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The Influence of Female Role Models on Women's Implicit Science Cognitions

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Abstract

Can female science professors benefit women? Women's negative implicit cognitions about science, technology, engineering, and mathematics (STEM) disciplines impact performance in these fields, marking implicit associations as a space for potential change to improve women's participation in STEM. Examining college student science majors ($N = 320$, 63% women) enrolled in chemistry and engineering courses, our study investigates how meaningful contact with female role models impacts women's implicit cognitions about STEM. We used the Implicit Association Test to measure attitudes toward science, identification with science, and gendered stereotypes about science, and we compared students with female versus male professors. Our study first demonstrates both direct and indirect paths between implicit cognitions and women's career aspirations in STEM. Next, when female professors were seen as positive role models, women automatically identified with science and stereotyped science as more feminine than masculine. Moreover, viewing professors as positive role models was associated with pro-science career aspirations and attitudes (both implicit and explicit), for men and women alike. The findings suggest that female science professors benefit women provided students identify with them as role models. We conclude that female STEM professors not only provide positive role models for women, but they also help to reduce the implicit stereotype that science is masculine in the culture-at-large. We further discuss how shifting implicit gendered stereotypes about science can impact women's investment in a science career.

Keywords

sexism, science education, role models, attitudes, stereotyped attitudes, implicit association test

Although far more women pursue college degrees in math and science than in the past, they remain underrepresented in science- and math-related careers, making up just 27% of the total science and engineering workforce and only 18% of full professors in science, technology, engineering, and mathematics (STEM) departments (National Science Foundation, 2009). Among the top 100 research universities, only 10% of STEM full professors are women (Nelson & Brammer, 2010; Rosser & Taylor, 2009), and gender-related discrimination can lead to job dissatisfaction among these female professors (Settles, Cortina, Buchanan, & Miner, 2013). As a result, women are deprived of female role models in STEM disciplines. Because the number of female role models on a college campus positively predicts female students' commitment to male-dominated professions (Tidball, Smith, Tidball, & Wolf-Wendel, 1999), their scarcity may help to explain why more women than men switch out of STEM majors in college (Seymour & Hewitt, 1997). Even when women are high performers, their enthusiasm for STEM disciplines lags behind men's (Webb, Lubinski, & Benbow, 2007). As a result, talented women are far less likely than their male peers to pursue STEM careers (Benbow, Lubinski, Shea, & Eftekhari-Sanjani, 2000). The need for more women to enter science and technology fields is inarguable—not only to draw on a pool of talent and expertise that has been overlooked but also to foster gender equality and challenge gender stereotypes in the culture-at-large.

What might combat the problem? Previous research suggests that female role models may positively impact women in a variety of traditionally male-dominated fields, including STEM disciplines (Dasgupta & Asgari, 2004; Stout, Dasgupta, Hunsinger, & McManus, 2011). The present study examined whether female role models have a positive influence on undergraduate women's implicit science attitudes, identity, and stereotypes—as well as their investment in STEM. Previous research suggests that female math instructors have positive benefits for women's implicit math attitudes

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and identity, but not their implicit math stereotypes (Stout et al., 2011, study 3). However, the authors did not examine whether identifying with instructors as role models moderates these implicit cognitions. We predict that *viewing* professors as role models will impact implicit cognitions, consistent with the contact hypothesis literature that suggests that the quality of contact with stereotyped others matters more than mere contact alone (Tropp & Pettigrew, 2005; van Dick et al., 2004). Previous research on altering implicit cognitions demonstrated that identifying with an African American male professor moderated the effects of a diversity seminar on White students' implicit prejudice and anti-Black stereotypes (Rudman, Ashmore, & Gary, 2001). Specifically, White students showed reduced automatic biases to the extent that they liked and admired the Black professor. Similarly, we expected female students to show reduced implicit male-science stereotypes and increased pro-science attitudes and identity to the extent that they liked and admired their female STEM professors.

