ability rely on the sub-sample of 18,217 who reported SAT-math and SAT-verbal scores.

Results and Discussion

Descriptive relations between stereotypes and majors

Overall, the average IAT score (M=.37, SD=.40) was indicative of strong science–male implicit associations (Cohen's d tested against zero=0.93; Descriptive statistics are listed in Table 2; All effects reported in the text are significant at p<.0001 unless noted otherwise). Men and women did not differ in the strength of this association (d=0.007, p=.33). However, substantial sex differences were observed among participants grouped by academic major (Figure 1), with the direction of the sex difference varying systematically with the "science-ness" of the majors. In the relatively low-science majors (e.g., Visual/Performing Arts and Humanities), women implicitly stereotyped science as male much more strongly than did men (*d*s>0.6), while in the relatively high-science majors (e.g., Biological and Physical sciences) men's stereotypes far exceeded women's (*d*s~0.8). This pattern yields a nearly perfect negative correlation between men's and women's average implicit gender–science stereotypes across the dozen major categories, $r(10)$ = -.93, p<.0001. As predicted from cognitive consistency principles (Greenwald et al., 2002), the strongest stereotypes associating science with male were observed among those whose sex was aligned with their major in a stereotype-congruent fashion (i.e., among female non-STEM majors and male STEM majors), while the weakest implicit stereotypes were found among those with stereotype-incongruent combinations. Women with strong *science–male* implicit stereotype associations (≥1 *SD* above the overall mean[2]) were relatively unlikely (22%) to be STEM majors of any kind, while those with weak implicit stereotypes were far more likely to have pursued STEM (67%). The opposite pattern obtained for men: those with strong *science–male* implicit stereotype associations were more likely to be STEM majors (65%) than were those with weak associations (33%). Notably, however, identity as a STEM major was not associated with a complete reversal of women's implicit stereotypes, such that science was more strongly associated with female than with male. On average, STEM women still implicitly stereotyped science as male (M .22, SD .41; d=0.53), and even those in the major categories with the lowest average stereotypes, biological and physical sciences, *d*s were 0.33 and 0.39, respectively.

Responses to the two explicit stereotype measures, science–gender and arts–gender, also averaged significantly non-zero in the stereotypical directions (i.e., science–male and arts–female, *d*s=1.01, 0.66, respectively). Sixty-three percent reported associating science at least "slightly" with male, compared with 2% reporting a counter-stereotypical association of science at least "slightly" with female. Arts was associated at least "slightly" with female by less than half, 46%, while 5% reported associating arts at least "slightly" with male. The modest correlation of the explicit science and arts gender stereotypes, *r*=.28, suggests that they are fairly distinct. Unlike for implicit stereotyping, there were overall sex differences in explicit stereotyping, men more likely than women (70% vs. 60%) to associate science with male, and women more likely than men (49% vs. 41%) to associate arts with female. These sex differences are driven by participants in the focal majors of the respective stereotypes (plots are available in online supplement). That is, the sex difference in science stereotyping occurred primarily in the science majors (men stereotyping more than women, *d*s ranging 0.34-0.54), while the sex difference in arts stereotyping occurred in the non-science majors (women stereotyping more than men, median *d*=0.33).

A composite explicit stereotype was created by averaging the explicit science and arts stereotypes—an ostensible parallel to the implicit constructs measured conjointly by the IAT. The explicit stereotype composite means are plotted by sex and major in Figure 2 and form a pattern of sex differences across majors with muted resemblance to that of the IAT means in Figure 1. Unlike the strong negative relation of men's and women's IAT means across majors, men's and women's composite explicit stereotypes were not significantly correlated across majors, $r(10) = -.16$, *ns*.

