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Retraining Attitudes and Stereotypes to Affect Motivation and Cognitive Capacity Under Stereotype Threat

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In a series of experiments, a retraining paradigm was used to test the effects of attitudes and stereotypes on individuals' motivation and cognitive capacity in stereotype-threatening contexts. Women trained to have a more positive math attitude exhibited increased math motivation (Study 1). This effect was not observed for men but was magnified among women when negative stereotypes were either primed subtly (Study 2) or indirectly reinforced (Study 3). Although attitudes had no effect on working memory capacity, women retrained to associate their gender with being good at math exhibited increased working memory capacity (Studies 3 and 4), which in turn mediated increased math performance (Study 4) in a stereotype-threatening context. Results suggest that although positive attitudes can motivate stigmatized individuals to engage with threatening domains, stereotypes need to be retrained to give them the cognitive capacity critical for success. Implications for interventions to reduce stereotype threat are discussed.

Keywords: stereotype threat, attitudes, stereotypes, motivation, working memory

Despite dramatic advancements in gender and racial equality over the past 30 years, stigmatized individuals still face an uphill battle when they progress into the upper echelons of domains in which they are stereotyped to lack competence. According to the theory of stereotype threat, the awareness of these stereotypes can fuel a motivation to disconfirm them while at the same time impairing the cognitive resources needed to perform well (Schmader, Johns, & Forbes, 2008; Steele, 1997). As a result, individuals can be left feeling that they have given their all but still fail to excel. This tension between increased motivation and impaired cognitive ability seems integral to one's experience in stereotyped domains, but prior research has not attempted to elucidate the independent factors that contribute to each. The present studies specifically examine the effects of attitude and stereotype retraining on an individual's motivation and cognitive capacity for performing complex cognitive tasks, especially when cues to stereotype threat are present.

The general goal of investigating the underperformance of stigmatized groups is to understand how we might better encourage their engagement and excellence in domains where they have been typically underrepresented. Taking women as an example, Nosek, Banaji, and Greenwald (2002) demonstrated that female undergraduates generally possess a stereotypical association of math with men and also show a stronger negative association with the domain of math compared with their male peers, even among those who are pursuing math-related majors. From this evidence alone one might speculate that both stereotypes that denote women's incompetence at math and negative personal attitudes toward the domain are obstacles to women's success in math. Indeed, among women in Nosek et al.'s research, both implicit stereotypes linking math with men and implicit negative attitudes toward math predicted lower SAT math scores. Perhaps by training women to adopt more positive attitudes and counterstereotypes (i.e., that women are good at math), we could improve their performance at math-related tasks, even in the face of stereotype threat.

However, there is also reason to believe that attitudes and stereotypes might have somewhat distinct effects. Amodio and Devine (2006) reviewed evidence suggesting that attitudes are products of neural networks including brain regions such as the amygdala, which are associated with basic motivational and appetitive behaviors. In contrast, stereotypes are derivatives of structures involved in semantic processing, including neocortical structures in the prefrontal cortex and associative networks in general. Thus at a basic level, whereas attitude associations likely help us seek out desired targets (or avoid undesirable ones), stereotyped associations shape information processing, albeit in a manner prone to stereotypical biases.

To demonstrate how this distinction plays out in the context of person perception and intergroup behavior, Amodio and Devine (2006) had White participants complete measures of their implicit attitudes and stereotypes of African Americans during an initial session. Several weeks later, participants returned for a second session, at which point they learned they would meet and work

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together with an African American partner on a series of intellectual tasks. White participants who had more negative implicit attitudes toward African Americans chose to sit farther away from their African American partner, but these negative attitudes did not predict more biased assessments of their partner's performance. Conversely, White participants who had stronger implicit negative stereotypic associations of African Americans expected their partner to do worse on the tasks, but these implicit stereotypes did not predict a motivation to avoid being close to their partner. Thus, attitudes uniquely predicted the motivation to engage with the attitude object, but implicit stereotypes predicted one's interpretation of that target.