Among the numerous factors responsible for the gender gap in scientific achievement and leadership is the fact that science and math continue to be stereotyped as masculine (Carnes & Bland, 2007; Roos & Gatta, 2009). People tend to gravitate toward and persist in activities in which they believe they will succeed (Eccles, 1994, 2010), and women are dissuaded from male-dominated domains by their own stereotypes as well as those of others (Diekman, Brown, Johnston, & Clark, 2010; Jacobs & Eccles, 1992; Jussim & Eccles, 1992). Because gender stereotypes are learned early and reinforced often, both genders possess an implicit stereotype that associates men with math more so than women (Nosek, Banaji, & Greenwald, 2002b). Implicit gender stereotypes are routinized cognitions that automatically associate men and women with stereotypic traits, abilities, and roles, resulting in rapid and involuntary stereotypic judgments (Banaji & Hardin, 1996; Greenwald & Banaji, 1995; Rudman & Glick, 2001; Rudman, Greenwald, & McGhee, 2001; Rudman & Kilianski, 2000). These stereotypes impede women's math performance, whether indexed by SAT scores (Nosek et al., 2002b) or calculus exams in a prospective study—supporting a causal link (Keifer & Sekaquaptewa, 2007a, 2007b). In addition, compared with men, women tend to automatically identify less with STEM fields and to have more negative implicit attitudes toward math (Nosek et al., 2002b; Stout et al., 2011), which may help to explain why women are less likely than men to pursue science careers (Roos & Gatta, 2009).

Given that the gender gap in scientific leadership reinforces stereotypes, female role models ought to benefit women, just as exposing women to famous female leaders may reduce their implicit male-leader stereotypes (Dasgupta & Asgari, 2004) and increase their identification with leadership concepts (Rios, Stewart, & Winter, 2010). Indeed, undergraduates and women in nontraditional careers frequently report that female role models have a profound impact on their achievement and aspirations, in part because they represent the possibility of overcoming gender-related barriers to success (Downing, Crosby, & Blake-Beard, 2005; Nauta, Epperson, & Kahn, 1998; Quimby, 2006; Zirkel, 2002). Consistent with this view, evidence suggests that reading about famous female mathematicians improves women's math performance (Marx & Roman, 2002), plausibly by making in-group achievement more salient (McIntyre, Paulson, & Lord, 2003). Similarly, female engineering students who identified with the biographies of female engineers were more likely to pursue an engineering career, and this relationship was partially mediated by their implicit math identity scores (Stout et al., 2011, study 2).

In the present research, we examined whether female STEM professors would have a positive effect on women's implicit science stereotypes—as well as their implicit attitudes toward, and identification with, science. In related research investigating math cognitions, women enrolled in introductory calculus courses showed stronger implicit pro-math attitudes and identity when their instructors were female rather than male (Stout et al., 2011, study 3). There was no benefit for implicit math stereotypes, but Stout, Dasgupta, Hunsinger, and McManus (2011) did not examine whether this benefit might be specific to students who identified with their female instructors as positive role models. Research suggests that prejudices are best reduced when people have *meaningful* contact with stereotyped others (Tropp & Pettigrew, 2005; van Dick et al., 2004).

This is also true of implicit biases. As noted, White students enrolled in a diversity seminar with a Black male professor showed reduced implicit prejudice and stereotypes at the end of the course, compared with the beginning, but only if they liked and admired the professor (Rudman, Ashmore, & Gary, 2001). These findings suggest that *admired* female science professors might bestow similar benefits on female science students, and do so under real-world conditions. This nuance is important because Stout et al. (2011) investigated implicit math cognitions under artificial conditions (designed to improve the internal validity of their quasi-experiment). For example, students were unaware of instructors' gender when they enrolled in the calculus course; the gender of the teaching assistant was yoked to instructors' gender; and male and female instructors were matched on career stage, teaching skills, and fluency in English. Because these variables are typically uncontrolled, whether having a female professor has positive effects on women's STEM orientations under real-world conditions is unknown. Unique to the present research, we examined the role model status of female professors as a moderator of any benefits accrued to women's implicit STEM cognitions (thus increasing implicit science attitudes and identity and decreasing science stereotypes).

We used the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) because, compared with other measures of implicit cognition, the IAT has shown superior psychometric properties (Bar-Anan & Nosek, 2012), including predictive utility (Greenwald, Poehlman, Uhlmann, & Banaji, 2009). Our main objective was to test whether female science professors have positive effects on women's science cognitions if they view them as positive role models. Hypothesis 1 stated that women students with a female STEM professor should possess positive implicit science attitudes to the extent they view their female professor as a positive role model (i.e., admire and identify with her). Hypothesis 2 stated that women with a female STEM professor should be more likely to implicitly identify with science to the extent they view their female professor as a positive role model. Hypothesis 3 predicts that women who view their female STEM professor as a positive role model should be less likely to implicitly stereotype science as masculine than women who do not view their female professor as a positive role model. Finally, Hypothesis 4 states if female STEM professors benefit women's investment in STEM, women students should be more interested in pursuing a science career when their professor is female, rather than male, provided they view their female professor as a positive role model. Although Stout et al. (2011) did not find any effects of instructor gender on students' explicit math-related attitudes, identity, or stereotypes, the authors did not examine the role of identifying with professors as role models. Thus, we reinvestigated this issue using science-related explicit counterparts to our IATs.

