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Implicit stereotypes and women's math performance: How implicit gender-math stereotypes influence women's susceptibility to stereotype threat

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Abstract

This experiment examined the effects of implicit gender-math stereotyping and implicit gender and math identification on women's math performance under stereotype threat and reduced threat conditions. Results showed that of the three, only implicit gender-math stereotyping moderated stereotype threat effects on women's math performance: women who showed less implicit math-gender stereotyping showed the largest performance difference across experimental conditions. These results suggest that women's implicit associations between gender and math interact with situational cues to influence their math performance: women who implicitly associate women more than men with mathematics were most benefited by reduction of stereotype salience during testing.

Keywords: Women; Math performance; Implicit associations; Stereotypes

Gender differences in mathematical performance are well known. For example, junior high school boys outperform girls on advanced quantitative assessments (e.g., Benbow, Lubinski, Shea, & Eftekhari-Sanjani, 2000), and high school and college men perform better than women on tests of advanced mathematical ability, including standardized tests such as the Scholastic Aptitude Test (SAT) and the Graduate Record Exam (GRE; Brown & Josephs, 1999; Hyde, Fennema, & Lamon, 1990). Gender differences in performance translate into different career trajectories: men are more likely than women to major in mathematics and pursue mathematics or math-intensive careers, such as engineering and computer science (U.S. Department of Education, 2005).

Contributing to these differences are stereotypes concerning gender and math ability that propose that women have less mathematical aptitude than men. A growing body of research evidence indicates that these *gender-math stereotypes* influence women's interest and performance in the math domain (Davies, Spencer, Quinn, & Gerhardstein, 2002; Jacobs & Eccles, 1992; Quinn & Spencer, 2001; Sekaquaptewa & Thompson, 2003; Shih, Pittinsky, & Ambady, 1999; Spencer, Steele, & Quinn, 1999). In particular, research has indicated that women's math performance is highly influenced by external or situational factors, most notably by stereotype threat (see Steele, Spencer, & Aronson, 2002, for a review). Stereotype threat occurs when people fear that their performance may be evaluated in light of a negative stereotype about their social group (Steele & Aronson, 1995). Under these circumstances, fear of confirming the stereotype poses a threat to targets of the stereotype, thereby undermining their performance (Steele & Aronson, 1995).

Stereotype threat has been shown to impair the test performance of a range of negatively stereotyped groups, including women being tested in mathematics (e.g., Sekaquaptewa & Thompson, 2003; Shih et al., 1999; Spencer et al., 1999). Under standard test-taking situations, in

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which math tests are perceived to be diagnostic of math ability, women typically experience stereotype threat (Smith & White, 2002) and perform worse than men. However, when stereotype threat is reduced by instructing women that the math test is gender-fair (e.g., Schmader, 2002), or by informing women that the test is not a diagnostic measure of mathematical ability (e.g., Gonzales, Blanton, & Williams, 2002; Quinn & Spencer, 2001), women perform as well as men.

Evidence suggests that unconscious processing of stereotype-relevant information during testing may be sufficient to cause the decrements observed in targets' performance under threat. Under stereotype threat, targets do not reliably report concerns about the stereotype, even when questioned directly (Steele & Aronson, 1995). Targets' reports of explicit concerns about being stereotyped or stereotype-consistent performance, such as evaluation apprehension, anxiety, and performance expectations, do not reliably mediate stereotype threat effects (Bosson, Haymovitz, & Pinel, 2004; Wheeler & Petty, 2001; but see also Johns, Schmader, & Martens, 2005), implying that participants cannot always accurately detect when their performance is affected by stereotypes. Furthermore, priming participants with a negative stereotype, even when the prime is subliminal and therefore not accessible to conscious awareness, impairs performance (Shih et al., 1999; Wheeler, Jarvis, & Petty, 2001). Similarly, if they are primed with the African American stereotype White participants perform worse on a subsequent test of intellectual ability (Wheeler et al., 2001). Thus stereotype threat effects occur—at least some of the time—without conscious awareness. If stereotype threat occurs through unconscious processing of stereotype-relevant information, then *implicit gender-math stereotypes*, or non-conscious associations of men more than women with mathematics, may influence women's susceptibility to stereotype threat.