Whereas this prior research focused on how attitudes and stereotypes about a group affect one's perceptions of members of that group, the present research applies this distinction to understand how attitudes and stereotypes about a domain (with respect to a relevant ingroup) affect one's own motivation and cognitive capacity to perform well in that domain. Borrowing the motivation versus information-processing distinction made by Amodio and Devine (2006), we predict that creating a more positive attitude association toward the domain would boost a basic motivation to pursue a stereotyped domain. Conversely, challenging traditional stereotypes in that domain would improve the cognitive-processing capabilities needed to combat stereotype threat.

Our basis for this general prediction lies in an important assumption that performance is a function of dual processes: the motivation to engage with the domain and the cognitive ability to excel in that domain when the task becomes difficult or complex. To understand performance, one must examine possible distinctions between these component elements. Although independent studies have examined how situations of stereotype threat affect motivation and cognitive capacity, research has not generally sought to distinguish these processes within the same set of studies or to examine the distinct role that attitudes and stereotypes, or the product of their interaction, might be playing in predicting these two component processes.

Retraining Stereotypes Can Boost Cognitive Capacity Under Stereotype Threat

Concerning the role of capacity, there is now a substantial amount of evidence pointing to the role of reduced cognitive capacity in mediating the effects of stereotype threat on complex cognitive processing tasks (Beilock, Rydell, & McConnell, 2007; Inzlicht, McKay, & Aronson, 2006; Schmader et al., 2008). In our integrated process model (Schmader et al., 2008), we argue that the experience of stereotype threat involves a complex integration of cognitive, affective, and physiological processes that work either alone or in concert to deplete working memory resources, thus depriving individuals of the cognitive capacity needed for successful performance on a variety of challenging cognitive tasks. These resource-depleting processes, such as negatively biased metamonitoring processes (Schmader, Forbes, Zhang, & Mendes, 2009), task-specific worries that consume verbal working memory (Beilock et al., 2007), or efforts to suppress unwanted thoughts and emotions (Johns, Inzlicht, & Schmader, 2008; Logel, Iserman, Davies, Quinn, & Spencer, 2009) are thought to be set in motion by the initial activation of a stereotype about one's group (Kiefer & Sekaquaptewa, 2007; Steele & Aronson, 1995).

Thus, just as social perceivers experience a depletion in their cognitive resources when attempting to control or suppress an unwanted racial stereotype that has been activated (Knutson, Mah, Manly, & Grafman, 2007; Payne, 2005; Richeson et al., 2003), the targets of these stereotypes also find it mentally draining to be on the receiving end of these negative associations. If individuals are trained to have a counterstereotypic association between their group and the domain (i.e., women believing they are good at math), these extra task processes should be disrupted and cognitive capacity improved even though cues to stereotype threat might still be present in the performance situation. In fact, training a counterstereotypic association of the group to the domain might even allow those who are traditionally stigmatized in the domain to exhibit the benefit of stereotype lift (Walton & Cohen, 2003).

Retraining Attitudes Can Boost Motivation Under Stereotype Threat

Extant research has suggested that training or enhancing the accessibility of a positive attitude toward a domain might increase one's motivation toward that domain (Fazio, Chen, McDonel, & Sherman, 1982). In a recent set of studies, Kawakami, Steele, Cifa, Phills, and Dovidio (2008) trained initially low math-identified women to approach math by having them pull a joystick toward their body (rather than push it away from their body) when they saw a math-related term on a computer screen. Those who were trained to pull math toward them increased their implicit math identification and exhibited more positive implicit math attitudes. Low math-identified women trained to approach math also attempted more math problems on a subsequent math test, but this increased math effort did not translate into better performance. These findings suggest that attitudes play a role in cuing motivation in a domain. However, although Kawakami and colleagues couched their research in terms of women's underrepresentation in math, their studies did not manipulate stereotype threat or examine effects with men. Thus, prior research has not specifically addressed the effect of attitudes on motivation when cues to stereotype threat are present.