It is noteworthy that the mean implicit science–male stereotypes among physical science majors and biological science majors of the same sex (Figure 1) are similar (*d*=0.06, *p*=.002, for the female difference, *d*=0.02, *p*=.52, for the male difference) because those fields have for years been characterized by quite different sex distributions at the undergraduate level. We might expect stronger implicit science–male associations among both sexes in the physical sciences, where women are a distinct minority (accounting for about 27% of the combined engineering, math, and physical science bachelor's degree-earners from 1997 to 2006; National Science Foundation, 2009), than in the biological sciences where women are the majority (increasing from 54% to 62% of biology degrees over the same decade). Inzlicht and Ben-Zeev's (2000) demonstration that higher male-to-female ratios in the immediate environment increase stereotype threat effects on women's math performance suggests that stereotypes are differentially activated for women as a function of their representation in STEM evaluation settings. If STEM−gender stereotypes are more often and more strongly activated in collegiate physical science courses than biological science ones because of average differences in sex ratios, then this difference is not translating to different mean levels of implicit science−male stereotyping in this sample. However, the explicit science stereotyping pattern was more congruent with such sex ratio differences. Physical science majors' self-reports of science–male associations were higher than those of biological science majors (*d*s for the difference were 0.31 and 0.32, respectively, for women and men), but similar to those of computer science majors, a field where female representation is also low.

These different patterns of strength for implicit and explicit associations across groups whose environments likely differ, on average, on a dimension relevant to stereotyping suggest that different evaluative processes were tapped by the implicit and explicit measures. It may be that explicit reports of gender–science associations reflect participants' attempts to account for the "truth value" (Gawronski & Bodenhausen, 2006) of different sex ratios in the environment. Implicit associations, in contrast, are argued by Gawronski and Bodenhausen to derive from automatic affective reactions and the self is the critical affective hub of such associations according to Greenwald et al. (2002). It may be that men and women identifying as majors in biological and physical sciences, sex ratio differences notwithstanding, have similarly strong implicit associations of themselves with science. According to the unified theory (Greenwald et al. 2002), strong positive associations for women in either of these majors between "me and science" and "me and female" should weaken the "science and male" association, while similarly strong self–science and self–male associations for men should strengthen the "science and male" association.

Logistic regression models of STEM major as a function of ability and stereotypes

Math and verbal SAT score means in this sample were substantially higher than national averages. Women averaged 592 (*SD* 124) in math and 608 (*SD* 116) in verbal, compared with the respective national averages of 498 and 502 (both *SD*s 109; College Board, 2001)[3]. Among men, mean math and verbal scores were 637 (*SD* 119) and 620 (*SD* 112), compared with national means of 533 (*SD* 115) and 509 (*SD* 112). While the accuracy of the self-reported scores cannot be verified, we observed the expected pattern of higher scores for STEM majors compared with non-STEM majors, especially in math. Also, Smyth and McArdle (2004) found strong correlations between self-reported and official SAT scores (r=.93 for math, .92 for verbal) for a sample of more than 14,000 selective college students.

To assess the value of implicit and explicit stereotypes in predicting a STEM major, while accounting for effects of academic ability, we fit a sequence of logistic regression models for the dichotomous outcome, yes or no, of reporting a STEM major as previously defined. These models were fit separately for men and women, given the large sample sizes for each sex and the observed different direction of relations between stereotypes and STEM majors for men and women (positive for men, negative for women; see Table 2). First, we estimated single-predictor models with each variable (since results for the composite explicit stereotype did not differ substantively from those of the distinct science–male and arts–female components, we discuss here only the composite effects but results of all models are listed in the online supplement). For women, these models arrayed the predictors, in order of variance explained[4], as follows: implicit stereotype (12.6%), SAT-math (11.0%), explicit stereotype (2.8%), and SAT-verbal (2.0%). When effects were estimated simultaneously in a multiple logistic regression model (R^2=.21), implicit stereotype uniquely accounted for 7.4% of the variance, SAT-math, 5.8%, and explicit stereotype and SAT-verbal each less than 0.5%. For men, the single-predictor ordering was SAT-math (14.7%), implicit stereotype (5.5%), SAT-verbal (1.6%), and explicit stereotype (1.2%). Men's unique variance estimates from the multiple regression model (R^2=.20) were SAT-math, 12.4%, implicit stereotype, 3.0%, SAT-verbal and explicit stereotype each below 0.5%. No SAT by stereotype interaction effects were significant. For women at any level of SAT-math, whether low (<500) or high (>700), the effect of implicit stereotyping (a one standard deviation increase) was to reduce by nearly half the likelihood of a STEM major (odds ratio=0.56).