Implicit gender-math stereotypes

The personality traits culturally ascribed to different genders are widely known, and these traits influence both implicit and explicit self-perception. At both an explicit and an implicit level, individuals associate feminine and masculine stereotypic traits with the categories men and women, respectively (Rudman, Greenwald, & McGhee, 2001). Women tend to implicitly associate their personal information, such as their names and hometowns, with stereotypically feminine traits, whereas men tend to associate their personal information with stereotypically male traits (Greenwald & Farnham, 2000; Lemm & Banaji, 1998). These associations extend to the academic domain as well. Men and women implicitly associate men more with math and science and women more with arts and humanities (Kiefer & Sekaquaptewa, in press; Nosek, Banaji, & Greenwald, 2002), that is, they possess implicit gender-math stereotypes. Moreover, these implicit stereotypes correspond to less explicit math identification, less favorable attitudes towards mathematics, and lower reported performance on math-related achievement tests for women but not for men (Kiefer & Sekaquaptewa, in press; Nosek et al., 2002), suggesting that they may indeed moderate stereotype threat.

In this study, we examined two possible hypotheses for how implicit gender-math stereotyping might influence susceptibility to stereotype threat. First, women who hold implicit stereotypes may be more affected by stereotype threat than those who do not, because women with greater (implicit) knowledge of gender-math stereotypes may be especially influenced by them. From this perspective, only the performance of women with strong implicit gender-math stereotypes would be diminished under stereotype threat, whereas performance would not differ depending on implicit stereotyping level in the reduced threat condition. Alternatively, the performance of women with strong implicit stereotypes may be *less* affected by a reduction of the salience of the stereotype during testing, because their implicit stereotypes are so firmly entrenched that standard stereotype threat reduction instructions (e.g., stating that this particular test is gender-fair or non-diagnostic) do not reduce the salience of stereotypes for them. Women with weak implicit stereotypes, on the other hand, may perform particularly well when the relevance of the stereotype to the situation has been reduced, because they only view the test through a stereotypic lens when the testing situation calls gender-math stereotypes to mind. According to this second hypothesis, only under reduced threat would women's math performance differ depending on their level of implicit math-gender stereotyping. Favoring the latter perspective, we predicted that women with strong implicit gender-math stereotypes would have these stereotypes chronically accessible, and thus experience stereotype threat even under "reduced threat" conditions. In other words, we expected that there would be a negative correlation between implicit gender-math stereotyping and performance only under conditions of reduced threat.

Other implicit moderators

Several studies have suggested moderating variables of the stereotype threat effect (see Steele et al., 2002, for a review). Among recently studied moderators are gender identification and math identification. For example, women who reported strong gender identification performed worse on a math test than women who reported less gender identification when their individual performance was described as representative of women's mathematical ability (Schmader, 2002). Similarly, stereotype threat is most detrimental to women who are explicitly invested in, i.e., strongly identified with, math (Spencer et al., 1999).

In contrast to the proposed effects of implicit gender-math stereotyping, strong implicit math and gender identification may heighten the effects of stereotype threat on performance. On the explicit level, highly gender identified and highly math-identified women are more impaired by threat (e.g., Schmader, 2002; Spencer et al., 1999). To the extent that these findings generalize to implicit math and gender identification, implicit gender identification and math identification should render the stereotype more personally threatening and thus more debilitating to performance under stereotype threat. Alternatively, the role of implicit math and gender identification may depend on factors specific to the testing environment; for example, the moderating role of explicit gender identification appears to depend on the specific type of threat manipulation employed (Brown & Pinel, 2003). In addition, the strength of implicit identification may not map onto to explicit identification, as, for example, implicit math identification may reflect the degree to which one has been placed in math contexts as opposed to the degree to which success in math is important to one's sense of self. Therefore, the potential roles of implicit gender and math identification are less clear than those of implicit gender-math stereotyping.

In this experiment, we examined whether implicit gender-math stereotyping, implicit gender identification, and implicit math identification moderated the effects of stereotype threat on women's math performance. We specifically hypothesized that women with strong implicit gender-math stereotypes would perform better than other women under reduced threat conditions, but would not perform better under threat conditions. We propose that implicit gender-math stereotyping influences susceptibility to stereotype threat. Specifically, we suggest that the performance of women with relatively weak implicit stereotypes may be *less* affected by a reduction of the salience of the stereotype during testing, because their implicit stereotypes are so firmly entrenched that standard stereotype threat reduction instructions (e.g., stating that this particular test is gender-fair or non-diagnostic) do not reduce stereotype salience for them. In other words, we expected implicit gender-math stereotypes to negatively predict math performance under conditions of reduced threat but not under conditions of threat. To ensure the proposed effects were not redundant with explicit stereotype endorsement, we also controlled for women's explicit gender-math stereotypes. In addition, we examined the effects of implicit gender and math identification on susceptibility to stereotype threat.