In addition, those studies that have examined the role of motivation in stereotype threat effects lead to seemingly different conclusions. On the one hand, the mere effort perspective on stereotype threat (Jamieson & Harkins, 2007) argues that the threat of confirming the stereotype increases arousal and motivates effort toward the task in a way that facilitates automatic deployment of the dominant response as well as efforts to correct erroneous responses. However, when the task calls for inhibition of this dominant response (Jamieson & Harkins, 2007) or requires more complex cognitive processing (O'Brien & Crandall, 2003), this increased arousal and motivation can be counterproductive and lead to performance decrements (Keller, 2007). On the other hand, other studies have found evidence that stereotype-threatened individuals are more likely to self-handicap their own performance by exhibiting less effort on a practice task that could have otherwise helped them prepare for an upcoming performance in the stereotyped domain (Stone, 2002). In conjunction with findings demonstrating that stereotype threat can decrease motivation by cuing disengagement and distancing from the domain in question (Murphy, Steele, & Gross, 2007; Smith, Sansone, & White, 2007; Steele, James, & Barnett, 2002; von Hippel et al., 2005), the exact role played by motivation in stereotype threat effects remains unclear.

One possible resolution to this issue can be achieved by considering the likelihood that personal attitudes toward the domain, in combination with the threat of being stereotyped, particularly enhances motivation. In their energization theory of motivation, Brehm and colleagues (Brehm & Self, 1989; Wright & Brehm, 1989) suggested that the intensity of motivation is maximized when one values a goal that is perceived to be moderately difficult (although not impossible) to attain. By this logic, training a more positive attitude toward a domain (or priming a positive attitude if it already exists) should boost its perceived value, whereas cuing an ingroup stereotype implying underperformance in that domain might make it seem relatively more difficult to attain that goal. This interpretation helps explain why stereotype-threatened minorities become particularly motivated to detect errors, to the extent that they value academics (Forbes, Schmader, & Allen, 2008). It also provides interesting insight into Steele's (1997) classic assertion that those who value success the most would be most threatened by, and thus most motivated to avoid confirmation of, a stereotype about their group. From an energization perspective, when a stereotype suggests it will be more difficult to excel in a domain that one likes, motivation is enhanced. An intriguing corollary that we will test is that increasing liking for a domain might not enhance motivation for those who benefit from a stereotype denoting domain success if we assume that such a stereotype implies that less effort is needed at the task.

We predict that, in contrast to these possible effects of attitude training on motivation, positive attitudes and the motivational processes that they may cue will not supply the cognitive capacity one needs to excel on complex cognitive tasks completed under stereotype threat. Rather, we assert that it is necessary to train individuals with a counterstereotype about their group to free up working memory resources when cues to threat are present (Schmader et al., 2008). For example, in the context of a quasiexperimental design, Kiefer and Sekaquaptewa (2007) found that gender-stereotyped associations made women more vulnerable to performance decrements in math, but strength of association between self and math did not relate to math performance. Likewise, Kawakami and colleagues (2008) showed that training an approach motivation toward math increased women's motivation to complete math questions but had no effect on their accuracy in solving these questions. The present research will examine experimentally whether changing stereotypes and attitudes differentially affects the cognitive capacity and motivation needed for successful test performance.

Overview of Studies

Four experiments were conducted to assess the distinct effects that attitude and stereotype retraining has on motivation and cognitive capacity, particularly in stereotype-threatening situations. These studies drew from past research indicating that pairing two constructs together repeatedly (be they semantic or evaluative in nature) is a simple, yet highly effective, way to facilitate basic learning of new attitudes and stereotypes that might override (but not necessarily overwrite) existing associations (Hebb, 1949; Kawakami, Dovidio, Moll, Hermsen, & Russin, 2000; Olson & Fazio, 2001). Using this method, we experimentally retrained women's attitudes and/or stereotypes associated with the math domain on Day 1 in order to test the causal effects of these associations on motivation and cognitive capacity measured 24–30 hr later. Study 1 tested the basic hypothesis that retraining women to have a positive attitude toward math would increase their motivation to do math in a neutral context but would not increase their working memory capacity when cues to stereotype threat are present. Study 2 then sought to show that the motivational benefits of retraining positive attitudes toward a domain would be specifically enhanced when one is targeted by a stereotype that asserts one's lack of competence in that domain.

Studies 3 and 4 focused more on the effects of retraining gender stereotypes about math. Study 3 retrained both math attitudes and gender stereotypes in a factorial design to isolate the differential and/or combinatory effects that these associations have on math motivation and cognitive capacity under stereotype threat. Finally, Study 4 assessed whether the benefits of stereotype retraining on women's working memory capacity only occur in a stereotype-threatening context and serve to mediate benefits to performance on a difficult math test.

