Journal of Personality and Social Psychology
2011, Vol. 100, No. 2, 255–270

0022-3514/10/$12.00 DOI: 10.1037/a0021385

STEMing the Tide: Using Ingroup Experts to Inoculate Women's Self-Concept in Science, Technology, Engineering, and Mathematics (STEM)

Jane G. Stout, Nilanjana Dasgupta, Matthew Hunsinger, and Melissa A. McManus
University of Massachusetts, Amherst

Three studies tested a stereotype inoculation model, which proposed that contact with same-sex experts (advanced peers, professionals, professors) in academic environments involving science, technology, engineering, and mathematics (STEM) enhances women's self-concept in STEM, attitudes toward STEM, and motivation to pursue STEM careers. Two cross-sectional controlled experiments and 1 longitudinal naturalistic study in a calculus class revealed that exposure to female STEM experts promoted positive implicit attitudes and stronger implicit identification with STEM (Studies 1–3), greater self-efficacy in STEM (Study 3), and more effort on STEM tests (Study 1). Studies 2 and 3 suggested that the benefit of seeing same-sex experts is driven by greater subjective identification and connectedness with these individuals, which in turn predicts enhanced self-efficacy, domain identification, and commitment to pursue STEM careers. Importantly, women's own self-concept benefited from contact with female experts even though negative stereotypes about their gender and STEM remained active.

Keywords: gender stereotypes, self-concept, implicit social cognition, role models, science and engineering

In 2008, *The Boston Globe* published an article describing the persistent gender gap in science, technology, mathematics, and engineering (STEM), in which the journalist cited social scientific research (Pinker, 2008; Rosenbloom, Ash, Dupont, & Coder, 2008) arguing that "when it comes to certain math- and science-related jobs, substantial numbers of women—highly qualified for the work—stay out of those careers because they would simply rather do something else" (McArdle, 2008). In other words, women had the "freedom to say no" to STEM careers, and they did. The tacit assumption in this article is that the decision to pursue one academic or professional path rather than another is a free choice determined purely by one's talent and intrinsic motivation, unconstrained by societal forces. But are these choices really free? Might women's "freedom" be constrained by gender stereotypes in academic cultures about who seems to naturally belong in which disciplines and professions and, by extension, who is likely to succeed (see Ceci, Williams, & Barnett, 2009)? If this is the case, what factors might release these constraints and allow women to identify with STEM, become confident in their abilities, acquire positive attitudes, and choose academic goals and careers in STEM? We developed a *stereotype inoculation model* to address these questions and tested the model empirically to assess whether the hypothesized inoculating factor (seeing ingroup experts in STEM) has an immediate effect, and importantly, whether its benefits accumulate over time longitudinally.

Stereotypes Link Gender to Achievement in STEM

At every stage of development, girls and women are exposed to the message that their ingroup is worse in science and math compared with their male peers. In elementary school, parents express lower expectations for daughters' than sons' ability in math and science (Furnham, Reeves, & Budhani, 2002; Lummis & Stevenson, 1990) and make different attributions for their success: daughters' success is attributed to effort and hard work, whereas sons' success is attributed to innate talent (Räty, Vänskä, Kasanen, & Kärkkäinen, 2002; Yee & Eccles, 1988). In high school, girls are subtly reminded that "science is for boys" by the lack of reference to female scientists in science textbooks and curricula (Sadker & Sadker, 1994) and by having less opportunity to use science equipment compared with boys (Jones et al., 2000).

By the time women enter college the gender disparity in STEM majors is stark, especially in the physical sciences and related disciplines (e.g., physics, mathematics, engineering, computer science). This gender disparity signals to women that their group

This article was published Online First December 13, 2010.

Jane G. Stout, Nilanjana Dasgupta, Matthew Hunsinger, and Melissa A. McManus, Department of Psychology, University of Massachusetts, Amherst.

The research reported was made possible by a CAREER grant from the National Science Foundation to Nilanjana Dasgupta (BCS 0547967). Our heartfelt thanks go to Professors Arline Norkin and George Avrunin in the Department of Mathematics who welcomed us into the math department and helped select appropriate sections of Math 131 with matched course instructors for Study 3. We also thank all the Math 131 professors and teaching assistants who gave us access to their classes. Our dedicated team of undergraduate research assistants made this research come to fruition with countless hours of data collection: Elizabeth Baker, Joseph Bove, Dante Ciliberti, Tori Dennis, Gavin Desmond, Diana Fiore, Jessica Gorman, Alexandra Hamill, Thomas Holubiak, Sarah Krieger, Jody Pangburn, David Satin, Priya Senecal, Nicole Stewart, Patricia Torgerson, Gwendolyn Vincent, and Octavia Willard. Finally, we thank Kate Burns for helping initiate Study 1.

Correspondence concerning this article should be addressed to Jane G. Stout or to Nilanjana Dasgupta, Department of Psychology, Tobin Hall, 135 Hicks Way, University of Massachusetts, Amherst, MA 01003. E-mail: jgstout@psych.umass.edu or dasgupta@psych.umass.edu

doesn't really belong in these professions (Walton & Cohen, 2007). In support of this idea, research indicates that subtle situational cues in STEM environments like low female representation (e.g., Murphy, Steele, & Gross, 2007) and even the presence of stereotypically masculine objects (Cheryan, Plaut, Davies, & Steele, 2009) decreases women's sense of belonging in these fields and reduces their interest in pursuing STEM majors. On top of this, female students also experience not-so-subtle reminders that they do not belong in STEM in the form of more overt sex discrimination in STEM than non-STEM majors (Steele, James, & Barnett, 2002).

Given this, it is not surprising then that more women than men switch out of STEM majors in college (Seymour & Hewitt, 1997). Beyond college, as the academic path becomes more advanced, the number of women in STEM dwindles further; only 26% of graduate students in the physical sciences are women, and 18% of full professors in STEM departments at research universities are women (National Science Foundation, 2009). The take-home message from these statistics is that for incoming generations of students who are being introduced to science, math, and engineering, female scientists and experts are practically invisible, especially in higher education environments. Clearly, the skewed gender ratio of STEM experts in academic environments undermines female students' identification with, positive attitudes about, and self-efficacy in STEM and saps their motivation to pursue careers in science, engineering, or technology.

A Stereotype Inoculation Model: Does Increasing Contact With Same-Sex Experts Enhance Women's Self-Concept in STEM, Attitudes, and Future Career Goals?

One factor that is likely to stop the cascade of negative psychological events for female STEM students is increased exposure to successful female experts in science and engineering. The psychological benefit of such experts on women is captured in the proposed stereotype inoculation model. As shown in Figure 1, the pervasiveness of gender stereotypes in science and engineering is reflected in the skewed gender composition of STEM environments that heavily favors men. Any evidence contrary to the stereotype that STEM-is-for-men is likely to have a powerful bolstering effect for young women entering these fields. Specifically, increasing young women's exposure to successful female scientists, mathematicians, and engineers ought to strengthen female students' self-identification with STEM and enhance positive attitudes, feelings of self-efficacy, and motivation to pursue STEM majors and careers.

Four predictions emerge from our model. First, the impact of same-sex role models on the self is likely to emerge more clearly in women's *implicit* rather than *explicit* self-conceptions, given past research indicating that the effect of situational cues on the working self-concept is subtle and often more reliably captured with indirect than direct measures (Markus & Kunda, 1986; Markus & Wurf, 1987; see next section for details). Second, the effect of same-sex experts on the self-concept will be more impactful for individuals whose ingroup is negatively stereotyped (women in STEM) compared with others whose ingroup is the cultural default and thus expected to excel in a domain (men in STEM). This prediction fits with past research showing that the tendency to feel good about oneself due to a fellow ingroup member's success occurs primarily among minority rather than majority group members (e.g., Brewer & Weber, 1994). Third, while contact with an occasional female scientist or engineer may not be sufficient to change *global stereotypes*, importantly, it will inoculate women from applying STEM stereotypes to their own *self-concept*. Finally, the impact of seeing same-sex experts is likely to be stronger for individuals who subjectively identify with these experts, which is consistent with Markus and Nurius's (1986) early research on the *possible self* (i.e., one's mental representation of what one could become in the future). This prediction is also compatible with existing research on role models suggesting that perceiving successful others as inspirational is contingent on seeing the other person's success as relevant to one's own interest and believing that it is personally attainable (e.g., Lockwood & Kunda, 1997, 1999).

Theoretical Contributions of the Stereotype Inoculation Model

The proposed model integrates existing research on the self-concept, stereotype threat, and role modeling to derive predictions about when and how changes in the gender composition of ste-

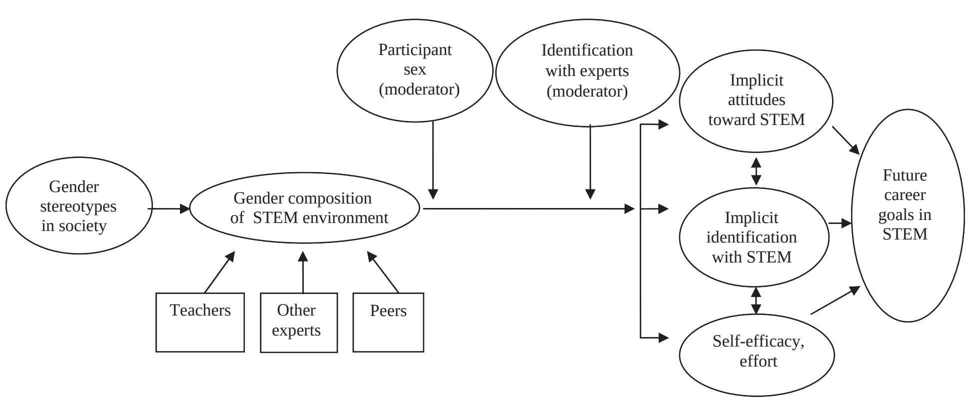

Figure 1. A stereotype inoculation model identifying environmental conditions that promote the malleability of women's implicit self-concept in science, technology, engineering, and mathematics (STEM).

reotypically masculine STEM environments is likely to inoculate women's self-concept and career goals against chronically activated stereotypes.

Exposure to Successful Ingroup Experts Is Likely to Enhance Implicit (But Not Explicit) Self-Conceptions in STEM

The present model gives special attention to students' *implicit self-concept* in STEM. We predict that modifying the gender composition of STEM environments by increasing contact with, or exposure to, same-sex experts will subtly but systematically benefit female students' implicit self-concept in the immediate situation where such individuals are encountered. After multiple exposures or contact experiences this benefit may linger even when same-sex experts are not present in the immediate situation. Moreover, shifts in implicit self-beliefs ought to predict future career goals.