Method

Participants

Participants were 138 female college students (114 Caucasian, 2 African-American, 9 Asian-American, 5 Latina, and 8 participants of mixed or unreported ethnic background) who participated in partial fulfillment of introductory psychology course requirements.

Measures

IAT. Three Implicit Association Tests (Greenwald, McGhee, & Schwartz, 1998) were administered on IBM compatible computers. The IATs assessed implicit gender-math stereotyping (greater male-math than female-math association), implicit gender identification (greater self-female than self-male association), and implicit math identification (greater self-math than other-math association).

Each IAT consisted of five stages in which participants were presented with a series of word categorization tasks. In stage one, participants classified words presented individually on the computer screen as belonging to one of two categories. If the word presented on the middle of the screen (e.g., "me") belonged to the category shown on the right of the screen (e.g., "self"), the participant responded by pressing the '5' key. If the word flashed in the middle of the screen (e.g., "them") belonged to the category shown on the left of the screen (e.g., "other"), then the participant responded by pressing the 'a' key. In stage two, a second pair of concepts was introduced. The participants again categorized words shown in the middle of the screen (e.g., "her," "him") according to whether they belonged to the category shown on the right (e.g., "female") or the left (e.g., "male"). In stage three, the categories from the first two stages were superimposed. The '5' key was used to respond to words that referred to "self" or "female," while the 'a' key was used for words that referred to "other" or "male." In stage four, participants categorized words from the first stage but used the opposite keys to respond. Finally, in stage five, the categories were again superimposed, but the key assignments for one pair were reversed from their position in the third stage. Each stage consisted of 60 trials, the first 20 of which were practice trials. Response latencies during each stage were recorded.

In the two IATs involving the concept of "self," participants entered their first and last names into the program (see Greenwald & Farnham, 2000). Their names were subsequently used as response words that belonged to the "self" category. (For the complete list of words used in each IAT, see Appendix A).

Explicit math-gender stereotyping

Participants rated the percentage of men and the percentage of women they believed were described by a series of traits. To minimize the effects of social desirability, participants first rated how many women each trait described and then how many men each trait described. To assess math-gender stereotyping, participants' rating of how many women were "good at math" was subtracted from their rating of how many men were "good at math." Ratings were made on a 0–100 scale. Higher scores indicated greater math-gender stereotyping.

Math test

This test (used by Shih et al., 1999) consisted of 12 multiple-choice questions used in a Canadian math competition. For each question participants were asked to select one of five possible solutions.

Demographic information

In addition to reporting demographic information including race, participants were asked to specify which math class they had most recently taken. Five different math classes, algebra, geometry, pre-calculus, calculus, and vector calculus were listed, and a blank was provided for participants to write in an unlisted class. Unlisted classes were categorized on the basis of which course from the standard mathematical sequence listed above were course prerequisites and difficulty (i.e., the level of the course number, 100-, 200-level, etc.) and placed into one of the existing categories.

Procedure

Participants were greeted at the laboratory by a White female experimenter. After giving informed consent, participants received the math test, accompanied by one of two sets of directions containing the stereotype threat manipulation. Following the procedure used by Quinn and Spencer (2001), directions described the test as either diagnostic (threat condition) or non-diagnostic (reduced threat condition) of mathematical ability. To ensure participants were aware of the manipulation, the experimenter also repeated the manipulation aloud. Participants were randomly assigned to the threat or reduced threat conditions.

Participants were given 10 min to work on the math test and then completed the IATs and explicit stereotyping measure. The order in which the participants completed the explicit measure and the IATs was counterbalanced. Last, participants completed the demographic information sheet, and were then thanked and debriefed.

Results

Scoring the math test

Two dependent measures were derived from the math test. First, total correct scores were computed as the total number of questions each participant answered correctly. Second, an adjusted correct score was computed as the number correct minus 1/5 the number incorrect, similar to the way that some standardized tests (e.g., the GRE) are actually scored. Because the two dependent measures were highly correlated ($r = .98$, $p < .001$) and did not produce different results, only results from analyses of total correct scores are presented. Finally, because order of the administration of the explicit and implicit measures did not affect the results, all results are reported collapsing across order.