Study 1

The purpose of Study 1 was to test the hypothesis that retraining women to have a positive math attitude will motivate them to spend more time working at math problems compared with women reinforced with a negative math attitude. In a recent study, Kawakami and colleagues (2008) observed that women trained to associate "approach" movements with "math" demonstrated more positive implicit math attitudes (see Study 1) and worked on more math problems (see Study 2), although they did not get more problems correct. Kawakami et al. concluded that training an approach motivation leads to more positive math attitudes. Our goal was to test the inverse—that training a positive attitude association to the domain would also increase women's tendency to approach the domain (i.e., the time they choose to spend working on math problems). In addition, whereas Kawakami and colleagues carried out training and outcome measures as part of the same two-part session, we wanted to minimize possible priming or demand effects while also taking advantage of evidence that sleep facilitates memory consolidation (Stickgold & Walker, 2005) by having participants return 24–30 hr later to complete the primary measures. Finally, we also wanted to make a finer distinction between having the motivation to engage in the task and having the processing capacity to excel. We hypothesized that retraining attitudes would elevate motivation in a neutral context but would not increase working memory capacity or performance on complex math problems when cues to threat are present.

Method

Participants. Fifty-eight moderately math-identified women participated in the experiment for course credit and were randomly assigned to a like math or dislike math training condition. Women were considered eligible if, on mass survey data, their average response to three items—"Being good at math is an important part of who I am," "I think that I am good at tasks that require the use of math," and "I like tasks that involve math or computation" ($\alpha =$ .90)—was between 3.50 and 5.50 on a 7-point scale ranging from

1 (*strongly disagree*) to 7 (*strongly agree*). We targeted moderately math-identified women because those who are at the extremes of identification are also likely to have extreme attitudes toward the domain (Nosek et al., 2002) that would be more resistant to attitude change (e.g., Abelson, 1995; Bassili, 2008; Miller, McHoskey, Bane, & Dowd, 1993; Petty & Wegener, 1998). For example, Kawakami et al. (2008) found that an attitude-training paradigm was ineffective on women who were already positively identified with math. Thus, we felt that selecting women who were moderately math-identified provided us with the best group on which to test our hypotheses.

Procedure. All of the studies reported in this article were conducted by female experimenters. Participants were recruited for a two-session study of how categorization abilities relate to memory. In actuality, all participants underwent attitude training during Session 1 using a modified version of the personalized implicit association test (pIAT; Olson & Fazio, 2004). The pIAT is structured as a dual categorization task in which participants see four category labels at the top of the computer screen: *I like* versus *I don't like*, and *Math* versus *Language*. Participants viewed words on the screen one at a time that were either idiosyncratic items they could like or dislike, or words pertaining to math or language (see the Appendix). Their task was to categorize the words from the first list as things that they either liked or didn't like and words from the second list as being either math- or language-related. All participants completed 12 blocks of 40 words for a total of 480 trials. Each block consisted of 10 math words, 10 language words, and 20 idiosyncratic items randomly selected from the lists in the Appendix and presented in random order. To train participants to either like math or not like math, the pIAT was manipulated so that across 480 trials, participants in the I like math condition always used a response mapping that associated "I like" and "Math" on the same key, whereas those in the I don't like math condition always associated "I don't like" and "Math" on the same key. Similar tactics in past research have been shown to directly alter implicit attitudes (Ebert, Steffens, von Stülpnagel, & Jelenec, 2009).

Participants completed the attitude-training pIAT on Day 1 and then came back 24–30 hr later and completed three different tasks: a math effort task, a working memory measure, and a math strategy test. Because we wanted to establish that retraining could affect motivation in a neutral environment before introducing possible effects of stereotype threat on motivation, participants were first given 10 min to complete a motivation task with no mention of math ability, testing, or gender (i.e., the motivation task was completed in a stereotype-neutral environment). After the motivation task, cues to stereotype threat were presented by having a recording of a male researcher describe that participants would next be taking a working memory measure followed by a math test designed to diagnose their natural mathematical ability. Participants were then asked to indicate their gender. These same procedures have been shown to be effective at inducing stereotype threat in prior research (Johns, Schmader, & Martens, 2005; Schmader et al., 2009; Schmader & Johns, 2003; Steele & Aronson, 1995).