While women's implicit self-concept is predicted to become malleable in response to environmental cues, their explicit self-concept is expected to remain relatively stable for two reasons. First, early influential research on the self-concept by Markus and Kunda (1986; also see Markus & Nurius, 1986) showed that environmental cues produce substantial shifts in people's working self-concept, but these were observable only when self-beliefs were measured indirectly, not directly. Specifically, some self-traits became more mentally accessible or more valued by the individual than other traits after a situational manipulation, even though the overall content of people's explicit self-descriptions remained unchanged across situations. These findings led Markus and Kunda (1986) to conclude:

> The malleability of the self-concept . . . suggests a need for measures of the self- concept that have the capacity to reveal the entire range of behavior involved in . . . self-definition, or in the creation of an identity for one's self. Measures that assume the self to be a static structure and require individuals to respond to very general descriptions about the self or to simply label one's self are often not adequate for revealing how the individual adjusts and calibrates the working self-concept in response to the social situation. (p. 865)

Applied to our work, contact with same-sex STEM experts is predicted to bring about spontaneous adjustment and calibration of female students' implicit self-concept toward science and engineering in small ways. But these changes may be too subtle to be consciously noticed and reported (Greenwald & Banaji, 1995; Greenwald et al., 2002).

A second reason for our prediction is that because participants in this research were already enrolled in multiple STEM classes and fairly invested in the physical sciences or engineering, they may be unwilling to waver in their explicit self-concept regarding STEM.[1] These students may adopt a self-protective strategy by underreporting self-doubt, especially when asked these questions in the context of a psychological study. Indirect support for this reasoning comes from evidence showing that women report less negativity toward STEM on explicit measures but substantially more negativity on implicit measures (Nosek, Banaji, & Greenwald, 2002). Moreover, people have the lay intuition that their personal choices in academic and professional domains are stable, driven by innate ability, and not easily moved around by vagaries in the environment. Thus, when asked to report their preferences, individuals are likely to self-report their global attitudes and identification with STEM in the same way regardless of academic context.

A Focus on Stereotyped Individuals' Self-Concept: Moving Beyond Test Performance

The current research overlaps with stereotype threat theory (for reviews see Aronson, Quinn, & Spencer, 1998; Schmader, Johns, & Forbes, 2008), which asserts that the knowledge that one's group is negatively stereotyped in a particular domain (here, women in STEM) activates the concern that one might fall prey to that stereotype or be judged in a stereotype-consistent manner by others. Extant research on stereotype threat has examined stereotyped individuals' performance on specific domain-relevant tests, together with cognitive, emotional, and physiological reactions during the test or in anticipation of it (for a review, see Schmader et al., 2008). We agree that documenting the effect of stereotypes on test performance is important.

At the same time, it is theoretically and practically critical to extend the scope of the inquiry to stereotyped individuals' *self-concept* (specifically, self-efficacy, identity, attitudes, and career intentions) for two reasons. First, test performance and self-conceptions in the same domain do not always go hand-in-hand, especially for negatively stereotyped groups. As a case in point, the *imposter phenomenon*, a term coined 30 years ago in a study on high-achieving women, indicates that individuals may privately believe they lack talent and skill despite their objectively outstanding performance (Clance & Imes, 1978; McGregor, Gee, & Posey, 2008). Thus, even when women's test performance in STEM improves, their self-efficacy, identity, attitudes, and career intentions in STEM may not follow. Second, recent research indicates that the gender gap on quantitative standardized tests has shrunk or disappeared (Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Hyde & Mertz, 2009), and female students in high school and college often earn equal or better grades in math classes than their male peers (Bridgeman & Lewis, 1996; Gallagher & Kaufman, 2005). Yet, women's self-investment in STEM is substantially lower than that of their male peers (Else-Quest, Hyde, & Linn, 2010; Mendez, Mihalas, & Hardesty, 2006), which may occur because stereotypes questioning their "real" talent render their self-concept fragile in STEM. Thus, it is theoretically and practically important to investigate women's self-concept in stereotyped domains independent of test performance.

Stereotype Inoculation by Same-Sex Role Models

Our proposed model focuses on shifting women's self-concept by exposing them to same-sex STEM experts whose existence

[1] One related finding by Pronin, Steele, and Ross (2004) revealed that under stereotype threat women explicitly disavowed particular feminine traits that are stereotypically dissonant with success in STEM. A major difference between Pronin et al. and the present research is that we assessed disidentification from an academic field, whereas Pronin et al. assessed disidentification from specific stereotypically feminine traits. We believe that explicit identification with STEM fields is likely to remain stable among students who already intend to major in science and engineering regardless of contextual cues, even though their identification with feminine traits may vary.

defies stereotypes. Several past studies have adopted similar role model strategies and found that exposure to fellow ingroup members who are counterstereotypic improves female and Black students' test performance (Marx, Ko, & Friedman, 2009; Marx & Roman, 2002; Marx, Stapel, & Muller, 2005; McIntyre, Paulson, & Lord, 2003), although a recent study failed to replicate this effect (Aronson, Jannone, McGlone, & Johnson-Campbell, 2009). In a different domain, our own work showed that long-term exposure to counterstereotypic professional women weakens women's implicit stereotypes about gender and professional leadership (Dasgupta & Asgari, 2004). Finally, another pair of studies examined the impact of same-sex versus other-sex role models on women and men's career aspirations (Lockwood, 2006), although the careers in question were not strongly gender stereotypic. Together, these past studies on role models have examined the effect of ingroup role models on individuals' (a) performance on a single test in a stereotyped domain, (b) ingroup stereotypes, or (c) self-perceptions in nonstereotypic careers. They have not investigated the effect of ingroup role models on individuals' self-concept in a strongly stereotyped domain, which, as noted earlier, may not fall in lockstep with test performance or beliefs about one's ingroup as a whole.

Yet other studies have inoculated women from the threat of ingroup stereotypes by using self-affirmation in nonstereotyped domains (Martens, Johns, Greenberg, & Schimel, 2006), group affirmation (Elizaga & Markman, 2008; Marx et al., 2005), or by activating alternative identities that are not negatively stereotyped (Shih, Pittinsky, & Ambady, 1999) in order to protect performance. Our work focuses on the unique benefit of same-sex role models, which simultaneously allow women to develop an efficacious sense of self in STEM while embracing their gender identity. Put simply, exposure to positive female role models allows women to flourish in STEM without feeling bad about their gender.

Study 1

Female students majoring in STEM disciplines met a male or female confederate posing as an advanced peer majoring in mathematics. We tested whether brief interactions with this female or male peer expert would differentially influence women's self-conceptions in mathematics as well as their effort and performance on an actual math test. We predicted that interactions with a female (compared with male) peer expert would enhance women's implicit attitudes toward, and identification with, math, but that implicit stereotypes linking math with men would remain unchanged across interactions. Additionally, for reasons described in the introduction, we predicted that at an explicit level, female students would consistently report more positive attitudes toward and identification with math over humanities (e.g., English), regardless of whether they encountered a female or male expert. In all the measures, responses to math as a discipline were compared with responses to a humanities discipline (English) because the distinction between science/math versus humanities is the basis of higher education in most academic institutions and students often have to choose among them as they advance academically.

Method

Participants. Seventy three undergraduate women majoring in STEM disciplines (e.g., biology, chemistry, engineering) at a large university were recruited to participate in exchange for $20 or course credit. One participant did not believe the experimental cover story (see Procedure) and was excluded from data analysis leaving a total $N = 72$.

Materials.

Implicit identification, attitudes, and stereotypes. Three Implicit Association Tests (IATs; Greenwald, McGhee, & Schwartz, 1998) assessed participants' implicit attitudes toward math versus English, their identification with math versus English, and stereotypes of math versus English as relatively masculine or feminine domains. The IAT is a computerized task that assesses the relative strength with which two target concepts (e.g., math vs. English) are differentially associated with two attributes (e.g., good vs. bad, me vs. not me, or masculine vs. feminine) using response latency to operationalize attitude or belief strength. In each IAT participants completed seven blocks of trials of which three were practice blocks and four were data collection blocks. The order of data collection blocks (stereotype-compatible vs. incompatible) was counterbalanced between participants. In the interest of conserving space, for task details see Nosek et al. (2002).

Attitude IAT. Implicit attitudes toward math versus English were assessed by measuring how quickly participants categorized words related to math (e.g., algebra, equation) and English (e.g., spelling, grammar) with positive versus negative words (e.g., joy, filth).

Identification IAT. Implicit identification with math versus English was assessed by measuring how quickly participants paired the same math and English words with first-person pronouns (e.g., me, myself) compared with third-person pronouns (e.g., they, them).

Stereotypes IAT. Implicit stereotypes linking math with men were assessed by measuring the speed with which participants paired the same math and English words with male versus female pronouns (e.g., he, him vs. she, her).

Explicit attitudes toward, identification with, and stereotypes about math and English. Participants also completed the following self-report measures.

Attitudes toward math versus English. Participants were asked to indicate their attitudes toward math and English on four items each using 11-point scales ranging from –5 (anchored by *dislike*, *hate*, *boring*, *bad*) to +5 (anchored by *like*, *love*, *fun*, *good*). Attitudes toward math and English were aggregated into separate indices (αs = .95).

Identification with math versus English. Three items assessed how much participants identified with math (e.g., "How important is math to you?"; $\alpha = .75$) using 11-point response scales ranging from 1 (*not at all*) to 11 (*very much*). Identification with English was rated using similar items in which the word *English* replaced *math* ($\alpha = .85$).

Stereotypes about math and English. Stereotypes of each discipline were measured by asking participants to complete four phrases using 11-point scales (e.g., "When I think of people who are very good at math [English], I think of . . ."). Scale anchors ranged from 1 (*mostly men*) to 11 (*mostly women*) with a midpoint of 6 (*both men and women*). Math and English items produced αs of .74 and .80, respectively.

Math test. A difficult math test composed of 10 questions was selected from the quantitative portion of a graduate record examination (GRE) subject test.