Method

Participants

Volunteers (N = 320, of whom 202 were women; M_{age} = 20.50, standard deviation [SD] = 2.74, range: 18–60) were recruited from engineering and chemistry courses. The majority (299, 93%) were science majors; only 21 (7%) were not; science major did not differ by gender, $\chi^2 = .66$, $p = .285$. Their reported ethnicity was 144 (44%) Asian; 127 (40%) White; 14 (4%) Hispanic; 11 (3%) African American; and 24 (8%) reported another ethnicity. The authors recruited the STEM faculty, who provided the authors with e-mail lists of their students from which we contacted students toward the end of the semester by e-mailing them the project announcement with the link to our survey's website. Students were informed that we were interested in "the factors that predict student interest in science" and that if they completed the online survey, they would be entered into a lottery for two $500 cash prizes (awarded in June 2011).

Nine male and nine female engineering professors agreed to allow us to recruit, and three male and three female chemistry professors did likewise. Because we promised professors complete anonymity, we did not ask students to report their professor's name (only their gender). The resulting sample consisted of 233 students taught by a male science professor and 87 taught by a female science professor.[1] Judging by their course number, 231 (72%) students were third-year students, 21 (7%) were second-year students, 37 (12%) were first-year students, and 31 (9%) were unknown.

Procedure and Materials

The order in which students performed the attitude, identity, and stereotype IATs was completely counterbalanced—a procedural factor that did not influence results. To alleviate participants' fatigue, students performed two IATs and then the self-report measures (in the order described in the following) before performing the third IAT. They then reported their demographics (age, gender, race, major) and the gender of their professor and course name before being fully debriefed.

Implicit Measures. Three IATs assessed participants' (a) implicit attitudes toward science (Attitude IAT), (b) their identification with science (Identity IAT), and (c) whether they stereotyped science as masculine more than feminine (Stereotype IAT). The IAT is a computerized task that measures the relative strength with which two categories (e.g., Science vs. Humanities) are associated with two attributes (e.g., good vs. bad). People who categorized good words faster than bad words with science possess a favorable implicit attitude toward science. Those who categorize the self faster with Science than with the Humanities have an implicit science identity. Those who categorized men faster than women with Science showed an implicit male science stereotype. Each IAT consisted of two practice blocks and four blocks of critical trials, and IAT effects were computed as the D statistic, which is the response latency difference in performing the two tasks divided by each participant's SD (for task details, see Nosek et al., 2002a; for scoring details, see Greenwald, Nosek, & Banaji, 2003).

Implicit attitudes toward science were scored as the difference between participants' response latencies when categorizing words related to science (e.g., chemistry, engineering, science) and the humanities (e.g., literature, music, philosophy) with positive versus negative words (e.g., good, smile, fortune vs. bad, pain, disaster). High scores reflect more positive attitudes toward science than the humanities. Implicit identification with science was measured as the difference between response latencies when categorizing the same science and humanities words with first-person pronouns (e.g., me, myself) versus third-person pronouns (e.g., they, them). High scores reflect identifying with science more than with the humanities. Implicit male science stereotypes were assessed by measuring how quickly participants paired the same science and humanities words with words related to men (e.g., male, man, boy, he) versus women (e.g., female, woman, girl, she). High scores reflected stereotyping science as more masculine than feminine.

Explicit Measures. In addition to implicit measures, we collected participants' explicit responses regarding their science attitudes, science identity, and gendering of science stereotypes.

To capture their science attitudes, participants responded to 4 items using scales ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). The items were "I very much like doing science"; "I would take more science classes even if I didn't have to"; "In general, I find working on science assignments very interesting"; and "I spend time on science work because I have to" (reversed). The items were averaged so that high scores reflect positive science attitudes ($\alpha = .89$). To measure explicit identity, participants responded to 5 items using the same scales. The items were "In general, being a science student is an important part of my current self-image"; "Being a science student is an important reflection of who I currently am"; "Being a science student is important to my sense of what kind of person I am now"; "Overall, being a science student has very little to do with how I feel about myself" (reversed); and "It is not important to me to be good at science" (reversed). The items were averaged so that high scores reflect greater identification with science ($\alpha = .84$). To assess gendered science stereotypes, participants rated science, chemistry, engineering, and physics on a scale ranging from 1 (*masculine*) to 7 (*feminine*). Responses were recoded and averaged so that a high score reflected stereotyping science as more masculine than feminine ($\alpha = .77$).