After the conclusion of the session, participants' self-reported math attitudes were obtained by asking them to rate on a scale of 1 (*strongly disagree*) to 7 (*strongly agree*) the extent to which they agreed with the statement "I like tasks that involve math or computation." Participants were then extensively debriefed, including probing for any connection participants might have made between the two sessions. It is notable that across the four studies presented here, few participants revealed any awareness that some of the tasks might have been designed to train a certain association (no one reported this suspicion in Study 1). Finally, participants were thanked and compensated for their time.

Measures.

Math motivation. The motivation task was comprised of 30 math and 30 remote associates (RAT) problems presented to participants on a series of choice screens. On each screen, participants were asked which type of problem they would like to work on: a math problem (e.g., "Solve for x: $20x - 16x + 19 = 7$") or a remote associates problem (e.g., "Find a fourth word that somehow relates to the following three words: athlete's, web, rabbit"). After making their selection, they were taken to a screen with the respective problem on it, and the time they spent looking at that screen was recorded. Participants had to answer one of the problem types presented on the choice screen, and once a problem was answered, they continued to the next choice screen, repeating this process until the 10-min time period expired. The total length of time spent working on or looking at math problems over the course of 10 min constituted our primary assessment of math motivation. Because we were somewhat concerned that an established preference for verbal over math (Nosek et al., 2002) could produce floor effects, we selected RAT problems that were relatively more difficult than the math problems. In addition, we created math problems that take some amount of effort to calculate the solution but are not of such complexity as to reveal performance deficits due to stereotype threat (Quinn & Spencer, 2001).

Working memory capacity. The working memory task that participants completed was a vowel-counting version adapted by Schmader and Johns (2003) from the Reading Span Test (Daneman & Carpenter, 1980). In this computer-based task, participants are presented with a series of sentences in which their task is to count the number of vowels present. Prior to each sentence, a word is presented for later recall. So for instance, participants might first see the word *dream* in the middle of the screen for 2 s, which would then be followed by the sentence "Don't give the fish too much food." After participants enter the number of vowels in the sentence, the next target word appears and the process repeats for 4–6 word/sentence trials. At the end of each set of 4–6 target words, participants are then cued to recall all of the words presented in that set.

Participants completed 12 randomized blocks of 60 trials (4 four-word sets, 4 five-word sets, and 4 six-word sets). Working memory scores were calculated using the absolute span scoring method, in which only words from perfectly recalled sets are counted toward the total score (i.e., recalling all four words in a four-target set earns the participant four points, whereas recalling three out of four words earns zero; Schmader & Johns, 2003; Turner & Engle, 1989).

Math performance. Math performance was assessed with the 15-item Necessary Arithmetic Operations Test (NAOT; Ekstrom, French, Harman, & Dermen, 1976), a measure shown to require substantial prefrontal cortical processing for successful performance (Prabhakaran, Rypma, & Gabrieli, 2001). In this test, which is to be completed in 5 min, participants are presented with word problems and asked to identify the correct procedure for solving the given word problem rather than solving the actual problem itself.

Results

Math motivation. Initial analyses of performance on the choice task revealed that participants looked at more math problems ($M = 9.10$, $SD = 5.26$) than RAT problems ($M = 5.59$, $SD = 6.76$), tended to provide an answer to the math problems they looked at ($M = 8.59$, $SD = 5.17$), and gave typically accurate answers to the math problems ($M = 81.10\%$, $SD = 26.87$). They also spent more total time on math problems ($M = 325.84$ s, $SD = 101.84$) compared with RAT problems ($M = 81.89$ s, $SD = 101.84$). This general preference for math was likely the result of our choosing math questions that were relatively easier compared with the RAT questions. What is most important is that all participants spent some time on both kinds of problems (i.e., there were neither floor nor ceiling effects), and there was considerable variability in time spent on both types of problems.