Procedure. Participants were randomly assigned to either the male or female peer expert condition and were tested individually. Upon entering the lab, the participant was greeted by the experimenter who informed her that he or she was double majoring in mathematics and psychology and had developed a number of math tests and psychological tasks for his or her senior project, which were to be tested on other undergraduate students. To ensure that participants recognized that the experimenter was a math expert, the experimenter mentioned that he or she was a math major a few times in passing and also wore a t-shirt displaying Einstein's equation from the theory of relativity ($E = mc^2$). The experimenter informed participants that they would be asked to complete one of several math tests (in actuality a GRE practice test) as well as a series of psychology-based tasks (three IATs and three explicit measures). Task order was counterbalanced such that half of the participants completed the math test followed by the IATs and explicit measures; the remaining half completed the IATs and self-report measures followed by the math test. Participants were given 10 min for the math test. Finally, participants were debriefed, probed for suspicion, and thanked for their participation.

Results

Does exposure to a female versus male peer expert influence implicit reactions toward mathematics?

Attitudes IAT. We calculated an implicit attitude score for each participant, which constituted the differential speed with which they completed the math + good | English + bad blocks compared with math + bad | English + good blocks in terms of effect size or modified Cohen's *d* (see Greenwald, Nosek, & Banaji, 2003). Positive difference scores indicate stronger implicit preference for math compared with English. As predicted, a two-way analysis of variance (ANOVA) with Peer Expert × Task Order revealed a significant main effect of peer expert such that participants who interacted with a male peer expert exhibited implicit negative attitudes toward math compared with English (IAT effect = –129 ms, IAT D = –.36), whereas those who interacted with a female peer expert exhibited equal liking for math and English (IAT effect = –23 ms, IAT D = –.04), $F(1, 68) = 7.13$, $p < .01$ (see Figure 2, Panel A). No other effects were significant ($ps > .10$).

Identification IAT. For each participant we calculated an implicit math identification score that constituted the differential speed with which they completed the math + me | English + not me blocks versus math + not me | English + me blocks in terms of effect size or modified Cohen's *d*. Positive difference scores indicate stronger implicit identification with math. As predicted, a two-way ANOVA using Peer Expert × Task Order revealed a significant main effect of peer expert such that participants implicitly identified with math substantially more in the presence of the female peer expert (IAT effect = 88 ms, IAT D = .21) than a male peer expert (IAT effect = –1 ms, IAT D = .003), $F(1, 68) = 4.80$, $p = .03$ (see Figure 2, Panel B). No other effects were significant ($ps > .10$).

Stereotyping IAT. We calculated a score to assess implicit gender stereotypic beliefs about math and English, which was the differential speed with which participants completed the math + female | English + male blocks compared with math + male | English + female blocks in terms of modified Cohen's *d*. Positive

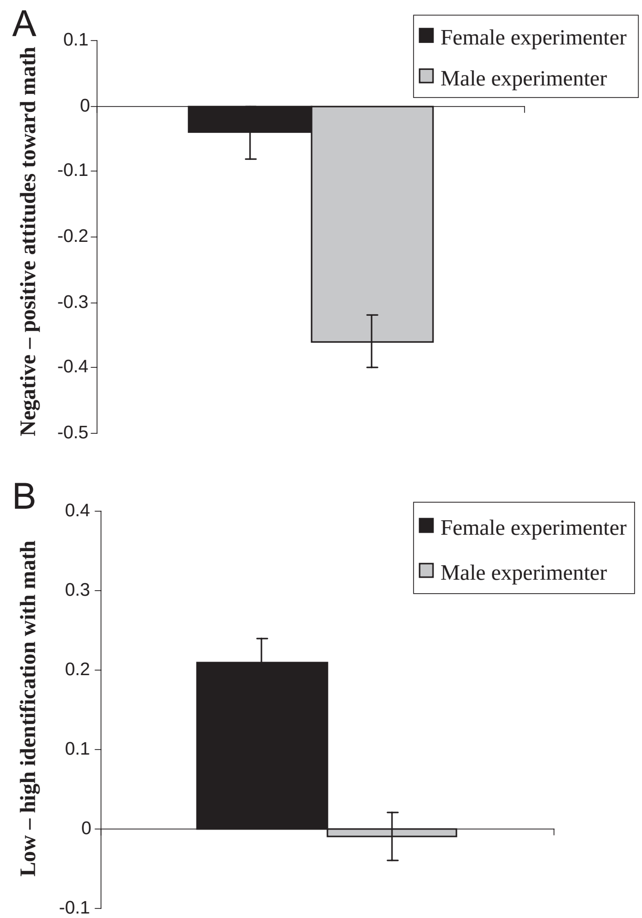

Figure 2. Women's implicit attitudes toward math (Panel A) and implicit identification with math (Panel B) as a function of contact with a female versus male peer expert. Error bars represent standard error of the mean.

difference scores indicate stronger stereotyping of math as a masculine domain. As expected, a two-way ANOVA with Peer Expert × Task Order showed that implicit stereotyping of math did not change after brief contact with the female peer expert in math (IAT effect = 28 ms, IAT D = .10) compared with a male peer expert (IAT effect = 44 ms, IAT D = .18; $p > .30$). On average, participants stereotyped math as masculine, which was represented by a positive IAT effect that was significantly different from zero (IAT effect = 37 ms, IAT D = .14), $t(71) = 3.37$, $p < .01$.

Does exposure to a female versus male peer expert influence effort or test performance? Effort on the math test was operationalized as the total number of items that participants attempted to complete, and test performance was operationalized as the total number of correct responses on the test. Using effort as a dependent variable, a Peer Expert × Task Order ANOVA revealed a significant main effect of peer expert such that women who met a female peer expert in math attempted more problems ($M = 7.73$, $SE = 0.34$) than women who met a male peer expert in math ($M = 6.39$, $SE = 0.33$), $F(1, 68) = 8.01$, $p < .01$. No other effects were significant ($ps > .40$).

When test performance was used as the dependent variable, a Peer Expert × Task Order ANOVA revealed that women's performance did not differ as a function of peer expert ($p > .50$). Given the extreme difficulty of the test, on average, all participants performed poorly on the test regardless of condition, producing a floor effect (female peer condition: $M = 2.41$ correct responses, $SE = 0.29$; male peer condition: $M = 2.66$ correct responses, $SE = 0.29$). These results did not change after controlling for participants' SAT scores or the total number of items they attempted.

Does exposure to a female versus male peer expert influence explicit reactions toward math? Recall that we expected that participants' explicit self-reports about math would not change as a function of who they met in the lab because, as students who had already committed to STEM majors, participants would be particularly motivated to avoid applying gender stereotypes about math to themselves. Consistent with this hypothesis, Peer Expert × Academic Discipline × Test Order mixed ANOVAs using explicit identification, explicit attitudes, and explicit stereotypes regarding math and English as dependent variables revealed only main effects of academic discipline. That is, participants held significantly more positive attitudes toward math ($M = 2.80$, $SE = 0.21$) than English ($M = 0.15$, $SE = 0.30$), $F(1, 68) = 49.83$, $p < .001$. Similarly, they identified more strongly with math ($M = 9.68$, $SE = 0.14$) than English ($M = 7.77$, $SE = 0.27$), $F(1, 68) = 43.62$, $p < .001$. Finally, they held stereotypic views such that they considered math to be more of a male domain ($M = 5.08$, $SE = 0.11$) and English to be more of a female domain ($M = 6.87$, $SE = 0.12$) rather than considering these disciplines to be gender neutral, $F(1, 68) = 90.10$, $p < .001$. No other effects were significant ($ps > .10$).

Discussion

Consistent with our theoretical model, Study 1 showed that when women who were pursuing STEM majors interacted with an advanced female peer who had expertise in math, they expressed more positive implicit attitudes toward math, showed more implicit identification with math, and increased their effort on a very difficult math test compared with others who interacted with an advanced male peer. However, women's implicit stereotypes about math did not change as a function of who they interacted with, suggesting that contact with a same-sex math peer expert inoculated women's self-concept about math despite their awareness of negative ingroup stereotypes.

This study complements and extends past research on the benefit of ingroup role models in two important ways. First, past research indicates that women report differential treatment due to their sex in male-dominated academic areas and express greater interest in exiting those disciplines compared with stereotypically feminine disciplines (e.g., Steele et al., 2002). Other work has shown that women exhibit more implicit negative attitudes toward STEM when gender is made salient (Steele & Ambady, 2006). Study 1 complements this work by suggesting that even when women are aware of their stereotyped status in STEM, their self-concept can be protected when they have personal contact with a same-sex peer expert in the field.

Second, past work indicates that seeing same-sex role models in stereotypically masculine fields can weaken women's implicit stereotypes about their ingroup (Dasgupta & Asgari, 2004) and enhance test performance in stereotypic domains (Marx & Roman, 2002; Marx et al., 2005; McIntyre et al., 2003). To the best of our knowledge, Study 1 is the first to show that contact with same-sex role models also benefits women's overall self-concept in STEM despite their awareness of negative group stereotypes. Importantly, this benefit accrues without women having to distance themselves from their gender.

Importantly, Study 1 did not address why female role models in STEM benefit women's implicit self-concept. As suggested in our model, we suspect that encountering same-sex (compared with other-sex) scientists and engineers evokes a stronger sense of subjective identification with the successful target because she is a fellow ingroup member; this may make the path from one's current self to a future self in science and engineering seem more attainable. We tested this prediction in Study 2 and also investigated the impact of same-sex experts on women's career goals and aspirations.

Study 2

Study 2 focused on a single STEM field (engineering) because we anticipated that women's identification with same-sex experts and their own career goals and aspirations would benefit most clearly if the experts' professional work was closely aligned with their own academic discipline. We predicted that stronger subjective identification with female experts but not male experts would enhance women's commitment to a future career in engineering and that this relation would be driven by stronger implicit identification with STEM and/or self-efficacy in STEM. Exposure to engineers was manipulated by having participants read biographies of successful female or male engineers who work in academia, industry, or government (e.g., the National Aeronautics and Space Administration [NASA]). We included a control condition in Study 2 to examine whether seeing female experts is beneficial to women's self-concept and future goals, whether seeing successful men in STEM is detrimental, or both.

Method

Participants. One hundred and one female undergraduate engineering majors were recruited from a variety of introductory-level engineering courses that represented the four types of engineering majors offered at the university (i.e., chemical, civil, electrical, and mechanical engineering). Participants were paid $20 for their time.

Manipulations, measures, and procedure. Participants were randomly assigned to the female engineer, male engineer, or control condition. They were told that they would complete a number of tasks, including a general knowledge task related to engineering (cover story for the biography manipulation), a hand–eye coordination task (IATs), and several questionnaires (explicit measures). IATs and explicit measures were administered in counterbalanced order.