Role Model Index and Science Career Aspirations. Using a scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), 4 items evaluated students' perceptions of the professor as a role model: "I admire and identify with the professor, who has been a positive role model for me"; "I think I am similar to my science professor"; "I view my professor as an expert I can identify with"; and "I like my science professor." The items were averaged so that high scores reflected viewing the professor as a positive role model ($\alpha = .91$). To measure their investment in STEM, participants responded to 3 items on scales ranging from 1 (*not at all*) to 7 (*very much so*): "How much would you like to pursue a career in science?"; "How much are you interested in becoming a scientist after you graduate from college?"; and "How interested are you in becoming a science teacher or professor?" Responses were averaged so that a high score reflected aspiring to a science career ($\alpha = .84$).

Results

IAT data for five participants were eliminated because they were outliers scoring above or below at least 3 *SD*s from the mean. Preliminary analyses ruled out participant race and type of science course as having significant main or interaction effects with participant gender and professor gender on IAT scores, all Fs < 2.39, ps > .21. We therefore collapsed across these variables for our main analyses.

Gender Differences and Correlations

The results of gender difference tests are shown in Table 1. Compared with women, men had more favorable implicit attitudes toward science and identified more with science. Men also possessed stronger implicit and explicit science stereotypes and scored higher on the professor role model index than women did. Unexpectedly, women scored higher than men on science aspirations, reporting a stronger interest in pursuing a science career. To further explore this result, we conducted gender difference tests comparing Whites, Asians, and sample minorities (Blacks and Latinos/Latinas, combined). Only the latter group differed significantly by gender, with minority women ($M = 6.63$, $SD = .68$) outscoring minority men ($M = 5.50$, $SD = 1.76$), $t(23) = 2.23$, $p = .03$, $d = 1.09$. Because there were very few minorities (19 women, 6 men), this finding is tentative in spite of the large effect size, and we conclude that for the majority of the sample, no gender differences emerged for science career aspirations.

Table 1. Descriptive Statistics by Gender.

	Male Students		Female Students		Gender Differences	
	M	*SD*	*M*	*SD*	*t*	*D*
Attitude IAT	.17	.56	−.01	.49	3.00**	.35
Identity IAT	.34	.45	.19	.44	2.74**	.33
Stereotype IAT	.43	.68	.04	.48	6.03***	.66
Attitude index	5.01	1.23	4.84	1.24	1.24	.15
Identity index	5.13	1.17	5.25	1.12	.93	−.11
Stereotype index	5.24	.88	4.90	.73	3.71***	.43
Career aspirations	5.92	1.26	6.23	1.15	2.26*	−.26
Role model index	3.91	1.28	3.61	1.33	1.96*	.23

Note. IAT = Implicit Association Test. IAT results are shown in *D* statistic form (Greenwald, Nosek, & Banaji, 2003). Positive scores reflect associating science with positive attributes (attitudes), the self (identity), and with men (stereotypes), respectively. The explicit stereotype, attitude, and identity indexes were scored in the same direction. Possible range for all explicit measures was 1–7, except for science major (1 = *no*, 2 = *yes*), and the role model index (1–5). The effect size (Cohen's *d*) for gender differences is based on the pooled *SD*. Positive scores indicate men scored higher than women. By convention, small, moderate, and large effect sizes correspond to .20, .50, and .80, respectively (Cohen, 1988).
*$p \leq .05$. **$p < .01$. ***$p < .001$.

Table 2 shows the correlations among the attitude, identity, and stereotype measures. We expected to replicate prior research examining implicit math cognitions (Nosek et al., 2002b). Specifically, attitudes and identity should be positively related for both genders, as well as positively related to stereotypes for men, but negatively related to stereotypes for women. Explicit stereotypes should not follow suit because only implicit cognitions reveal a pattern of liking and identifying with domains that are stereotyped as favoring one's in-group (Greenwald et al., 2002).

As can be seen in Table 2, implicit attitudes and identity were positively linked, but only for women. In addition, women who implicitly stereotyped science as masculine showed less implicit liking of science and less implicit identification with science. Further, women's implicit stereotypes were negatively correlated with their explicit attitudes and

Table 2. Correlations Among Study Variables by Participant Gender.