IAT scoring

IAT scores were computed following the scoring procedure recommended by Greenwald, Nosek, and Banaji (2003).[1] Mean response latencies were computed for the practice and actual trials of stages three and five. The difference score for the practice trials was computed by subtracting the mean response latency for stage three practice trials from the mean response latency for stage five. This difference score was then scaled by the standard deviation for all the practice trials. The same procedure was followed for the actual trials. The scaled practice trial and actual trial difference scores were then averaged to create the final IAT scores. Positive scores indicate a tendency to associate the concepts paired in the third stage together more than the concepts paired in the fifth stage, whereas negative scores indicate a tendency to associate the concepts paired in the third stage together more than the concepts paired in the fifth stage.

Implicit gender-math stereotyping, gender identification, and implicit math identification

Implicit gender-math stereotyping scores were computed from responses on the “gender-math” IAT by subtracting the average response latency when “women” was paired with English/Humanities and “men” was paired with math, from the average response latency when “men” was paired with English/Humanities and “women” paired with math. Positive scores indicate greater implicit gender-math stereotyping: men are more associated with math than are women. Overall, participants associated men more than women with mathematics (implicit gender-math stereotyping), $M = .28$, $SD = .45$; their scores were significantly above zero, $t(137) = 6.62$, $p < .001$.

Implicit gender identification scores were computed from responses on the “self-gender” IAT by subtracting the average response latency when “self” was paired with female and “other” was paired with male, from the average response latency when “self” was paired with male, and “other” was paired with female. Positive scores indicated greater implicit identification with being female. Overall participants showed implicit gender identification, $M = .59$, $SD = .37$; their identification scores differed significantly from zero, $t(137) = 16.70$, $p < .001$.

Implicit math identification scores were computed from responses on the “self-math” IAT by subtracting the average response latency when “self” was paired with math and “other” was paired with English/Humanities, from the average response latency when “self” was paired with English/Humanities and “other” was paired with math. Positive scores indicated greater implicit math identification. Overall, participants did not show implicit identification with math, $M = -.17$, $SD = .40$; their scores were significantly below zero, $t(137) = -4.52$, $p < .001$.

Math performance

Math test scores were regressed on the scaled and centered predictor variables: threat condition, implicit gender identification, implicit math identification, and implicit gender-math stereotyping scores, and the interactions of the

[1] Because of our use of an older version of IAT software, one deviation was made from the scoring algorithm recommended by Greenwald et al. (2003): latencies from error trials were included in final IAT scores. Results presented here are unchanged by using means or logged IAT scores using the procedure employed by Greenwald et al. (1998).

Table 1
Math test score predicted by stereotype threat condition and implicit gender-math stereotyping

	β	p
Stereotype threat condition	.15	.08
Implicit gender-math stereotyping	−.07	.46
Implicit gender-math stereotyping × stereotype threat condition	−.19	.04

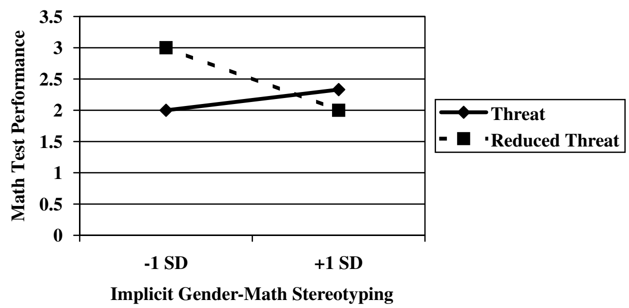

Fig. 1. Interaction of implicit gender-math stereotyping and threat condition.

implicit variables with threat, and explicit gender-math stereotyping. Difficulty of their most recent math class ($\beta = .32$, $p < .001$) was entered as a control variable.[2] To avoid bias in the estimation of interaction effects (Yzerbyt, Muller, & Judd, 2004), the interaction of recent math class with threat was also entered as a control variable ($\beta = .05$, $p > .60$).