Biographies of engineers and descriptions of engineering innovations. Using information culled from professional websites of female engineers nationwide, we created paragraph-long biographies of five female engineers for the experimental condition. Each biography was accompanied by a picture of the individual. We sought to maximize the likelihood that participants would subjectively identify with the depicted individuals in four ways: (a) by ensuring that the female engineers represented all the engineering subfields taught on campus to enhance the overlap between students' interests and the experts' professional work; (b) by selecting engineers who were from diverse racial backgrounds (2 White, 1 African American, 1 Asian American, and 1 Latina); (c) by selecting engineers who were young, in the event that participants might find it easier to identify with individuals who are relatively close to them in age; and (d) by including interesting information about why these engineers were initially attracted to the discipline, why they decided to pursue it as a career, and the engineering innovations that have emerged from their work. For the male engineer condition, the biographies were identical to those in the female engineer condition, except that pronouns were modified and the pictures of female engineers were replaced with pictures of men who were matched in age, race, and attractiveness. In the control condition, participants saw five images and descriptions of engineering innovations taken directly from the biographies.

Identification with engineers portrayed in the biographies. After reading the biographies or innovation descriptions, participants completed six items ($\alpha = .78$) that tapped their subjective identification with the female or male engineers or with the sex-unspecified engineers who had created the innovations in the control condition. Sample items are "How much do you identify with the engineers you just read about?" and "How much do you relate to the engineers you just read about?" Participants responded on scales ranging from 1 (*not at all*) to 7 (*very much*).

IAT measures. The same three IATs from the previous study were used here to assess students' implicit attitudes toward STEM, identification with STEM, and stereotypes that STEM is a male domain. Because of experimenter oversight the labels in these IATs were "math" versus "English" as in Study 1 (rather than "engineering" vs. "English"). However, this oversight is unlikely to change the results because all engineering students know that the core foundation of engineering is mathematics, and the heavy emphasis on math is the reason why engineering is stereotyped as masculine.

Explicit attitudes, identification, and stereotypes. These measures were virtually identical to Study 1 except engineering was the target domain instead of math.

Self-efficacy in engineering. We included a new measure (three items) assessing participants' self-efficacy in engineering (e.g., "In general, how confident are you about your engineering ability?"). Participants responded on 7-point scales anchored by 1 (*not at all*) to 7 (*very*), which yielded a reliable index ($\alpha = .76$).

Intention to pursue a career in engineering. Participants indicated the degree to which they intended to pursue a career in engineering by responding to two questions ($r = .52$): (a) "How likely are you to pursue graduate study in engineering?" and (b) "How likely are you to pursue a professional job in engineering?" They gave responses on 7-point scales anchored by 1 (*not at all likely*) to 7 (*very likely*).

Results

Does exposure to female versus male engineers or engineering innovations differentially influence women's implicit self-concept and implicit stereotypes?

Attitudes IAT. A planned contrast comparing the female biography condition to the male biography and innovations conditions revealed that participants exposed to male engineers or engineering innovations showed significant negative implicit attitudes toward math and relative preference for English (IAT effect = –70 ms, IAT D = –.21; IAT effect = –41 ms, IAT D = –.22, respectively), whereas others exposed to female engineers preferred math and English equally (IAT effect = –16 ms, IAT D = .01), $t(70) = 2.25$, $p < .05$, Cohen's $d = 0.54$ (see Figure 3).

Identification IAT. Unexpectedly, a one-way ANOVA revealed that women's implicit identification with math was not stronger after reading about female engineers (IAT effect = 79 ms, IAT D = .22) compared with male engineers (IAT effect = 56 ms, IAT D = .19) or engineering innovations (IAT effect = 91 ms, IAT D = .25; $p = .97$). We speculate about why this may have occurred in the Discussion section that follows. Notwithstanding this null effect at the ANOVA level, we found support for our hypothesis at an individual difference level (see below).

Does subjective identification with female engineers influence career goals? If so, is this effect mediated by implicit identification with STEM and/or self-efficacy? We first assessed whether individual differences in identification with women engineers predicted female students' intention to pursue engineering as a career by running a regression using subjective identification with female engineers (centered continuous variable) as the predictor variable and future career intentions as the outcome variable. Results revealed a significant positive relationship such that stronger identification with female engineers was associated with greater intentions to pursue an engineering career ($B = 0.53$, $SE = 0.23$, $p = .03$). Next, we tested if this relationship was mediated by students' implicit identification with STEM or by their greater self-efficacy in STEM. Accordingly, we ran two sets of mediational analyses separately using implicit identification with STEM and self-efficacy as potential mediators, following the procedure outlined by Baron and Kenny (1986).

Is implicit identification with STEM a mediator? Subjective identification with female engineers (predictor variable) significantly predicted stronger implicit identification with STEM (proposed mediator; $B = 0.17$, $SE = 0.08$, $p < .05$). Similarly, implicit identification with STEM (proposed mediator) significantly predicted more intention to pursue a career in engineering (outcome variable; $B = 1.11$, $SE = 0.48$, $p = .03$). When implicit identification with STEM was controlled in Step 1 of the regression, the relation between identification with female engineers and future

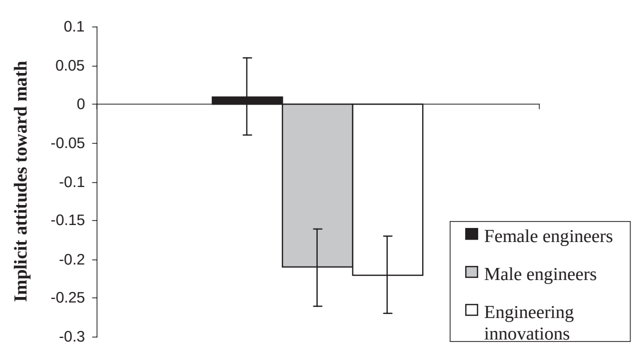

Figure 3. Women's implicit attitudes toward math after exposure to biographies of female engineers, male engineers, or descriptions of engineering innovations. Error bars represent standard error of the mean.

career goals was no longer significant ($B = 0.34$, $SE = 0.24$, $p = .16$; see Figure 4, Panel A). A one-tailed Sobel test revealed that this drop in significance was marginally significant ($Z = 1.56$, $p = .058$).

Is self-efficacy in engineering a mediator? We also found that subjective identification with female engineers significantly predicted greater self-efficacy in engineering (proposed mediator; $B = 0.48$, $SE = 0.20$, $p = .02$). More self-efficacy predicted significantly more investment in pursuing a career in engineering (outcome variable; $B = 0.68$, $SE = 0.17$, $p < .001$). When self-efficacy was controlled, subjective identification with women engineers no longer predicted career goals (see Figure 4, Panel B; $B = 0.20$, $SE = 0.21$, $p = .35$; one-tailed Sobel test: $Z = 2.05$, $p = .02$).[2,3]

The equivalent regressions for the link between subjective identification and future career goals were not significant for either the male engineer condition ($B = 0.12$, $SE = 0.22$, $p = .60$) or the control condition ($B = 0.50$, $SE = 0.33$, $p = .14$) and therefore did not meet the first criterion necessary to test for mediation.

Secondary analyses.

Stereotype IAT. As in the previous study, exposure to same-sex engineers did not significantly reduce implicit stereotypes about STEM. Although participants exposed to female engineers appeared to exhibit slightly less implicit stereotyping (IAT effect = 38 ms, IAT $D = .09$) compared with the male engineer condition (IAT effect = 57 ms, IAT $D = .18$) and the engineering innovations condition (IAT effect = 59 ms, IAT $D = .20$), this difference was not significant ($p = .18$).

Do explicit attitudes, identification, and beliefs about engineering change after reading female versus male engineers' biographies? We conducted several mixed ANOVAs using Biography Condition (between-subjects variable) × Academic Discipline (engineering vs. English; within-subjects variable) as independent variables and explicit attitudes, explicit identification, and explicit stereotypes as dependent variables in separate analyses. Not surprisingly, women reported that they liked engineering ($M = 6.00$, $SE = 0.08$) significantly more than English ($M = 4.21$, $SE = 0.12$), $F(1, 97) = 156.01$, $p < .001$; they explicitly identified with engineering ($M = 6.54$, $SE = 0.06$) significantly more than English ($M = 4.96$, $SE = 0.13$), $F(1, 97) = 125.53$, $p < .001$; and they stereotyped engineering as a masculine domain ($M = 4.40$, $SE = 0.09$) and English as a feminine domain ($M = 3.30$, $SE = 0.11$), $F(1, 97) = 47.98$, $p < .001$. As expected, biography condition did not moderate any of these self-reports (ps $> .10$).

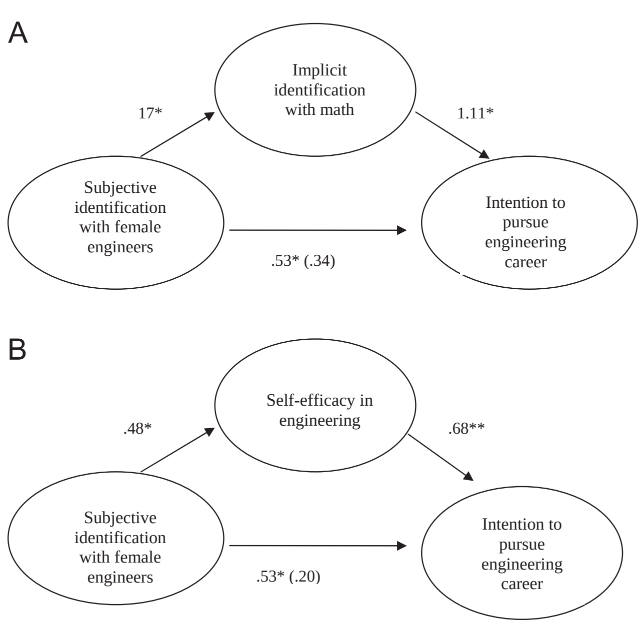

Figure 4. The relation between subjective identification with women engineers and stronger intention to pursue engineering in the future is mediated by implicit identification with math (Panel A) and by self-efficacy in engineering (Panel B). The values are unstandardized beta weights; the numbers inside parentheses indicate that the relationship between the predictor variable and the outcome variable becomes nonsignificant after controlling for the mediator. $^{*} p < .05$. $^{**} p < .001$.