Although these correlational findings do not illuminate causal mechanisms, they indicate a strong relation between implicit stereotyping and the pursuit and attainment of STEM majors, positive for men and negative for women. For both sexes, the measure of implicit stereotyping was more useful than the measures of explicit stereotyping in predicting a STEM major, and for women it even eclipsed the utility of an indicator of math ability, which is an important factor in many models of STEM attainment. Remarkably, the negative correlation of implicit stereotyping with women's choices of STEM majors was as powerful for the most mathematically-able women as for the least. The patterns conform well to cognitive consistency expectations for the relation between sex, gender stereotypes about science (especially implicit) and self-identification as a STEM major. Participants whose sex aligned with their major in a stereotype-congruent fashion had stronger stereotypic associations of male with science.

Experiment 2

Overview

In Experiment 1, participants directly chose the *gender-science* stereotype topic from a list of options that included advance notice of normative findings. In contrast, Experiment 2 participants were randomly assigned to the *gender-science* study without knowing the topic ahead of time. Thus, this replication allows for some assessment of the potential impact of self-selection on results observed in Experiment 1.

Method

Participants

Between December, 2006 and October, 2009, 7,415 *Research* site participants completed the *gender–science* study and reported U.S. citizenship, at least some college experience and an academic major (see Table 1 for demographic details). Compared with Experiment 1 participants, they were similarly comprised of women, 69% vs. 70% in Experiment 1, slightly less comprised of whites, 77% vs. 81%, and somewhat older, median age 28 vs. 25. Seventy-five percent (vs. 62% in Experiment 1) were outside the typical college age range of 18-22. A higher proportion reported graduate school experience or a degree, 25% vs. 19%, but fewer reported SAT scores (48% vs. 56%) or admission scores of any kind (64% vs. 77%). They were comparably comprised of STEM majors, 34% vs. 35%.

Results and Discussion

To preview the findings, results were very similar to Experiment 1. The major difference was that implicit stereotypes were a stronger predictor of STEM major choice for men than in Experiment 1.

Stereotypical associations of science as male were again the norm both implicitly, *d*=1.05, and explicitly, *d*=1.15, and arts was explicitly stereotyped as female, *d*=0.65.

And when participants were grouped by academic major substantial sex differences in stereotyping were again observed, especially for implicit stereotyping (plots are available in the online supplement). Implicitly, women in all but one of the non-STEM majors stereotyped science as male more strongly than did men (no sex difference in Business), but women in all four STEM majors stereotyped less strongly than men. A strong negative correlation, $r(10) = -.86$, $p<.0001$, was again observed between men's and women's average implicit biases across majors. Among participants with relatively strong implicit stereotypes, one standard deviation or more above the overall Experiment 2 mean[5], only 16% of women, compared with 56% of men, were STEM majors. Conversely, among those with relatively weak stereotypes, women were twice as likely as men to be STEM majors, 49% vs. 25%.

Logistic regression models of STEM major as a function of ability and stereotypes

Forty-eight percent of eligible *Research* site participants provided SAT math and verbal scores, yielding a sub-sample of n=3,591. With respect to the substantive variables of this analysis, this group differed notably from the SAT-reporting group of Experiment 1. First, they were considerably less likely to be STEM majors, 34% vs. 45%. This difference held both for women (31% vs. 42%) and men (40% vs. 50%), and was not accounted for by the lower test scores of the Experiment 2 STEM majors[6]. Furthermore, the female STEM majors in Experiment 2 had stronger stereotypes of each kind (at $p<.01$) than the female STEM majors of Experiment 1.

Using the same sequence of logistic regression models as in Experiment 1, we tested implicit and explicit stereotypes as predictors of STEM major, while accounting for effects of SAT math and verbal scores (details of model results are available in the online supplement). For women, we again found that implicit stereotype was the strongest predictor of majoring in STEM, accounting for 8.3% of the variance when used as the lone predictor (compared with 5.7% for math and verbal SATs combined), and 5.9% uniquely when included with explicit stereotype and SAT scores in the full multiple logistic regression model (R^2=.12). SAT-math followed, accounting uniquely for 3.6% of the STEM major variance, then SAT-verbal, 1.7%, and explicit stereotype, 0.1%. Implicit stereotyping was also the strongest predictor for men—unlike the pattern for men in Experiment 1—accounting for 8.8% of the variance when sole predictor (compared with 8.2% for math and verbal SATs combined). In the full multiple regression model (R^2=.15), implicit stereotype uniquely accounted for 5.9% of the STEM major variance, compared with 5.7% for SAT-math, 2.1% for SAT-verbal, and 0.1% for explicit stereotype. And, again, implicit stereotype effects did not function differently depending on SAT score levels for either sex (i.e., no SAT by stereotype interaction).