An independent samples t test conducted on the total amount of time participants spent working on math problems during the choice task revealed that, as predicted, women trained to like math spent significantly more time working on math problems compared with women trained to dislike math, $t(56) = –2.23$, $p < .03$, $d = 0.59$ (see Table 1), although they were not necessarily more accurate in their solutions to the problems they answered, $t(56) = –0.19$, $p = .85$, $d = 0.05$.[1] Thus, even with a 24-hr delay, the retraining task was successful at affecting women's motivation for math. Interestingly, the parallel analysis conducted on the total time spent working on RAT problems revealed no differences between the two conditions, $t(56) = 1.11$, $p = .27$, $d = 0.29$. Because participants had a fixed amount of time to work on either type of problem or do nothing, this suggests that the pattern of motivation effects was shaped more by the training of women's attitudes toward math than by the yoked inverse training of their attitudes toward language.

Working memory and math test performance. An independent samples t test on women's working memory scores and performance accuracy on the math test revealed no significant differences on either variable (see Table 1), $t_{\text{working memory}}(56) = 0.97$, $p = .34$, $d = 0.25$; $t_{\text{math test}}(56) = –0.63$, $p = .53$, $d = 0.17$. Importantly, neither variable showed floor or ceiling effects. Thus, these analyses provide no evidence that retraining attitudes enhances working memory or performance on a complex math test when cues to threat are present.

Table 1
Means and Standard Deviations for Math Motivation, Working Memory, and Math Strategy Accuracy in Study 1 as a Function of Attitude Retraining

Attitude	Math motivation[a]	Working memory[b]	Math strategy accuracy[c]
Like math	357.40_a (100.22)	33.17_a (16.39)	66.13_a (20.21)
Dislike math	292.03_b (122.17)	36.93_a (12.68)	63.28_a (13.58)

Note. Means within a column not sharing the same subscript are significantly different from one another ($p < .05$).
[a] The number of seconds spent on math. [b] The absolute span score. [c] Percentage of correct answers out of the number of problems attempted.

Self-reported math attitudes. Women trained to like math reported comparable levels of self-reported math liking ($M = 3.97$) compared with women trained to dislike math ($M = 3.61$), $t(56) = –0.80$, $p = .43$, $d = 0.21$. Furthermore, when both retraining condition (0 = *dislike math*, 1 = *like math*) and posttraining self-reported attitudes were entered simultaneously in a regression analysis predicting math motivation, both attitude retraining ($\beta = .24$, $p < .05$, $R^2 = .06$) and self-reported math attitudes ($\beta = .40$, $p < .01$, $R^2 = .15$) had unique but independent relationships to math motivation. Thus, there was no evidence that the effects of attitude retraining on motivation were due to conscious changes in women's attitudes toward math. Self-report measures of math liking were taken in subsequent studies but showed no effects of the attitude-retraining manipulation and thus are not discussed further.[2]

Discussion

Results from Study 1 provide evidence that retraining math attitudes affects women's motivation for choosing to work on math. Women instructed to indirectly yet repeatedly associate math-related constructs with things they like chose to spend more time solving math problems compared with women trained to associate math with things they dislike. Thus, just as training low math-identified women to have an approach orientation to math can lead them to also have a more positive association to math (Kawakami et al., 2008), retraining them to have a positive attitude association to math also seems to increase their approach motivation toward the domain. Whereas Kawakami and colleagues (2008) showed motivation effects immediately following their approach-retraining manipulation, we were able to confirm that attitude-associative-training effects persist even with a 24-hr delay, thus minimizing a simple priming explanation. We found no evidence that retraining math attitudes improved women's work-

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[1] Additional independent samples t tests revealed that participants in the like math retraining condition also tended to choose more math problems on the choice task, $t(56) = –1.88$, $p < .07$, $d = 0.49$, and answer more math problems, $t(56) = –1.84$, $p = .07$, $d = 0.48$, compared with participants in the dislike math condition. Total time spent on math was highly correlated with the number of math problems chosen and the number of problems answered ($r = .66$, $r = .62$, respectively, ps $< .001$). Just as researchers in eye-tracking studies use time spent looking at a target as a measure of interest, we deemed total time to be the most valid measure of motivation on this task. In addition, the finer grained increments of time provide increased sensitivity over the coarser measure of discrete problems chosen or attempted.