Threat condition emerged as a marginally significant predictor of math test scores, $\beta = .15$, p (one-tailed) $< .05$, such that women's math test scores were lower in the threat ($M = 2.43$, $SD = 1.41$) than in the reduced threat condition ($M = 2.78$, $SD = 1.66$). Implicit stereotyping was not a significant predictor of test scores, $\beta = -.07$, $p < .4$, but the threat condition by implicit math-gender stereotyping interaction term was a significant predictor, $\beta = -.19$, $p < .05$ (see Table 1). Within cell regression analyses showed that, as expected, implicit gender-math stereotyping significantly predicted math test scores in the reduced threat condition, such that women who showed implicit gender-math stereotyping scored lower than women who did not, $\beta = -.27$, $p < .05$, whereas implicit gender-math stereotyping did not predict math test scores in the threat condition, $\beta = .19$, $p > .10$; see Fig. 1. These findings support our contention that women with strong implicit gender-math stereotypes chronically activate these stereotypes and thus experience stereotype threat even under so-called "reduced threat" conditions, whereas women with weak or counter implicit gender-math stereotypes are most benefited by threat reduction Table 2.

In contrast, there were no significant effects of implicit gender or implicit math identification or explicit gender-math stereotyping, neither alone nor in conjunction with threat, all p's $> .10$. Thus, these variables did not affect performance and further did not moderate the effects of stereotype threat.

Table 2
Correlations between measured variables

	(2)	(3)	(4)	(5)	(6)
Implicit gender identification (1)	−.14	$-.15^{+}$	$-.17^{*}$	$-.21^{*}$	−.01
Implicit math identification (2)	—	−.10	−.04	.07	.11
Implicit gender-math stereotyping (3)		—	.04	$.36^{***}$	.07
Math test score (4)			—	$.30^{***}$	.05
Math class difficulty (5)				—	.07
Gender-math stereotyping (6)					—

* $p < .05$.
*** $p < .001$.
\+ $p < .10$.

Threat effects on IAT scores

There were no significant effects of threat condition on implicit gender-math stereotyping, $t(137) = -1.07$, $p = .29$, nor on implicit gender identification, $t(137) = -0.73$, $p = .47$. There was, however, an unexpected significant effect of threat on implicit math identification, $t(137) = 2.54$, $p < .05$: women's implicit math identification was higher in the threat condition ($M = -0.08$, $SD = 0.41$) than in the reduced threat condition ($M = -0.25$, $SD = 0.40$).

Correlations between measures

Math test scores were negatively correlated with implicit gender identification. In addition, math class difficulty was positively correlated with implicit gender stereotyping but negatively correlated with implicit gender identification. All correlations are presented in Table 1.

Discussion

As predicted, implicit gender-math stereotyping moderated the effect of stereotype threat on women's math test performance. When stereotype threat was reduced by describing the math test as non-diagnostic, the less women possessed implicit gender-math stereotypes, the better they performed. In contrast, implicit stereotyping did not predict women's math performance under conditions of stereotype threat. These findings suggest that women who possess strong implicit gender-math stereotypes have these stereotypes chronically accessible and therefore may activate gender-math stereotypes even in the absence of stereotypic cues within the test-taking environment. Strong implicit associations between men and math than women and math likely reflect the influence of societal messages and images promoting the idea that women lack mathematical ability (e.g., hearing that math is "not for girls," or exposure to only male mathematicians). As such, women's implicit stereotypes may reflect greater personal knowledge of, or exposure to, gender-math stereotypes. These results suggest

[2] Results are unchanged by the exclusion of math class difficulty as a covariate.

that implicit gender-math stereotyping may be a critical variable in determining women's math performance, particularly when women perform under conditions of reduced stereotype threat (see also Kiefer & Sekaquaptewa, in press).

The performance of women who do not implicitly stereotype, i.e., who associate women with math, was most benefited by the reduction of stereotype threat. We suggest that women who do implicitly stereotype have gender-math stereotypes so firmly entrenched that threat-reducing instructions fail to eliminate the salience of the stereotype, leading to poor performance regardless of the test-taking environment. For women with weak implicit gender-math stereotypes, this stereotype is not as firmly held, allowing for greater influence by instructions that reduce stereotype salience in the testing environment. Women who do not show implicit math-gender stereotyping appear to have the potential to do well in math when stereotype salience is reduced. However, when the situation activates the stereotype, as when a test is described as diagnostic of one's math ability, the performance of women with relatively weak implicit stereotypes is reduced to the level seen among women with strong implicit stereotypes. These findings highlight the importance of social identity threat in preferences and behavior, especially at the implicit level.