Discussion

Consistent with our proposed theoretical model, the findings of Study 2 suggest that exposure to biographies of influential female engineers (compared with male engineers or engineering innovations) boosted female students' implicit positive attitudes toward STEM. Moreover, in the female engineer condition, the more women identified with these same-sex experts the more they reported wanting to pursue STEM careers. This relationship was mediated by two closely related variables—greater implicit identification with STEM and greater self-efficacy in STEM. As expected, identification with equivalent male engineers or sex-unspecified engineers did not predict women's career goals, implicit domain identification, or self-efficacy in engineering.

[2] Reverse mediational analyses were also significant, indicating that stronger identification with female engineers predicted stronger intentions to pursue engineering as a career (mediator), which in turn enhanced (a) implicit identification with STEM ($Z = 1.55$, $p = .06$) and (b) self-efficacy in engineering ($Z = 1.94$, $p = .03$). Collectively, our original mediational analyses and the reverse mediational analyses suggest that when female students identify strongly with same-sex engineers it bolsters their (a) implicit identification with the field, (b) self-efficacy, and (c) future career goals. But, it is not entirely clear whether identification with same-sex experts increases domain identification and self-efficacy first (as we predict) or if it increases commitment to engineering careers first (reverse mediation effect). Logic dictates that identification with engineering as a field and mastery (self-efficacy) must be acquired first before students can imagine a future career in that field, but future studies need to confirm this. Perhaps using samples of younger students who have not yet committed to engineering majors will provide clearer mediational evidence.

[3] We also ran a multiple mediator model using bootstrapping (5,000 resamples; see Preacher & Hayes, 2008) to assess the simultaneous indirect effect of implicit identification and self-efficacy as mediators on future career intentions (dependent variable). We found that self-efficacy continued to be a significant mediator, even after controlling for implicit identification ($B = 0.60$, $SE = 0.17$, $p < .01$), but the mediating effect of implicit identification became a weaker trend after controlling for self-efficacy ($B = 0.70$, $SE = 0.43$, $p = .10$). This indicates that self-efficacy and implicit identification work together to influence students' future career intentions but that the effect of self-efficacy is a bit stronger.

One unexpected finding in Study 2 was that exposure to biographies of female engineers did not increase participants' implicit identification with STEM compared with the other two conditions. Upon reflection we think this occurred because reading biographies of ingroup experts is not as psychologically powerful as actually meeting such individuals. Although prior work has shown that media exposure to counterstereotypic ingroup members boosts women's performance on a STEM test (e.g., Marx & Roman, 2002, Study 3; McIntyre et al., 2003), we believe that when it comes to changing self-conceptions and going against strong societal stereotypes, the immediacy of personal contact may be more effective. We addressed this problem in Study 3 by ensuring that students had direct personal contact with female versus male experts and then compared the effect of such contact on students' self-conceptions and attitudes in STEM.

Study 3

We recruited female and male students from multiple sections of an introductory calculus class; some sections were taught by female professors while others were taught by male professors. Students were tracked from the beginning of the semester (September) to the end (December). This calculus class is a prerequisite and gateway for all STEM majors in the physical sciences; such gateway courses are well-known sites of student attrition from STEM fields. Thus, any intervention in this calculus class is likely to have a high impact in preventing attrition of female students from STEM.

Although this was a quasi-experimental study, several important strengths of the study bring it very close to a controlled laboratory experiment. First, students preregistered for specific sections of this calculus class before professors had been assigned to each section. Thus, students could not have self-selected into specific sections on the basis of prior knowledge of course professors, including their sex. Second, thanks to unparalleled help from the Department of Mathematics, male and female professors who taught the sections from which we drew our sample were matched in terms of their teaching skills, their stage of career, and their fluency in English. In terms of race and ethnicity, these professors were White American, Eastern European, Chinese, and Latin American (more than 50% were international faculty). Third, professors teaching these sections were yoked to same-sex teaching assistants (TAs) to ensure that in the context of the class participants came into contact exclusively with female experts in mathematics (i.e., a lecture taught by a female professor and a discussion section led by a female TA) or male experts in mathematics (i.e., a lecture taught by a male professor and a discussion section led by a male TA). All professors and TAs were blind to the real purpose of this study; they were told generically that the study was on students' interest in math and related majors. Fourth, all course sections had identical syllabi and exams; thus students learned the same material and were tested in the same way regardless of who their professors were. Finally, instructors and TAs graded blind to students' identity, and grading was shared across sections so that instructors did not necessarily grade their own students' exams. Thus, instructors' evaluation of students' exams and their final grade could not have been biased by their preexisting expectations of any student.

The longitudinal design allowed us to assess whether the hypothesized benefit of contact with same-sex experts for female students takes effect immediately and remains stable across the semester or if it grows stronger over time. It also allowed us to test whether the benefit of same-sex experts endures after students leave class and move to other situations where the experts are not physically present. If the positive effect of contact is confined to the classroom where experts are physically present, then testing students outside the calculus class in other situations should wipe out the benefit.

The longitudinal design of Study 3 makes it very different from past work that examined women's experience in stereotypically masculine classrooms (Steele et al., 2002), which assessed students' perceptions at a single point in time. Our own past work that utilized a longitudinal design examined changes in women's implicit beliefs about their ingroup after exposure to counterstereotypic ingroup members (Dasgupta & Asgari, 2004); it did not assess changes in the self-concept across time.

Method

Participants. One hundred undergraduates (47 women and 53 men) who intended to major in STEM disciplines were recruited from 15 sections of an introductory calculus class to participate in a semester-long study that consisted of two hour-long sessions in exchange for $40. Roughly 25% of students in this calculus class were women and 75% were men. Seven sections were taught by female professors and TAs, and eight sections were taught by male professors and TAs. Each section had 25–30 students. A total of nine students were excluded because of poor English speaking skills ($n = 2$), unusually low SAT scores on the quantitative section ($n = 2$), or failure to complete the second session ($n = 5$), leaving a final sample size of 91 students (42 women and 49 men).

Manipulations, measures, and procedure.

Time 1. Each participant met one-on-one with an experimenter in a quiet location on campus (e.g., library cubicle, empty lab, or classroom). Participants were left alone to complete the three IATs that were identical to those in Studies 1 and 2, followed by explicit attitudes, domain identification, stereotypes, and subjective identification measures used in Study 2. Participants also reported their expected grade in the course (i.e., letter grade ranging from A to F), which served as a measure of their perceived self-efficacy in math.

Time 2. In the second session, participants completed the same measures as in Time 1. Then they were asked if they would allow the Registrar's Office to release their final course grade to us. Only one student did not consent to releasing his grade; his data were excluded from analyses involving course grades. Participants were then debriefed.

Classroom observations. To supplement and enrich the quantitative measurement of students' attitudes and self-concept, we also collected qualitative data on classroom dynamics by conducting in-class observations at the beginning and end of the semester. Research assistants observed students' behavior in class and coded interactions with their professor once at the beginning and once at the end of the semester. Specific behaviors and coding protocol are discussed in the Results section.

Results

Does contact with female versus male professors differentially influence implicit attitudes toward and identification with mathematics? For each IAT we conducted a 2 (professor sex) × 2 (student sex) × 2 (time of semester) mixed ANOVA where time of semester was assessed within participants and the other two variables were assessed between participants.

Attitude IAT. Implicit attitudes toward math relative to English were calculated as in Studies 1–2 such that positive IAT D scores reflected more positive attitudes toward math and negative IAT D scores reflected more negative implicit attitudes toward math compared with English. Results revealed a significant main effect of professor sex; on average students implicitly liked math and English equally when their professor was a woman (IAT effect = −0.89 ms, IAT D score = –.03), whereas they expressed more negative attitudes toward math when he was a man (IAT effect = –116 ms, IAT D = –.33), $F(1, 87) = 8.23$, $p = .01$. We also found a marginally significant main effect of student sex; female students on average expressed more negative implicit attitudes toward math (IAT effect = −82 ms, IAT D = –.28) than did male students (IAT effect = –35 ms, IAT D = –.08), $F(1, 87) = 3.63$, $p = .06$. More importantly, these main effects were superseded by a significant Professor Sex × Student Sex interaction, $F(1, 87) = 4.71$, $p = .03$ (see Figure 5, Panel A); female students implicitly liked math and English equally when their professor was a woman (IAT effect = 7 ms, IAT D = .01) but strongly disliked math when their professor was a man (IAT effect = –171 ms, IAT D = –.55), $F(1, 40) = 11.68$, $p = .001$. However, male students did not differ in their implicit attitudes toward math regardless of whether their professor was a woman (IAT effect = −8 ms, IAT D = –.04) or a man (IAT effect = −62 ms, IAT D = –.12; $p > .60$). Time of semester did not influence implicit attitudes toward math; there was no main effect or interactions with time (ps > .30). Note that contact with same-sex math professors benefited female students even though the professors were not present in the situation in which attitudes were measured.

Identification IAT. Implicit identification with math relative to English was scored such that positive IAT D scores represented stronger identification with math and negative IAT D scores signified relative disidentification from math. A Professor Sex × Student Sex × Time of Semester mixed ANOVA revealed a significant main effect of student sex; on average, female students showed weaker implicit identification with math (IAT effect = 44 ms, IAT D = .08) compared with male students (IAT effect = 97 ms, IAT D = .29), $F(1, 87) = 7.37$, $p < .01$. More importantly, and as predicted, the main effect was qualified by a significant two-way Professor Sex × Student Sex interaction, $F(1, 87) = 5.12$, $p = .03$ (see Figure 5, Panel B). Deconstruction of this interaction revealed that female students implicitly identified with math significantly more when their professor was a woman (IAT effect = 101 ms, IAT D = .22) rather than a man (IAT effect = –14 ms, IAT D = –.06), $F(1, 40) = 5.77$, $p = .02$, but male students did not differ in their implicit identification with math regardless of professor sex (female professor: IAT effect = 85 ms,