Overall, therefore, the hypothesis that implicit stereotyping will predict STEM majoring and do so differently for men and women was again supported. For this sample, less self-selected with respect to interest in the topic of gender–science stereotypes, implicit stereotyping was the leading predictor of being a STEM major for both women and men, exceeding the explanatory value of SAT-math and verbal scores and explicit stereotypes. Among women with strong implicit science–male associations less than one-fifth identified themselves as STEM majors, while among those with relatively weak associations roughly half reported a STEM major. Men's data again revealed the opposite pattern: among men with the strongest science–male associations more than half were STEM majors, compared to a quarter having STEM majors among those with the weakest associations.

General Discussion

In two large studies of the relation between academic gender stereotyping and identifying as a science, technology, engineering or mathematics (STEM) major or degree-holder, we found support for the hypothesis that an implicit science–male stereotype would relate to such identification more strongly than would explicit stereotypes, and do so in different directions for men and women. Science–male implicit stereotyping, as measured by an Implicit Association Test (IAT) contrasting science and liberal arts associations with male and female, was negatively related to majoring in STEM for women, but positively related for men. STEM-identified women evidenced much weaker implicit science–male associations than did non-STEM women, while the opposite pattern was observed for men. These patterns resulted in large sex differences in implicit stereotyping when participants were grouped by major, men stereotyping much more strongly than women among the STEM majors, women much more strongly than men among the non-STEM majors. For women in both studies, implicit stereotyping was more strongly related to majoring in STEM than was SAT-math performance, an indicator of math ability that is often prominent in models of post-secondary STEM interest and achievement. Implicit stereotyping also out-performed SAT-math for men in the second study, in which participants were less self-selected with respect to interest in the topic of gender–science stereotyping.

Explicit academic gender stereotypes, science associated with male and arts with female, did not vary as systematically with participants' gender and major as did implicit stereotypes and were only weakly correlated with each other. This relatively weak mapping between self-reported gender-stereotypical academic associations and the consequential behavioral outcome of identifying, or not, as a STEM major, is thought to derive from multiple influences on self-reports, including lack of self-awareness, social-desirability pressure, personal egalitarian values, and attempts to accurately reflect "truth values" of the environment (Gawronski & Bodenhausen, 2006; Greenwald et al., 2002; Nisbett & Wilson, 1977; Nosek, 2005).

Our findings suggest an important relation between implicit stereotyping and identifying as a scientist, perhaps especially for women, but do not provide leverage on questions of causation. Recent empirical evidence supports the plausibility of bi-directionality of influence, stereotyping influencing science identity and science identity influencing stereotyping, both of which fit within a cognitive consistency theory of relationships among gender identity, gender stereotypes, and self-concepts (Greenwald et al., 2002). An influential causal role of implicit stereotyping is consistent, for example, with Cvencek, Meltzoff, and Greenwald's (2009) finding that elementary school children already, on average, implicitly stereotype math as male. This stereotyping precedes the age at which gender differences in math achievement emerge (Hyde, Lindberg, Linn, Ellis, & Williams, 2008) and that at which specific plans tend to be made to pursue a STEM major (Tai et al., 2006). If girls implicitly stereotype math and science as male prior to adolescence, they may be more prone to disidentify with such fields and eventually explicitly devalue the worth of engaging with them. Such valuation, in turn, is central to expectancy-value theories of academic and occupational choice and persistence

(Eccles et al., 1983; Feather, 1982; Wigfield & Eccles, 1992). Evidence also suggests that women's scientific identity may be weakened through routine contact with implicitly biased men in scientific classrooms or workplaces. Logel and colleagues (2009) demonstrated that interacting with implicitly sexist men can cause social identity threat among female engineering students and have deleterious effects on their engineering test performance. Disidentification with the stereotyped domain, in turn, is a hallmark response to such threats (Aronson, Fried & Good, 2002; Steele, 1997).