	Attitude IAT	Identity IAT	Stereotype IAT	Attitude Index	Identity Index	Stereotype Index	Career Aspirations
Implicit							
Attitude IAT	—	**.22****	**−.16***	.23**	.07	.05	.23**
Identity IAT	**−.04**	—	**−.38*****	.20**	.15*	−.19**	.20**
Stereotype IAT	**.20****	**−.23***	—	−.15*	−.21**	.16*	−.06
Explicit							
Attitude index	.28**	.16	.01	—	.53***	.05	.47***
Identity index	.20*	.13	.01	.54***	—	.13	.37***
Stereotype index	−.01	.18	−.13	.01	.17	—	.09
Career aspirations	.09	.27**	−.03	.52***	.45***	.04	—

Note. IAT = Implicit Association Test. Women's correlations are above the diagonal (*n*s range from 198 to 202); men's, below (*n*s range from 114 to 118). Correlations among the IATs are in boldface type. *$p < .05$. **$p < .01$. ***$p < .001$.

identity, suggesting a generalized depressing effect of implicit stereotypes on women's STEM cognitions. As predicted, men who automatically stereotyped science as masculine also implicitly liked science, but unexpectedly, they identified *less* with science. Because this finding contradicts past results (Greenwald et al., 2002; Nosek et al., 2002b), we view it with caution. Because our sample consisted mainly of third-year science majors, it is possible that men with more experience with science courses (which should increase their implicit identity) also had more experience with female STEM professors (which should decrease their implicit stereotypes). In fact, when accounting for the influence of year in college, the correlation between men's science identity and stereotype becomes nonsignificant, $r(108) = -.10$, $p = .32$.

Turning to explicit measures and science career aspirations, both genders showed a positive link between explicit attitudes and identity (Eccles, 1994). Moreover, explicit and implicit attitudes covaried for both genders, but only women showed convergence among the explicit and implicit identity and stereotype measures. Because implicit–explicit correspondence improves when people are instructed to base self-reports on their "gut feelings" (Ranganath, Smith, & Nosek, 2008), it is possible that women are more likely than men to do so without specific instructions. Table 2 also shows that women's career aspirations were positively related to their implicit (and explicit) attitudes and identity. For men, career aspirations were correlated with their implicit (and explicit) identity as well as with their explicit attitudes.

In summary, men outscored women on all three IATs and showed the expected positive link between implicit stereotypes and attitudes, whereas women's implicit stereotypes were *negatively* related to their attitudes and identity (whether implicit or explicit). Because women's attitudes and identity were positively related to their career aspirations, implicit stereotypes may have an indirectly negative influence on their willingness to pursue a STEM career. Figure 1 depicts a path model that illustrates support for this post hoc hypothesis. The model showed adequate fit with $\chi^2(4) = 4.88$, $p = .30$, comparative fit index = 1.00, normed fit index = .97, and root mean square error of approximation = .03. In addition to suggesting that possessing implicit science stereotypes has a negative distal effect on women's career aspirations, Figure 1's results support the incremental validity of the attitude and identity IATs when predicting women's investment in STEM.

Hypothesis Testing

Our primary goal was to examine whether women with a female professor would implicitly like and identify with science as well as be less likely to stereotype science as masculine—but all moderated to the extent that students viewed their professor as a positive role model. We expected a similar benefit to emerge for career aspirations. To test our four hypotheses, we mean-centered the predictor variables (Aiken & West, 1991) and then separately regressed the attitude, identity, and stereotype IATs on student gender, professor gender, the role model index, and all interactions. Gender was originally coded as 0 (*male*) and 1 (*female*).

Hypothesis 1: Implicit science attitudes. Do women with a female STEM professor have pro-science implicit attitudes—provided they view their professor as a positive role model? Results showed a significant main effect for student gender, with men scoring higher than women, $\beta = -.24$, $p = .001$ (see Table 1). The expected Student Gender × Professor Gender × Role Model Index interaction was not significant $\beta = -.16$, $p = .11$. Thus, Hypothesis 1 was not supported. Instead, students who admired their female STEM professors also liked science, regardless of their gender (cf. Stout et al., 2011). A comparable analysis using explicit attitudes also showed a main effect for the role model index, $\beta = .3$, $p = .003$ (i.e., students who evaluated their professors favorably also reported liking science). No other effects were significant, all *p*s > .39.