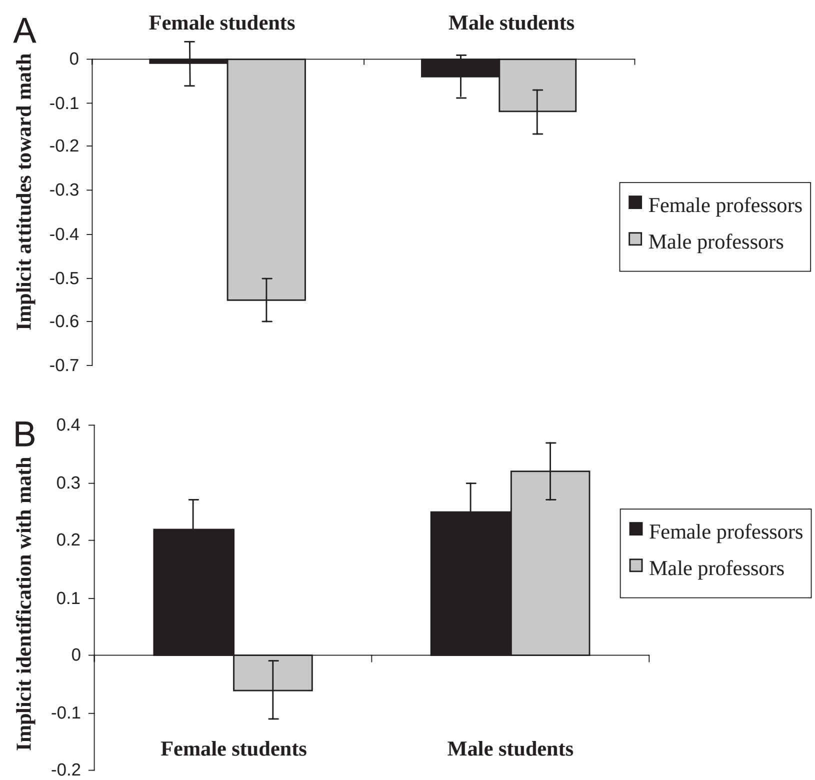

Figure 5. Women versus men's implicit attitudes toward math (Panel A) and implicit identification with math (Panel B) as a function of professor sex. Error bars represent standard error of the mean.

IAT $D = .25$; male professor: IAT effect = 110 ms, IAT $D = .32$; $p > .40$). Time of semester did not matter; we did not find a main effect of time or interactions ($ps > .10$).

Stereotype IAT. Implicit stereotypes linking math versus English with gender were assessed with IAT D scores such that larger positive scores reflected stronger implicit stereotypes associating math with men and English with women and smaller IAT scores reflected weaker gender stereotypic associations. A Professor Sex × Student Sex × Time of Semester mixed ANOVA revealed a significant main effect of student sex such that female students held weaker implicit gender stereotypes (IAT effect = 55 ms, IAT $D = .19$) than did male students (IAT effect = 143, IAT $D = .46$), $F(1, 87) = 11.88$, $p = .001$. However, as in Studies 1 and 2, implicit stereotypes did not vary as a function of professor contact; the Professor Sex × Student Sex interaction was nonsignificant for implicit stereotyping ($p = .32$), and time of semester did not influence this result (three-way interaction, $p = .17$).

Does exposure to female versus male professors differentially influence students' self-efficacy in math and actual performance?

Self-efficacy (expected grade) in class. Next, we conducted a Professor Sex × Student Sex × Time of Semester mixed ANOVA using participants' expected course grade as the dependent variable. The expected grade scale ranged from A to D and was transformed into an ordinal scale for data analysis such that D = 7, C = 8, B = 9, A = 10. As predicted, we found a significant Professor Sex × Student Sex interaction, $F(1, 87) = 4.25$, $p < .05$, showed that female students expected to receive significantly higher grades when their professor was a woman ($M = 8.60$, $SE = 0.28$) rather than a man ($M = 7.76$, $SE = 0.32$), $F(1, 40) = 4.02$, $p = .05$; however, male students did not differ in their expected grade regardless of professor sex (female professor: $M = 7.80$, $SE = 0.36$; male professor: $M = 7.90$, $SE = 0.31$; $p > .30$; see Figure 6, Panel A). There was no main effect of time, nor did time interact with professor sex ($ps > .20$).

Actual final grade for the course. To test whether students' actual course grade varied as a function of professor sex, we conducted a Professor Sex × Student Sex analysis of covariance using students' quantitative SAT score as a control variable. The only significant finding was a main effect of student sex, $F(1, 85) = 6.41$, $p < .05$, such that, interestingly, women outperformed men in terms of final grades (female students: $M = 9.25$, $SE = 0.18$; male students: $M = 8.65$, $SE = 0.17$) regardless of professor sex ($ps > .40$; see Figure 6, Panel B).

Does contact with female versus male professors evoke differential feelings of identification? We assessed students' subjective identification with their professor using a Professor Sex × Student Sex × Time of Semester mixed ANOVA to determine if

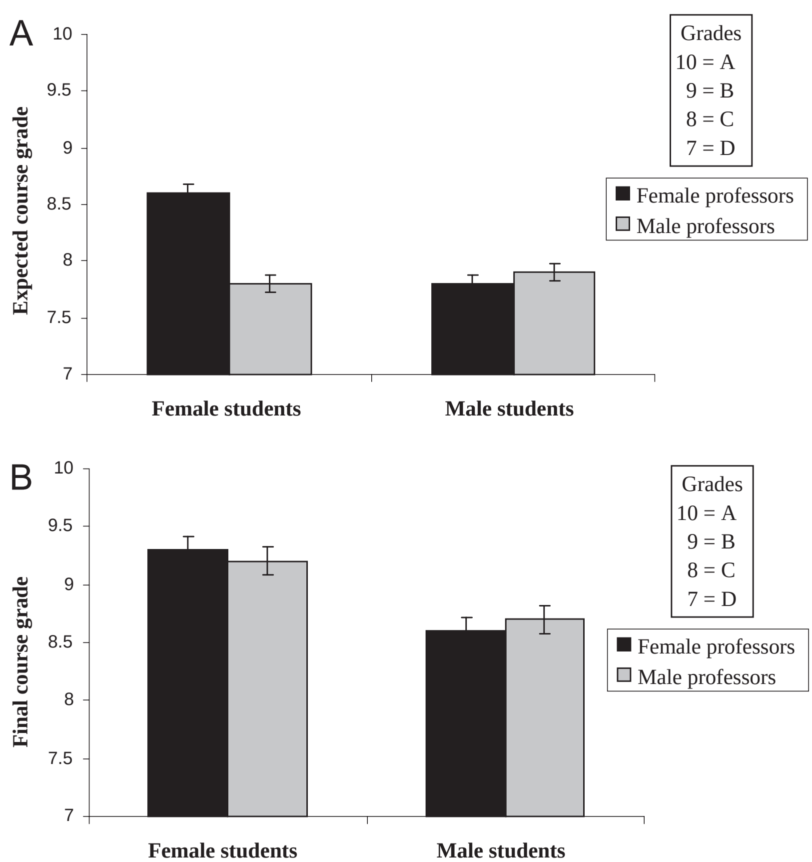

Figure 6. Women versus men's expected course grades (Panel A) and actual course grades (Panel B) in a calculus class as a function of professor sex. Grades in Panel B have been converted to the same scale as that of Panel A for ease of comparison. Error bars represent standard error of the mean.

students would identify more strongly with professors who were ingroup rather than outgroup members. As predicted, a significant Professor Sex × Student Sex interaction, $F(1, 87) = 4.41$, $p = .04$, showed that female students identified more with math professors if they were women ($M = 3.90$, $SE = 0.33$) rather than men ($M = 3.18$, $SE = 0.28$), but this effect was marginally significant, $F(1, 40) = 2.86$, $p = .09$. Male students identified equally with male ($M = 3.63$, $SE = 0.28$) and female professors ($M = 3.23$, $SE = 0.27$; $p > .20$).

Does identification with same-sex professors at Time 1 predict self-efficacy at Time 2? We then tested whether greater subjective identification with professors at the beginning of the semester would predict more self-efficacy in math at the end of the semester, and importantly, if this relation would depend on the "match" between students' sex and their professors' sex. To that end, we conducted a linear regression in which professor sex, student sex, subjective identification with professor, and interaction terms (all centered) were entered as predictor variables; we found a significant three-way interaction ($B = 0.56$, $SE = 0.21$, $p = .01$). When disaggregated by student sex, results showed a significant Professor Sex × Subjective Identification interaction for female students ($B = 0.26$, $SE = 0.13$, $p = .05$) such that greater identification with female math professors at the beginning of the semester (Time 1) predicted more self-efficacy in math at the end of the semester (Time 2; $B = 0.19$, $SE = 0.09$, $p = .03$). However subjective identification with male professors did not benefit female students' self-efficacy ($B = -0.07$, $p = .47$; see Figure 7, top panel). Among male students, although the Professor Sex × Subjective Identification interaction was also significant ($B = -0.33$, $SE = 0.15$, $p = .04$), the simple slopes were nonsignificant or marginal. Identification with male professors at the beginning of the semester did not predict self-efficacy in math at the end of the semester ($B = 0.14$, $SE = 0.11$, $p = .20$); however, *less* identification with female professors at the beginning of the semester predicted higher self-efficacy at the end of the semester ($B = -0.18$, $SE = 0.10$, $p = .08$; see Figure 7, bottom panel).

Does contact with female versus male professors influence classroom dynamics? Because the number of sections taught by female versus male professors was too small to run inferential statistics, we present only descriptive statistics for the classroom observations. Observers coded the number of times students (a) asked questions in class, (b) answered professors' questions in class, and (c) sought help from professors after class. Coders noted the total number of students who performed each behavior and their sex, with the caveat that each behavior was counted only once per student to control for individual differences among students (e.g., a particularly talkative student). We calculated the percentage of female and male students who engaged in each behavior by dividing the number of female (or male) students who performed each behavior by the total number of female (or male) students in class on that day and multiplying the result by 100 (see Table 1 for results). All of the following descriptive statistics are described as percentages.

Answering the professor's questions in class. The first column of Table 1 shows students who responded to their professors' questions in class. Because these professors directed questions to the class as a whole (not to any specific student), students' decisions to answer professors' questions are examples of proactive class participation rather than reactive behavior in response to being called upon. At Time 1, a smaller percentage of female students (9%) compared with male students (23%) answered questions regardless of professor sex. However, a different pattern emerged in Time 2: Now female students were much more likely to participate by answering questions when the professor was female (46% of women participated) rather than male (7% of women participated). This same pattern occurred among male students, although the difference in the percentage of male students who answered female (42%) versus male professors' (26%) questions was less dramatic. These numbers suggest that as the semester progressed, female students' participation in class increased noticeably when their professor was a woman (7% to 46%), but participation did not change when their professor was a man (11% to 7%).