Our findings indicate that interventions to improve women's math performance should focus not only on removing stereotypic cues from the test-taking environment, but also on reducing women's implicit associations of men with math. Previous research has shown that implicit stereotypes are highly malleable and can be altered by presentation of counterstereotypic images (e.g., Blair, Ma, & Lenton, 2001; Dasgupta & Greenwald, 2001; Karpinski & Hilton, 2001) and diversity training (Rudman, Ashmore, & Gary, 2001). Exposure of women to female mathematicians and female math instructors may improve their performance by reducing implicit stereotypes (Dasgupta & Asgari, 2004).

Interestingly, the difficulty of women's most recent math class was positively correlated with implicit gender-math stereotyping, but negatively correlated with implicit gender identification. Although somewhat counterintuitive at first, the correlation between women's math class advancement and implicit stereotyping might result from advanced mathematical courses being male-dominated (Benbow et al., 2000). This domination could reinforce implicit associations of men with math. Supporting this idea, women in co-ed colleges show an increase in gender-math stereotyping over time, whereas women in all-female colleges demonstrate a decrease in implicit stereotyping (Dasgupta & Asgari, 2004).

The difficulty of women's most recent math class was also negatively correlated with implicit gender identification. This finding is consistent with research showing that math-identified women explicitly distance themselves from stereotypically feminine traits when exposed to gender-math stereotypes (Pronin, Steele, & Ross, 2004). This correlation suggests women may also distance themselves from their gender on an implicit level to avoid the negative effects of these stereotypes. Conversely, a relatively weak level of implicit gender identification may have buffered these women against the negative effects of stereotypes on their motivation to enroll in advanced math courses. Future research should explore this relationship.

The potential roles of implicit gender and math identification

While implicit gender-math stereotyping moderated women's susceptibility to stereotype threat, implicit math identification and implicit gender identification did not predict performance. These results suggest that on an implicit level, it is the association of women with mathematics, not their associations of the self with mathematics or of the self with gender, that affects women's performance. Under different testing circumstances, however, implicit math and implicit gender identification may significantly affect women's math performance. Research on stereotype threat has used a variety of different threat reducing manipulations, which may vary considerably in their effects. In this study, we used a description of the math test as diagnostic or non-diagnostic to manipulate stereotype salience. Research using this manipulation has not found moderation by explicit gender identification (e.g., Brown & Pinel, 2003), whereas other research, using a manipulation of the test being described as gender-biased or not, has found that explicit gender identification exacerbates the effects of stereotype threat on performance (cf. Schmader, 2002). As Brown and Pinel (2003) have argued, the different manipulations of stereotype salience may therefore alter the mechanisms through which stereotype threat affects performance, possibly contributing to the difficulty in finding reliable mediators of stereotype threat (Wheeler & Petty, 2001; but see also Schmader & Johns, 2003).

Previous research also suggests that implicit moderators might have distinct effects from explicit moderators. Reports are mixed as to whether and when implicit cognition corresponds to explicit cognition (Blair, 2001; Cunningham, Preacher, & Banaji, 2001). In most studies, implicit and explicit attitudes are weakly correlated, and thus appear to represent related but distinct constructs (Nosek et al., 2002; Nosek, Greenwald, & Banaji, 2005). For example, explicit gender identification involves attributing importance to one's gender identity, whereas implicit gender identification is the association of the self with the concept "female." Clearly, these constructs are theoretically distinct. Furthermore, women would be expected to vary more in the former than the latter. Thus, for theoretical reasons, explicit but not implicit identification might be expected to influence susceptibility to stereotype threat.

Limitations

Because of the correlational nature of this research, it is unclear whether implicit gender stereotyping actually caused performance decrements. An alternative explanation for these findings is that the testing situation led to greater stereotype activation, resulting in greater implicit math stereotyping. Arguing against this possibility, women's implicit stereotyping did not vary between the threat and reduced threat conditions, suggesting that the stereotypes affected performance, rather than the reverse. Moreover, if performance predicted implicit stereotyping, it seems likely this relationship would have been observed in both the threat and reduced threat conditions; instead, a relationship between these variables was only observed in the reduced threat condition. Further supporting the idea that implicit stereotypes led to worse performance, implicit stereotypes have been shown to prospectively predict women's performance in an introductory calculus class, i.e., when the two measures are given in separate testing sessions (Kiefer & Sekaquaptewa, in press).

A second concern regarding the present study is that some other factor, related to implicit stereotyping, but not implicit stereotyping *per se* was responsible for the observed moderation. We cannot conclusively rule out this possibility; however, we did find effects of implicit stereotyping on performance even while controlling for women's abilities and math education. We believe that the persistence of this effect strongly implies that implicit stereotyping, not some related factor, was responsible for these findings.