Hypothesis 2: Implicit science identity. Do women with a female STEM professor have a pro-science implicit identity—provided they view their professor as a positive role

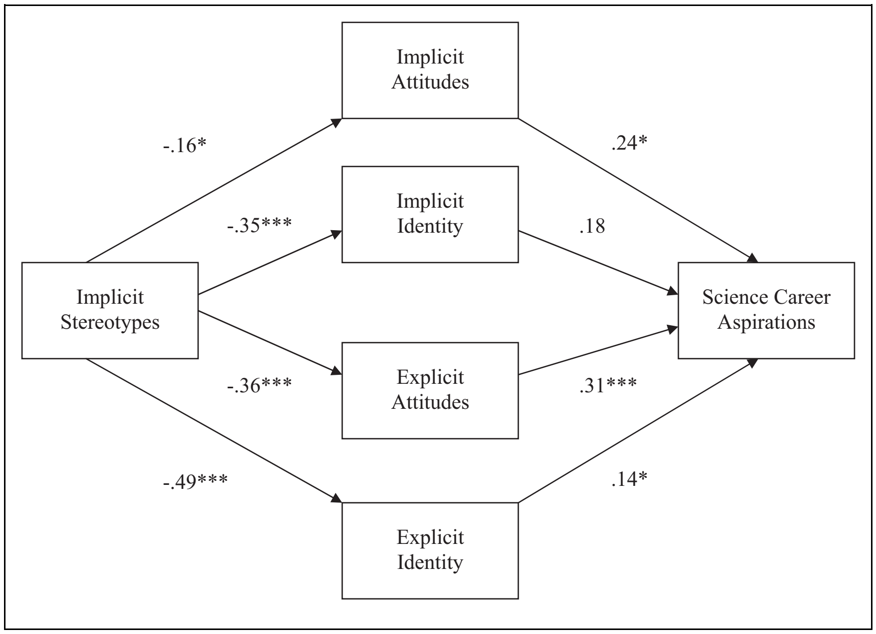

Figure 1. Path model illustrating support for the indirect effect of women's implicit science stereotypes on their career aspirations through implicit and explicit attitudes and identity ($n = 198$). Path coefficients are unstandardized. $R^2 = .25$ for career aspirations. $^*p < .05$. $^{***}p < .001$.

model? Results showed the hypothesized Student Gender × Professor Gender × Role Model Index interaction, $\beta = .27$, $p = .003$. Men showed no significant effects, all ps > .11. However, women showed the expected Professor Gender × Role Model Index interaction, $\beta = .16$, $p = .006$. As predicted, women with a female professor showed a stronger implicit science identity to the extent they viewed her as a positive role model, $\beta = .12$, $p = .009$. However, for women with a male professor, the relationship between the role model index and the science identity IAT was not significant, $\beta = -.03$, $p = .24$. Thus, Hypothesis 2 was supported. Results for explicit identity showed only a main effect for the role model index, $\beta = .26$, $p = .007$ (i.e., students who viewed their professor as a role model also reported identifying with science).

Hypothesis 3: Implicit science stereotypes. Are women with a female STEM professor less likely to automatically stereotype science as masculine provided they view their professor as a positive role model? Results for the stereotype IAT revealed a main effect for student gender, $\beta = -.48$, $p < .001$, with men outscoring women (see Table 2), and also a Student Gender × Professor Gender × Professor Identification interaction, $\beta = -.42$, $p < .001$. Results for women showed the expected Professor Gender × Role Model Index interaction, $\beta = -.38$, $p < .001$. In support of Hypothesis 3, women who admired their female STEM professor were less likely to automatically stereotype science as masculine, $\beta = -.25$, $p < .001$. By contrast, women with a male professor showed a negligible relationship between the stereotype IAT and the role model index, $\beta = .02$, $p = .33$. These results are depicted in Figure 2, in which the stereotype IAT is predicted for women scoring ± 1 *SD* from the mean on the role model index separately for women with female and male professors. As can be seen, women who viewed their female professor as a role model were likely to associate science more with femininity than with masculinity, whereas women who did not identify with their female professor were especially likely to stereotype science as more masculine. Results for men showed only a marginal main effect for professor gender, such that men with a female professor stereotyped somewhat less than those with a male professor, $\beta = -.25$, $p = .08$. A comparable analyses using explicit stereotypes as the dependent measure showed only the known main effect for student gender, with men scoring higher than women, $\beta = -.39$, $p < .001$ (see Table 1).