Approaching professors for help after class. The percentage of students who approached professors after class did not differ much at Time 1 as a function of student sex or professor sex (among female students, 12% approached female professors and 13% approached male professors; among male students, 9% approached female professors and 5% approached male professors). However, at Time 2, the percentage of female students who approached male professors dropped to zero, whereas the percentage of women who approached female professors remained roughly similar across timepoints (12% at Time 1, 14% at Time 2). The number of male students who approached their professor at Time 2 did not differ by professor sex (7% for classes taught by both women and men).

Asking questions without prompting in class. More students asked questions in classes taught by female professors (22% of students) than male professors (15% of students). This trend did not differ by student sex or time of semester.

Does contact with female versus male professors differentially influence explicit identification, attitudes, and stereotypes about math? Each self-report measure was analyzed using Professor Sex × Student Sex × Time of Semester × Academic Discipline (math vs. English) mixed ANOVAs. Similar to Studies 1 and 2, results showed that all students had more positive attitudes toward math ($M = 5.26$, $SE = 0.09$) than English ($M = 3.97$, $SE = 0.11$), $F(1, 87) = 65.91$, $p < .001$, regardless of student sex, professor sex, or time of semester ($ps > .10$). They also identified significantly more strongly with math ($M = 5.97$, $SE = 0.09$) than English ($M = 4.84$, $SE = 0.10$), $F(1, 87) = 57.27$, $p < .001$, regardless of student sex, professor sex, or time of semester ($ps > .10$). At the same time, students explicitly endorsed the stereotype that math was more of a male domain ($M = 3.09$, $SE = 0.07$) and English more of a female domain ($M = 4.90$, $SE = 0.07$), $F(1, 87) = 259.69$, $p < .001$. Endorsement of this stereotype was significantly moderated by student sex, $F(1, 87) = 6.42$, $p = .01$, such that male students endorsed this stereotype more strongly (math: $M = 2.93$, $SE = 0.09$; English: $M = 5.03$, $SE = 0.10$) than did female students (math: $M = 3.24$, $SE = 0.10$; English: $M = 4.77$, $SE = 0.11$); there was no effect of time on explicit stereotypic beliefs ($ps > .10$).

Discussion

Study 3 revealed the benefit of contact with same-sex STEM experts on female students' implicit self-concept and self-efficacy in math, even when female students were outside the classroom where female experts were not physically present. We also found that subjective identification with same-sex math experts predicted

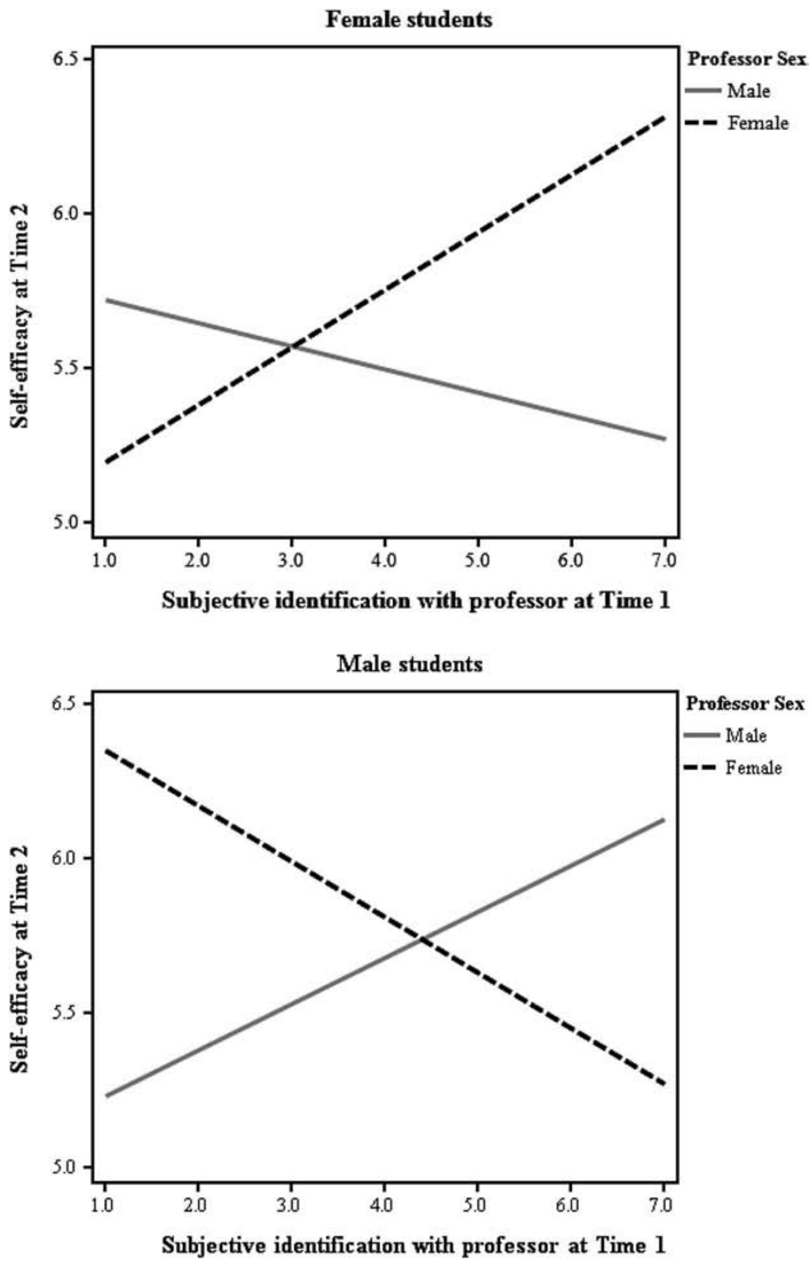

Figure 7. Top panel: Female participants: Subjective identification with female (but not male) professors at the beginning of the semester predicts increased self-efficacy at the end of the semester. Bottom panel: Male participants: Subjective identification with male professors at the beginning of the semester does not significantly predict increased self-efficacy at the end of the semester.

female (but not male) students' confidence and self-efficacy in their math ability, which is consistent with our prediction that identification with same-sex role models is particularly influential for negatively stereotyped group members' self-efficacy in a stereotyped domain. Importantly, even though the female students in this study clearly had strong ability in math and, as a group, outperformed their male peers, they were less confident about their performance when their professor was a man compared with when she was a woman.[4] Our observations of students' behavior in class

[4] Although this finding might invite the assumption that female students expected female professors to be more lenient in their grading than male professors (or to create easier exams), we think this is unlikely because students were fully aware that the exams were common across all sections, that course grading was done blind to students' identity (no names were on the exams), and that grading was shared by instructors (i.e., different questions within the same exam were graded by different instructors).

Table 1
Percentage of Female and Male Students' Behavior in Calculus Class

Student	Professor sex	Responded to questions professor posed in class (%)	Asked professor for help after class (%)	Asked questions in class (%)
Female students				
Time 1	Female	7	12	20
	Male	11	13	15
Time 2	Female	46	14	23
	Male	7	0	13
Male students				
Time 1	Female	18	9	22
	Male	28	5	16
Time 2	Female	42	7	22
	Male	26	7	15

Note. All values are percentages and were computed separately such that each represents the percentage of female (male) students who performed the behavior out of all of the female (male) students present that day.

complement the inferential statistics. Specifically, female students became more responsive over time toward their female professors in terms of speaking up in class (this behavior did not change when professors were male) and more avoidant with their male professors over time in terms of after-class help-seeking (this behavior did not change for female professors). Together, these results suggest that female experts may produce an approach-oriented response in terms of women's motivation to stay in STEM, while at the same time male experts may produce an avoidance-oriented response.

General Discussion

Increasing Exposure to Female Scientists, Engineers, and Mathematicians Benefits Female Students' Self-Concept, Attitudes, Effort, and Career Goals

Three studies tested the stereotype inoculation model to determine whether, when, and why exposure to same-sex role models in STEM might protect women's self-concept from being infected by negative ingroup stereotypes and, in turn, enhance women's intentions to pursue STEM careers. Consistent with our model in Figure 1, we found that, first, when women encountered other women who were experts in science, math, and engineering, they expressed more positive implicit attitudes toward STEM (Studies 1, 2, and 3), showed more implicit identification with these disciplines (Studies 1 and 3), exerted more effort on difficult math tests (Study 1), and felt more efficacious about their ability and future performance (Study 3) compared with other women who encountered male STEM experts. Second, the presence versus absence of same-sex experts was far more impactful for women than for men (Study 3), which fits past research showing that women rely on same-sex role models for inspiration more than men do (Lockwood, 2006).

Third, all three studies consistently showed that seeing same- versus opposite-sex experts in STEM did not change students' implicit or explicit stereotypes of these disciplines as masculine domains. When juxtaposed against the findings for implicit attitudes and identification with STEM, these data suggest that seeing female role models acts as a metaphorical antibody that protects women's self-conceptions in STEM from becoming vulnerable to societal stereotypes that are very much active in their minds.

Exposure to Same-Sex Experts Is Beneficial Because It Increases Feelings of Connectedness Between the Expert and Self, Making Future Careers in STEM More Plausible

Our theoretical model and data also address the question of why exposure to same-sex experts benefits women's self-concept and future career goals. Our data showed that exposure to same-sex versus opposite-sex experts enhanced women's subjective identification with those STEM experts (Studies 2 and 3), which in turn bolstered their self-efficacy in and implicit identification with STEM and predicted more commitment to pursue future STEM careers (Study 2). Thus, subjective identification makes the path from one's present self to a future self concrete because one can imagine emulating the trajectory of the successful ingroup member (cf. Markus & Nurius, 1986).

The quantitative evidence that seeing same-sex experts enhances self-efficacy (Studies 2 and 3) was complemented by observational data from Study 3 suggesting that increased self-efficacy manifested itself in female students' behavior in class. Compared with the beginning of the semester, by the end of the semester female students were more overtly participatory in class and more likely to seek after-class help from their professors when those individuals were women rather than men. Together, these findings suggest that increased self-efficacy and implicit domain identification translated into behavioral engagement in class and intentions to pursue STEM after college—all of this, over time, is likely to increase female students' commitment to STEM disciplines and careers in the future.

Theoretical Implications

This work underscores the importance of assessing the self-concept and attitudes using both implicit and explicit measures. All three studies showed that when asked, female students in STEM strongly and explicitly preferred math and engineering over English; they identified more strongly with math and engineering rather than English; and these explicit responses were identical to those of their male peers. Although these self-reports might suggest that a situational cue such as professor sex is trivial, women's *implicit* self-perceptions and attitudes were profoundly affected by the presence versus absence of female experts. Given the evidence that women's implicit identification with STEM predicts their future career goals, understanding psychological factors that alter women's implicit as well as explicit self-conceptions should be given high priority.