Consistent with the opposite causal mechanism, whereby science identity influences stereotyping, Gawronski, Deutsch, Mbirkou, Seibt and Strack (2008) found that practice affirming counter-stereotypical stimulus pairings (e.g., "Betsy" and "powerful") reduced activation of an automatic strong–male/weak–female stereotype. Given the centrality and positivity of the self in associative cognitive networks (Greenwald et al., 2002), practice that likely strengthens girls' and women's science–self associations (e.g., succeeding in advanced high school science or selecting a college STEM major) should strengthen their science–female associations and reduce their science–male ones.

Longitudinal research is critical to understanding the relative contributions of such causal influences to the patterns we have identified. Given the present findings that pervasive implicit gender–science stereotypes are strongly related to choices of STEM majors for even the most math-talented women, and that men and women in STEM differ markedly in their implicit stereotypes, the stakes of understanding are high.

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Table 1

Demographics by sample.

	Experiment 1: Demonstration site			Experiment 2: Research site		
	Full *N*= 104,296	No SAT* *n*= 86,079	Yes SAT* *n*= 18,217	Full *N*= 7,415	No SAT^ *n*= 3,824	Yes SAT^ *n*= 3,591
Characteristic						
Female	70%	70%	68%	69%	71%	68%
Ethnicity						
Hispanic	6.3%	6.2%	6.3%	7.4%	7.3%	7.4%
Not-Hispanic	89.4%	89.2%	89.7%	87.0%	86.1%	87.9%
Unknown	4.3%	4.7%	3.9%	5.7%	6.6%	4.7%
Race+						
American Indian	0.5%	0.7%	0.4%	0.5%	0.6%	0.5%
East Asian	2.7%	1.4%	4.1%	2.9%	2.0%	3.8%
South Asian	1.6%	1.0%	2.2%	2.3%	2.4%	2.1%
Islander	0.6%	0.5%	0.7%	0.6%	0.4%	0.9%
Black	5.2%	5.3%	5.1%	6.5%	5.3%	7.7%
White	80.9%	83.1%	78.7%	77.2%	79.6%	74.7%
Multi-Black/White	0.7%	0.6%	0.9%	1.1%	1.1%	1.2%
Multi-other	4.5%	4.2%	4.8%	5.5%	5.4%	5.7%
Other	3.2%	3.2%	3.2%	3.4%	3.4%	3.5%
Education						
Some college	50%	52%	44%	40%	44%	36%
BA/BS	31%	30%	33%	35%	34%	36%
Post-BA	19%	18%	23%	25%	22%	27%
Age						
Median	25	25	24	28	29	28
Mean	30	30	28	32	33	31
SD	11.7	11.8	10.9	11.9	12.0	11.6
STEM major	35%	33%	45%	34%	34%	34%

All participants reported U.S. citizenship, at least some college and an academic major. Exp. 1 limited to Project Implicit *Demonstration* site participants between Jan. 2004 and July 2008; Exp. 2 to *Research* site participants, Dec. 2006 to Oct. 2009. *SAT score questions were added to the *Demonstration* survey in December 2006, so the majority (83%) in the "no SAT" sample were not asked for scores; 56% of participants who were asked reported SAT scores. ^All *Research* site participants were asked for test scores and 49% provided SAT scores. All other demographic questions were answered by at least 90% of participants in each sample. +Full text of response options is listed in online supplement. STEM major defined by a first or second major reported in biological, computer, health or physical sciences, including engineering and mathematics.

Table 2

Substantive variable means, standard deviations and correlations by sex.