Hypothesis 4: Career aspirations. Are women with a female STEM professor more interested in pursuing science as a career—provided they view their professor as a positive role model? Results showed a main effect, the role model index, $\beta = .24$, $p = .04$ but no evidence of the expected Gender × Professor Gender × Role Model Index interaction, $\beta = -.14$, $p = .54$. Thus, there was no support for Hypothesis 4. Instead, viewing a professor as a positive role model was positively linked to students' career aspirations, regardless of the professor's gender.

Discussion

Hypotheses 1 and 4 were not supported because all students (a) implicitly liked science and (b) were interested in science careers to the extent they viewed their professor as a positive

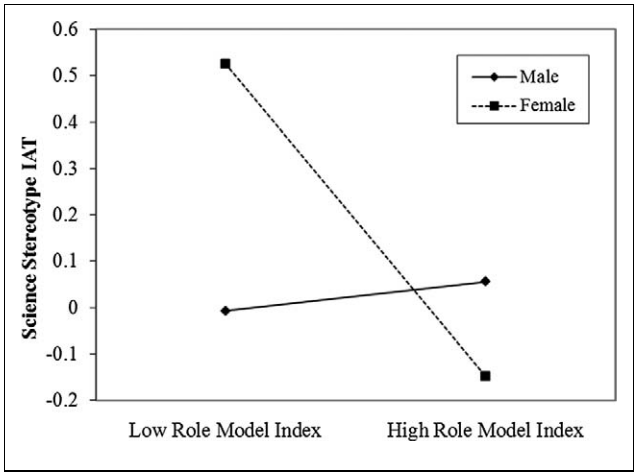

Figure 2. Regression lines predicting stereotype Implicit Association Test (IAT) *D* scores for women ± 1 *SD* from the mean of the role model index, graphed separately for those with female and male professors. High scores reflect automatically stereotyping science as more male than female.

role model; it was not only women with a female professor who showed these links (also see Cheryan, Drury, & Vichayapai, 2013). Nonetheless, Hypotheses 2 and 3 were fully supported: For women, viewing a female professor as a role model was linked to increased implicit science identity and decreased implicit gender stereotyping. Thus, female role models may be most effective at the automatic (i.e., implicit but not explicit) level when women admire them and view them as similar to themselves (Rudman, Ashmore, & Gary, 2001). For men, the role model index was linked to more positive implicit science attitudes, but otherwise played no role in their implicit STEM cognitions.

Using self-reports, students who identified with their instructor also liked and identified with science, regardless of professor gender. Thus, identifying with role models likely has a positive influence on students' explicit STEM attitudes and identity (Eccles, 1994, 2010). However, explicit stereotypes were unaffected by either professor gender or professor identification. Therefore, our finding that women who identified with their female professor showed decreased stereotyping was specific to the IAT, not self-reports (Rudman, Ashmore, & Gary, 2001).

The present research suggests there are advantages for women of having a female STEM professor—provided they view her as a positive role model. First, they were more likely to automatically identify themselves with science; and second, they automatically associated science with women more so than with men. The finding of a reversed gender stereotype is rare. Because implicit stereotypes are robust, they can generally be reduced, but not reversed. For example, Rudman, Ashmore, & Gary (2001) found reduced implicit racial stereotypes on the part of Whites enrolled in diversity education with a Black professor (provided they liked and admired him), but not reversed implicit stereotypes. Moreover, Stout et al. (2011) found no effect of female math instructors on students' implicit math stereotypes. The authors argued that stereotypes are more intractable than implicit attitudes; yet, the present study found that when women identify with a female professor as a role model, their stereotypes can be not only reduced, but inverted.

As a further benefit of having a female professor, we showed in the current study that students viewed female more so than male professors as positive role models, and viewing professors as role models positively covaried with students' implicit and explicit attitudes as well as their explicit science identity and career aspirations. Taken together, our findings suggest that female role models may have positive effects on women's implicit STEM cognitions and their investment in STEM, but they also feature the importance of identifying with professors as role models. The fact that female professors were viewed as more positive role models than male professors, and bestowed several advantages for female students without disadvantaging male students, supports the need for more female STEM professors (also see Stout et al., 2011).