Note that the benefit of contact with same-sex experts on female students' implicit self-concepts lingered when the experts were absent from the immediate environment. Repeated contact with same-sex experts in a short 2-week period before Time 1 data collection in Study 3 enhanced female students' implicit self-concept enough to allow this effect to endure even when those experts were not physically present.

The current studies contribute to the stereotype threat literature by focusing on factors that influence women's self-concept, self-efficacy, and career goals, independent from test performance. The data suggest that the disproportionate "leakage" of women from the STEM educational pipeline may not be due to their actual performance—female students actually outperformed male students in their final grades in calculus regardless of who their professors were! Rather, women may be leaving STEM because, regardless of their accomplishments, the virtual absence of same-sex others in expert roles (in STEM classes, labs, textbooks, etc.) makes them feel like imposters (see Clance & Imes, 1978). Thus, our work extends past work that identified techniques to deflect the effect of stereotype threat on test performance (e.g., Huguet & Régner, 2007; Marx & Roman, 2002; McIntyre et al., 2003) by underscoring the added importance of interventions that enhance women's self-efficacy and sense of belonging in STEM while at the same time embracing their gender identity rather than shying away from it.

Conclusion

We began this article by suggesting that women are not completely free to choose whether they want to pursue STEM careers. Rather, their professional choices are strongly constrained by cultural assumptions about their ingroup's abilities or lack thereof. The current work suggests that seeing other successful women in STEM promises to free young women in the present generation from a societally constrained view of their abilities. Though these cultural stereotypes are deep seated and reinforced by the continued scarcity of women within STEM, the gender disparity has been decreasing over time, albeit not fast enough. Even in the absence of gender parity (which of course should be the long-term goal), our work suggests that increasing the visibility of a critical mass of scientists, engineers, and mathematicians, and providing women opportunities to have personal contact with them, has a profound positive effect on young women's self-perceptions in science, math, and engineering.

References

Aronson, J., Jannone, S., McGlone, M., & Johnson-Campbell, T. (2009). The Obama effect: An experimental test. *Journal of Experimental Social Psychology, 45,* 957–960. doi: 10.1016/j.jesp.2009.05.006

Aronson, J., Quinn, D. M., & Spencer, S. J. (1998). Stereotype threat and academic underperformance of minorities and women. In J. K. Swim & C. Stangor (Eds.), *Prejudice: The target's perspective* (pp. 83–103). San Diego, CA: Academic Press.

Baron, R. M., & Kenny, D. (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

Brewer, M. B., & Weber, J. G. (1994). Self-evaluation effects on interpersonal versus intergroup social comparison. *Journal of Personality and Social Psychology, 66,* 268–275. doi: 10.1037/0022-3514.66.2.268

Bridgeman, B., & Lewis, C. (1996). Gender differences in college mathematics grades and SAT–M scores: A reanalysis of Wainer & Steinberg. *Journal of Educational Measurement, 33,* 257–270. doi: 10.1111/j.1745-3984.1996.tb00492.x

Ceci, S. J., Williams, W. M., & Barnett, S. M. (2009). Women's underrepresentation in science: Sociocultural and biological considerations. *Psychological Bulletin, 135,* 218–261. doi: 10.1037/a0014412

Cheryan, S., Plaut, V. C., Davies, P. G., & 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

Clance, P. R., & Imes, S. A. (1978). The imposter phenomenon in high achieving women: Dynamics and therapeutic intervention. *Psychotherapy: Theory, Research, and Practice, 15,* 241–247. doi: 10.1037/h0086006

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

Elizaga, R., & Markman, K. (2008). Peers and performance: How in-group and out-group comparisons moderate stereotype threat effects. *Current Psychology, 27,* 290–300. doi: 10.1007/s12144-008-9041-y

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

Furnham, A., Reeves, E., & Budhani, S. (2002). Parents think their sons are brighter than their daughters: Sex differences in parental self-estimations and estimations of their children's multiple intelligences. *Journal of Genetic Psychology, 163,* 24–39. doi: 10.1080/00221320209597966

Gallagher, A. M., & Kaufman, J. C. (2005). *Gender differences in mathematics.* New York, NY: Cambridge University Press.

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

Greenwald, A., Banaji, M., Rudman, L., Farnham, S., Nosek, B., & Mellott, D. (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. L. K. (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

Huguet, P., & Régner, I. (2007). Stereotype threat among schoolgirls in quasi-ordinary classroom circumstances. *Journal of Educational Psychology, 99,* 545–560. doi: 10.1037/0022-0663.99.3.545

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008, July 25). Gender similarities characterize math performance. *Science, 321,* 494–495. doi: 10.1126/science.1160364

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

Jones, G. M., Brader-Araje, L., Carboni, L. W., Carter, G., Rua, M. J., Banilower, E., & Hatch, H. (2000). Tool time: Gender and students' use of tools, control, and authority. *Journal of Research in Science and Teaching, 37,* 760–783. doi: 10.1002/1098-2736(200010)37:8<760::AID-TEA2>3.0.CO;2-V

Lockwood, P. (2006). "Someone like me can be successful": Do college students need same-gender role models? *Psychology of Women Quarterly, 30,* 36–46. doi: 10.1111/j.1471-6402.2006.00260.x

Lockwood, P., & Kunda, Z. (1997). Superstars and me: Predicting the impact of role models on the self. *Journal of Personality and Social Psychology, 73,* 91–103. doi: 10.1037/0022-3514.73.1.91

Lockwood, P., & Kunda, Z. (1999). Increasing the salience of one's best selves can undermine inspiration by outstanding role models. *Journal of Personality and Social Psychology, 76,* 214–228. doi: 10.1037/0022-3514.76.2.214

Lummis, M., & Stevenson, H. (1990). Gender differences in beliefs and achievement: A cross-cultural study. *Developmental Psychology, 26,* 254–263. doi: 10.1037/0012-1649.26.2.254

Markus, H., & Kunda, Z. (1986). Stability and malleability of the self-concept. *Journal of Personality and Social Psychology, 51,* 858–866. doi: 10.1037/0022-3514.51.4.858

Markus, H., & Nurius, P. (1986). Possible selves. *American Psychologist, 41,* 954–969. doi: 10.1037/0003-066X.41.9.954

Markus, H. R., & Wurf, E. (1987). The dynamic self-concept: A social psychological perspective. *Annual Review of Psychology, 38,* 299–337. doi: 10.1146/annurev.ps.38.020187.001503

Martens, A., Johns, M., Greenberg, J., & Schimel, J. (2006). Combating stereotype threat: The effect of self-affirmation on women's intellectual performance. *Journal of Experimental Social Psychology, 42,* 236–243. doi: 10.1016/j.jesp.2005.04.010

Marx, D. M., Ko, S. J., & Friedman, R. A. (2009). The "Obama effect": How a salient role model reduces race-based performance differences. *Journal of Experimental Social Psychology, 45,* 953–956. doi: 10.1016/j.jesp.2009.03.012

Marx, D. M., & Roman, J. S. (2002). Female role models: Protecting women's math test performance. *Personality and Social Psychology Bulletin, 28,* 1183–1193. doi: 10.1177/01461672022812004

Marx, D. M., Stapel, D., & 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

McArdle, E. (2008). The freedom to say 'no.' *The Boston Globe.* Retrieved from http://www.boston.com/bostonglobe/ideas/articles/2008/05/18/the_freedom_to_say_no/

McGregor, L., Gee, D., & Posey, K. (2008). I feel like a fraud and it depresses me: The relation between the imposter phenomenon and depression. *Social Behavior and Personality, 36,* 43–48. doi: 10.2224/sbp.2008.36.1.43

McIntyre, R. B., Paulson, R. M., & Lord, C. G. (2003). Alleviating women's mathematics stereotype threat through salience of group achievements. *Journal of Experimental Social Psychology, 39,* 83–90. doi: 10.1016/S0022-1031(02)00513-9

Mendez, L., Mihalas, S., & Hardesty, R. (2006). Gender differences in academic development and performance. In G. G. Bear & K. M. Minke (Eds.), *Children's needs III: Development, prevention, and intervention* (pp. 553–565). Washington, DC: National Association of School Psychologists.

Murphy, M. C., Steele, C., & Gross, 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. (2009). *Women, minorities, and persons with disabilities in science and engineering: 2007.* Arlington, VA: National Science Foundation.

Nosek, B. A., Banaji, M., & Greenwald, A. (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

Pinker, S. (2008). *The sexual paradox: Extreme men, gifted women and the real gender gap.* Mississauga, Ontario, Canada: Random House.

Preacher, K. J., & Hayes, A. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40,* 879–891. doi: 10.3758/BRM.40.3.879

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.

Räty, H., Vänskä, J., Kasanen, K., & Kärkkäinen, R. (2002). Parents' explanation of their child's performance in mathematics and reading: A replication and extension of Yee and Eccles. *Sex Roles, 46,* 121–128. doi: 10.1023/A:1016573627828

Rosenbloom, J. L., Ash, R. A., Dupont, B., & Coder, L. (2008). Why are there so few women in information technology? Assessing the role of personality in career choices. *Journal of Economic Psychology, 29,* 543–554. doi: 10.1016/j.joep.2007.09.005

Sadker, M., & Sadker, D. (1994). *Failing at fairness: How America's schools short change girls.* New York, NY: Touchstone.

Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological Review, 115,* 336–356. doi: 10.1037/0033-295X.115.2.336

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

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

Steele, J. R., & Ambady, N. (2006). "Math is hard!" The effect of gender priming on women's attitudes. *Journal of Experimental Social Psychology, 42,* 428–436. doi: 10.1016/j.jesp.2005.06.003

Steele, J., James, J. B., & Barnett, R. C. (2002). Learning in a man's world: Examining the perceptions of undergraduate women in male-dominated academic areas. *Psychology of Women Quarterly, 26,* 46–50. doi: 10.1111/1471-6402.00042

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

Yee, D. K., & Eccles, J. S. (1988). Parent perceptions and attributions for children's math achievement. *Sex Roles, 19,* 317–333. doi: 10.1007/BF00289840

Received January 27, 2010
Revision received July 29, 2010
Accepted August 19, 2010 ■