	(1)	(2)	(3)	(4)	(5)	(6)[w]	(7)[w]
Women (*n* 72,938)							
M	0.32	0.37	0.94	0.72	0.83	592	608
SD	0.47	0.40	0.99	1.00	0.80	124	116
(1) STEMmajor	1.00						
(2) Implicit sci=male	**-0.26**	1.00					
(3) Explicit sci=male	**-0.13**	**0.21**	1.00				
(4) Explicit arts=female	**-0.07**	**0.14**	**0.31**	1.00			
(5) Explicit composite	**-0.12**	**0.21**	**0.81**	**0.81**	1.00		
(6) SAT-math[w]	**0.28**	**-0.17**	**-0.10**	**-0.12**	**-0.14**	1.00	
(7) SAT-verbal[w]	**0.12**	-0.02	**-0.04**	**-0.09**	**-0.08**	**0.66**	1.00
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)[m]**	**(7)[m]**
Men (*n* 31,358)							
M	0.43	0.37	1.20	0.53	0.86	637	620
SD	0.49	0.40	1.00	0.99	0.79	119	112
(1) STEMmajor	1.00						
(2) Implicit sci=male	**0.17**	1.00					
(3) Explicit sci=male	**0.08**	**0.19**	1.00				
(4) Explicit arts=female	**0.08**	**0.15**	**0.25**	1.00			
(5) Explicit composite	**0.11**	**0.22**	**0.79**	**0.79**	1.00		
(6) SAT-math[m]	**0.33**	**0.09**	**0.05**	-0.01	0.03	1.00	
(7) SAT-verbal[m]	**0.11**	-0.03	-0.02	**-0.11**	**-0.08**	**0.60**	1.00

STEMmajor is coded 1 if a first or second major was in STEM, otherwise 0. Implicit sci=male is effect size *D* for science-male/liberal arts-female IAT, with possible range -2 to +2 and 0 indicative of no science-gender bias. Explicit sci=male and arts=female stereotypes are reported as Cohen's *d* s because earlier participants had 5-point response options and later ones had 7-point options. Explicit composite is the average of the explicit sci=male and arts=female *d* scores. SAT-math and verbal scores have possible range of 200-800. [w]12,470 women and [m]5,747 men had SAT scores. Boldfaced correlation coefficients are significant at $p < .0001$.

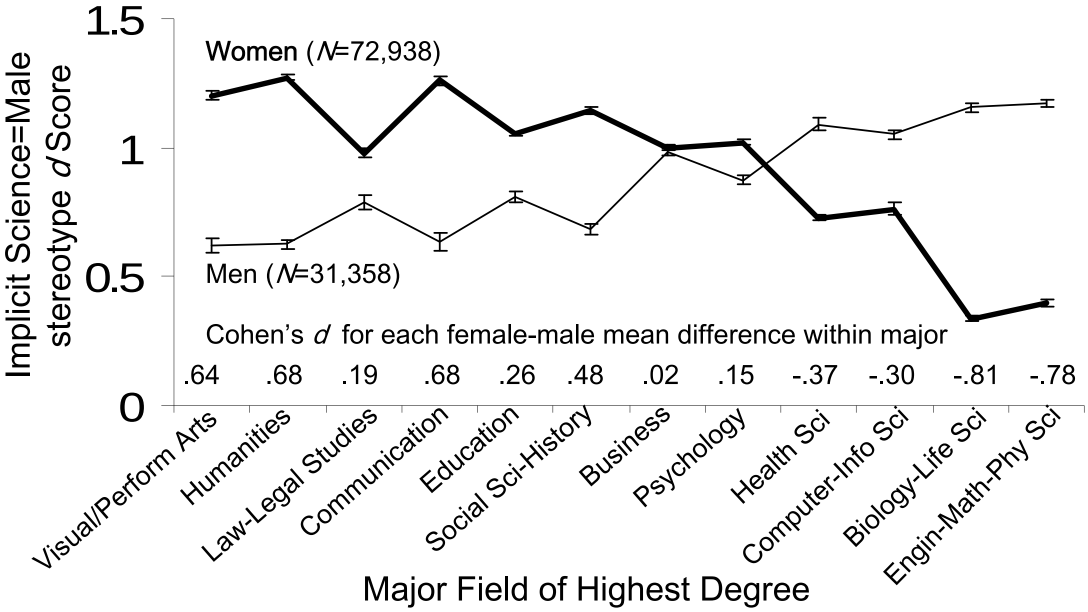

Figure 1. Mean implicit science=male IAT *d* score (+/- 1 *se*) by sex and major field of highest degree for Study 1 participants. Majors are ordered, left to right, by ratings of science content (method described in supporting information online). A *d* score of zero indicates no academic gender bias. Women's and men's means are correlated $r(10) = -.93$, $p < .0001$.