Notably, while implicit gender-math stereotyping moderated the effects of stereotype threat on performance, explicit stereotyping did not. This discrepancy is not surprising, as explicit and implicit gender-math stereotyping has been shown to explain unique variance on past performance on the quantitative SAT (Nosek et al., 2002). In fact, some researchers argue that implicit stereotyping reflects knowledge and personal exposure to societal stereotypes, largely independent of an individual's personal endorsement of these stereotypes (Banaji, Nosek, & Greenwald, 2004; Karpinski & Hilton, 2001).

There are multiple reasons why explicit stereotyping might not have moderated stereotype threat. The measure used in this study was different from that used by Schmader, Johns, and Barquissau (2004), which emphasizes the belief that gender-math differences are biologically rooted, and thus might have tapped a different aspect of stereotype endorsement. Moreover, the evidence on whether endorsement of gender-math stereotypes enhances stereotype threat is mixed (Kiefer & Sekaquaptewa, in press; but see also Schmader et al., 2004).

Conclusions

Despite certain limitations, the findings of this study add to a growing body of research on how stereotypes affect targets' self-perceptions and behavior. Most importantly, our results imply that women's implicit stereotyping of women has an impact on their math performance. As such, these findings suggest that gender stereotypes influence women's perceptions of, and performance in, mathematics, and may undermine their desire to pursue mathematically intensive careers, potentially without awareness of their influence.

Appendix A

List of words used as IAT stimuli

Math	Humanities	Self	Other	Female	Male
Calculate	Art	I	Others	Female	He
Compute	Classics	Me	Their	Her	Him
Math	English	Myself	Theirs	She	Male
Multiply	Humanities	First name	Them	Woman	man
Sum	Literature	Last name	They	Women	Men

References

Banaji, M. R., Nosek, B. A., & Greenwald, A. G. (2004). No place for nostalgia in science: a response to Arkes and Tetlock. *Psychological Inquiry, 15*(4), 279–310.

Benbow, C. P., Lubinski, D., Shea, D. L., & Eftekhari-Sanjani, H. (2000). Sex differences in mathematical reasoning ability at age 13: their status 20 years later. *Psychological Science, 11*, 474–480.

Blair, I. V. (2001). Implicit stereotypes and prejudice. In *Cognitivesocial psychology: The princeton symposium on the legacy and future of social cognition* (pp. 359–374). Mahwah, NJ: Erlbaum.

Blair, I. V., Ma, J. E., & Lenton, A. P. (2001). Imagining stereotypes away: the moderation of implicit stereotypes through mental imagery. *Journal of Personality and Social Psychology, 81*(5), 828–841.

Bosson, J. K., Haymovitz, E. L., & Pinel, E. C. (2004). When saying and doing diverge: the effects of stereotype threat on self-reported versus non-verbal anxiety. *Journal of Experimental Social Psychology, 40*, 247–255.

Brown, R. P., & Josephs, R. A. (1999). A burden of proof: Stereotype relevance and gender differences in math performance. *Journal of Personality and Social Psychology;, 76*, 246–257.

Brown, R. P., & Pinel, E. C. (2003). Stigma on my mind: individual differences in the experience of stereotype threat. *Journal of Experimental Social Psychology, 39*(6), 626–633.

Cunningham, W. A., Preacher, K. J., & Banaji, M. R. (2001). Implicit attitude measures: consistency, stability, and convergent validity. *Psychological Science, 121*, 163–170.

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.

Dasgupta, N., & Greenwald, A. G. (2001). On the malleability of automatic attitudes: combating automatic prejudice with images of admired and disliked individuals. *Journal of Personality and Social Psychology, 81*(5), 800–814.

Davies, P. G., Spencer, S. J., Quinn, D. M., & Gerhardstein, R. (2002). Consuming images: how television commercials that elicit stereotype threat can restrain women academically and professionally. *Personality and Social Psychology Bulletin, 28*(12), 1615–1628.

Gonzales, P. M., Blanton, H., & Williams, K. J. (2002). The effects of stereotype threat and double-minority status on the test performance of Latino women. *Personality and Social Psychology Bulletin, 28*, 659–670.

Greenwald, A. G., & Farnham, S. D. (2000). Using the Implicit Association Test to measure self-esteem and self-concept. *Journal of Personality and Social Psychology, 79*, 1022–1038.