Our findings extend those of Stout et al.'s (2011, study 3) by demonstrating that (a) implicit science stereotypes have an indirect, negative influence on women's career aspirations (through implicit and explicit attitudes and identity) and (b) women's implicit science identity and stereotypes are positively influenced when women identify with their female professors as role models. Stout et al. did not examine teacher identification as a moderator, but instead found main effects of instructor gender on women's implicit math attitudes and math identity (but not stereotypes). Because they investigated introductory calculus students, whereas we examined primarily third-year science majors, we speculate that female science majors may be more attuned to the quality of their relationship with their female professor rather than their gender. Our results are consistent with the contact hypothesis literature, whereby *meaningful* contact matters more than *mere* contact (Tropp & Pettigrew, 2005) and uniquely extend this approach to the domain of implicit science cognitions (cf. Rudman et al., 2002).

Limitations and Future Directions

The present study is limited by its quasi-experimental design. Causal claims cannot be made because students not only self-selected courses but also may have registered for courses based on the professor's gender. Although these are clear limitations, they simultaneously improve the external validity of our results because we examined the influence of STEM role models under real-world conditions. Nonetheless, professors and students who agreed to participate in our study may have been nonrepresentative, and our students were primarily science majors, which limits the generality of our findings. Moreover, we only included chemistry and engineering students, potentially reducing generalizability to other STEM areas. It is important to note, however, that chemistry and engineering are fields with low female representation, making these disciplines an important place to situate the current research (National Science Foundation, 2009). Still, future research should consider how identification with teachers influences science attitudes and stereotypes in the full range of STEM disciplines. Our sample also consisted of a majority of White and Asian students, limiting our ability to draw conclusions about the intersectional impact of ethnicity and gender on science attitudes, identity, and stereotypes. We believe that future research will greatly benefit from pursuing these intersectional avenues (Else-Quest, Mineo, & Higgens, 2013). Finally, we did not assess students at the beginning and at end of the semester. Although time of assessment did not influence any variables in Stout et al.'s (2011) research, more longitudinal research is necessary to examine the evolution of implicit STEM cognitions over time.

Practice Implications

Improving the recruitment and retention of women in STEM fields should be of great interest to administrators and policy makers. The results of our research can help inform practitioners and policy makers in their efforts to increase the participation and investment of women in STEM fields in three ways. First, our study demonstrates the importance of STEM role models with whom students identified in a general, not just a gendered, context. Identifying with a role model positively impacted both implicit and explicit attitudes, identification with, and intent to pursue a career in science. This suggests that pairing mentees with mentors with whom they identify has the potential to increase recruitment and retention of a variety of social groups in STEM.

Second, identifiable female role models in STEM fields can increase a woman's implicit identification with science, while simultaneously decreasing, and indeed inverting, implicit gendered stereotypes about science. Female role models in STEM can increase how well women students feel they fit in STEM fields, a known factor in increasing women's intentions to pursue a career in these fields (Cheryan et al., 2013). Because female professors positively impacted female students without detriment to male students, increasing the number of female professors in STEM fields is likely to enrich the quality of these departments. Furthermore, visible and identifiable female scientists have the potential to lessen, and possibly reverse, the association of masculinity with science in the general population. A reduction of this prevalent stereotype (Nosek et al., 2002a) could have far-reaching consequences for how women think about, and choose to associate with, STEM fields.

Third, our research demonstrates that implicit stereotypes about science impacts women's science career aspirations through explicit and implicit attitudes and identity. Implicit stereotypes about science can be seen as an important site to affect change in women's participation in STEM, and thus future interventions to increase the recruitment and retention of women in STEM may focus on reducing implicit gendered science stereotypes.

Conclusion

Female STEM professors bestowed several advantages to women without disadvantaging men, and all students evaluated female STEM professors as more favorable role models than male professors. Therefore, the disciplines of chemistry and engineering are likely to benefit when universities hire more female STEM instructors. If implicit stereotypes stem, as least in part, from students' exposure throughout their lives to more male than female STEM experts, it follows that hiring and promoting more female STEM professors would have the positive effect of reducing this source of bias, positively benefiting female science students without placing their male counterparts at risk.

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Note

1. We also asked students to report the name of their science course. Of the chemistry students ($n = 266$), 136 were enrolled in Organic Chemistry, 70 in Organic Chemistry Lab, 37 in General Chemistry, and 23 merely wrote "Chemistry." Fifty-eight chemistry students (36 female students) reported having a female professor. Of the engineering students ($n = 48$), 21 were enrolled in Introduction to Biomedical Engineering, 18 in Biomedical Transport & Phenomena, 7 in Biomedical Kinetics & Thermodynamics, and 2 merely wrote "Engineering." Twenty-eight of these students (12 female students) had a female engineering professor. Six students failed to list their course.

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