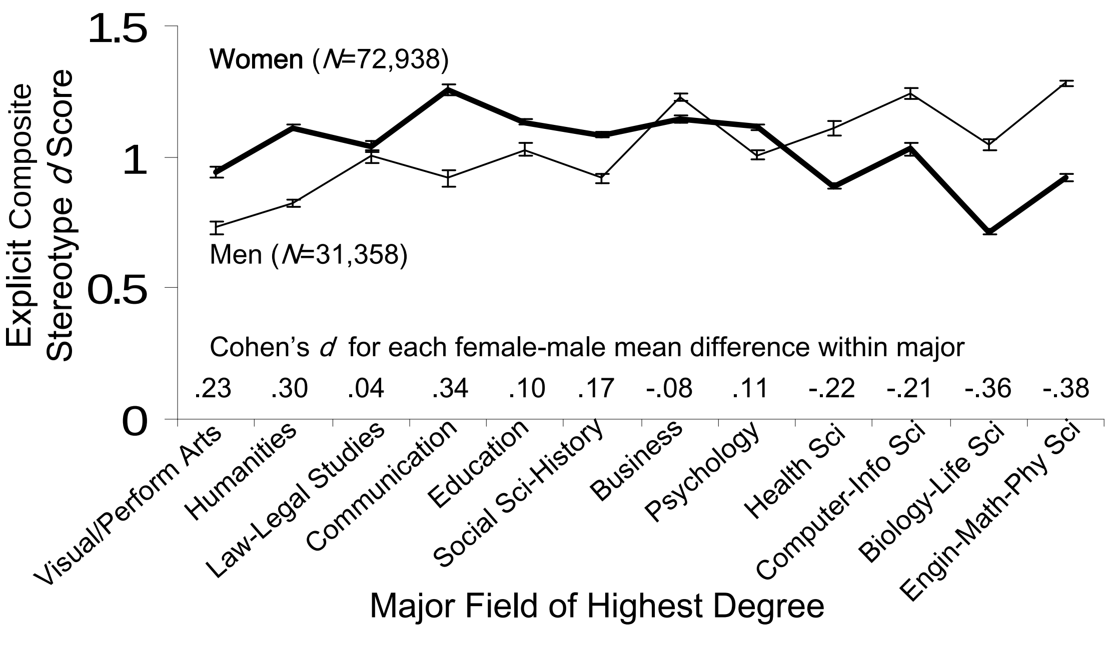

Figure 2. Mean composite (science=male + arts=female) explicit stereotype *d* score (+/- 1 *se*) by sex and major field of highest degree for Study 1 participants. Majors are ordered, left to right, by ratings of science content (method described in supporting information online). A *d* score of zero indicates no academic gender bias. Women's and men's means correlated $r(10) = -.16$, *ns*.

Footnotes

[1] These higher-than-average proportions of STEM majors reflect both our classification methods (i.e., considering first and second majors and excluding the "Other" category—usually treated as non-science) and their higher-than-average educational attainment (i.e., more advanced degrees, higher test scores) that correlates with higher probability of STEM interest (College Board, 2001).

[2] Women and men were evenly represented at the high and low extremes of implicit stereotyping: 16.2% of women and 16.5% of men scored ≥1 *SD* above the overall mean; 16.2% and 16.3%, respectively, scored ≤1 *SD* below.

[3] National means and *SD*s from 2001 were used for comparison since the median-aged participant in this sample would have been 18 in that year, an age when the SAT is commonly taken.

[4] Max-rescaled R^2 for logistic regression (Nagelkerke, 1991).

[5] 17% of women and 14% of men had IAT scores ≥1 *SD* above the mean.

[6] *Research* participants were significantly less likely than *Demonstration* participants to be STEM majors (*odds ratio*=.61 for women [99% CI .54-.69] and .67 for men [99% CI .57-.79]). With SAT scores held constant, *Research* participants were even less likely to be in STEM, *odds ratio*=.59 for women [99% CI .52-.67] and .63 for men [99% CI .53-.75].