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.

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*(2), 197–216.

Hyde, J. S., Fennema, E., & Lamon, S. J. (1990). Gender differences in mathematics performance: a meta-analysis. *Psychological Bulletin, 107*, 139–155.

Jacobs, J. E., & Eccles, J. S. (1992). The impact of mothers' gender-role stereotypic beliefs on mothers' and children's ability perceptions. *Journal of Personality and Social Psychology, 63*(6), 932–944.

Johns, M., Schmader, T., & Martens, A. (2005). Knowing is half the battle: teaching stereotype threat as a means of improving women's math performance. *Psychological Science, 16*, 175–179.

Karpinski, A., & Hilton, J. L. (2001). Attitudes and the Implicit Association Test. *Journal of Personality and Social Psychology, 81*, 774–788.

Kiefer, A. K., & Sekaquaptewa, D. (in press). Implicit stereotypes, gender identification, and math performance: a prospective study of female math students. *Psychological Science*.

Lemm, K., & Banaji, M. R. (1998). Implicit and explicit gender identity and attitudes toward gender. Paper presented at the seventieth annual meeting of the Midwestern Psychological Association, Chicago, IL.

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math = male, me = female, therefore math ≠ me. *Journal of Personality and Social Psychology, 83*, 44–59.

Nosek, B. A., Greenwald, A. G., & Banaji, M. R. (2005). Understanding and using the implicit association test: II. method variables and construct validity. *Personality and Social Psychology Bulletin, 31*(2), 166–180.

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.

Quinn, D. M., & Spencer, S. J. (2001). The interference of stereotype threat with women's generation of mathematical problem-solving strategies. *Journal of Social Issues, 57*, 55–71.

Rudman, L. A., Ashmore, R. D., & Gary, M. L. (2001). "Unlearning" automatic biases: the malleability of implicit prejudice and stereotypes. *Journal of Personality and Social Psychology, 81*(5), 856–868.

Rudman, L. A., Greenwald, A. G., & McGhee, D. E. (2001). Implicit self-concept and evaluative implicit gender stereotypes: self and ingroup share desirable traits. *Personality and Social Psychology Bulletin, 27*(9), 1164–1178.

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

Schmader, T., & Johns, M. (2003). Converging evidence that stereotype threat reduces working memory capacity. *Journal of Personality and Social Psychology, 85*, 440–452.

Schmader, T., Johns, M., & Barquissau, M. (2004). The costs of accepting gender differences: the role of stereotype endorsement in women's experience in the math domain. *Sex Roles, 50*(11), 835–850.

Sekaquaptewa, D., & Thompson, M. (2003). Solo status, stereotype threat, and performance expectancies: their effects on women's performance. *Journal of Experimental Social Psychology, 39*, 68–74.

Shih, M., Pittinsky, T. L., & Ambady, N. (1999). Stereotype susceptibility: identity salience and shifts in quantitative performance. *Psychological Science, 10*, 80–83.

Smith, J. L., & White, P. H. (2002). An examination of implicitly activated, explicitly activated, and nullified stereotypes on mathematical performance: it's not just a women's issue. *Sex Roles, 47*, 179–191.

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

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African-Americans. *Journal of Personality and Social Psychology, 69*, 797–811.

Steele, C. M., Spencer, S. J., & Aronson, J. (2002). Contending with group image: The psychology of stereotype and social identity threat. In *Advances in Experimental Social Psychology* (pp. 379–440). San Diego, CA: Academic Press.

U.S. Department of Education. (2005). National Center for Educational Statistics, National Assessment of Educational Progress, 1990, 1992, 1996, 2002, and 2003 Mathematics Assessments. Retrieved March 10, 2005, from <http://nces.ed.gov/>.

Wheeler, S. C., Jarvis, W. B. G., & Petty, R. E. (2001). Think unto others: the self-destructive impact of negative racial stereotypes. *Journal of Experimental Social Psychology, 37*, 173–180.

Wheeler, S. C., & Petty, R. E. (2001). The effects of stereotype activation on behavior: a review of possible mechanisms. *Psychological Bulletin, 127*, 797–826.

Yzerbyt, V. Y., Muller, D., & Judd, C. M. (2004). Adjusting researchers' approach to adjustment: on the use of covariates when testing interactions. *Journal of Experimental Social Psychology, 40*, 424–431.

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