[2] Similar analyses conducted on these variables in Studies 2 and 3 were consistent with findings from Study 1; attitude training had no effect on self-reported math liking (ps $> .11$). In addition, simultaneous regression analyses conducted on self-reported math attitudes collected postexperiment and math attitude retraining predicting math motivation revealed that attitude retraining had effects on math motivation that were independent of self-reported math attitudes ($\beta_{\text{Study 2}} = .46$, $p < .01$, $R^2 = .05$; $\beta_{\text{Study 3}} = .34$, $p < .03$, $R^2 = .04$). When similar simultaneous regression analyses were performed on stereotype retraining and stereotype knowledge reported by participants in an earlier mass survey testing session, stereotype retraining was the only significant predictor of working memory effects ($\beta_{\text{Study 3}} = –.19$, $p < .05$, $R^2 = .04$; $\beta_{\text{Study 4}} = .36$, $p < .01$, $R^2 = .04$) and math performance ($\beta = .26$, $p = .07$, $R^2 = .02$).

ing memory capacity or math performance under standard stereotype threat conditions. As we have argued, having a positive association with math might not improve complex cognitive processing.

Although these findings provide initial evidence that attitude retraining can shape motivation, important questions remain unanswered. Recall that in Study 1 we measured women's motivation for math before we exposed women to stereotype threat, but given that women so often face cues to their stereotyped status in science and math, it is important to know how retraining might affect motivation when cues to threat are present (an issue that has not been addressed in prior research; Kawakami et al., 2008). It's also imperative to examine whether the effects of attitude retraining on motivation are specific to women. Kawakami et al. (2008) focused exclusively on women, given the larger social problem of women's underinvolvement in math. However, it is important to ascertain whether these are general effects whereby attitudes shape behavior that would be experienced by anyone.

Study 2 tested the hypothesis that the effects of attitude retraining on motivation would be specific to women and would be enhanced in the context of stereotype threat cues. Such a pattern would be consistent with an energization model (Brehm & Self, 1989) in which motivation is maximized on tasks that are both positively valued (e.g., "a domain I like") and perceived to be especially difficult (e.g., "a domain where I am stereotyped to do poorly"). To examine this hypothesis, we retrained women and men to like or dislike math in Session 1 and then had them complete the choice task in Session 2 with or without cues to stereotype threat present.

Study 2

Method

Participants and design. Participants were 149 moderately math-identified men and women recruited via the same guidelines outlined in Study 1. Three women were excluded for correctly identifying the purpose of the study, and three additional women were excluded for not following directions during the training task. The final sample consisted of 63 women and 80 men, who were randomly assigned to one of three conditions: like math/stereotype threat, like math/stereotype neutral, or dislike math/stereotype neutral.

Procedure. As in Study 1, participants completed two sessions: The first included the same attitude-retraining task used in the prior study, and approximately one day later, participants returned and completed the math motivation measure in mixed-gender groups with cues to stereotype threat present or not (Schmader & Johns, 2003). Participants in the threat condition were led to believe that they would complete a diagnostic math and verbal test as part of a study of people's natural intellectual abilities; they were seated so that they could see another male participant and were asked to mark their gender on an initial demographic questionnaire. Participants in the neutral condition were told they would complete problem-solving tasks to examine their strategy preferences; they were seated such that they could not view any male participants, and their demographic questionnaire did not include a question about gender.

Prior to doing what participants thought would be the central task (i.e., a diagnostic math test or neutral problem-solving task), a staged computer failure prompted the experimenter to give participants the option to complete a separate pilot study while she fixed the problem. This pilot study, which all participants agreed to complete, constituted our primary dependent variable consisting of a 20-min version of the choice task used in Study 1. This procedure allowed us to tap into incidental motivation for math cued by an upcoming performance situation, as opposed to a more conscious motivation exerted as part of a presumed math test (vs. neutral problem-solving task). Participants then subsequently spent 20 min working on a challenging math test.[3] At the end of the session, participants completed a final questionnaire, were debriefed in the manner described in Study 1, and were compensated.

Results

To test our critical hypothesis, we conducted a 2 × 3 analysis of variance (ANOVA) on the total time participants spent working on math problems during the choice task. Neither main effect was significant, $F_{\text{condition}}(1, 137) = 2.39$, $p = .10$, $\eta^2 = .03$; $F_{\text{gender}}(1, 137) = 2.14$, $p = .15$, $\eta^2 = .02$; however, there was a significant interaction, $F(1, 137) = 3.88$, $p < .03$, $\eta^2 = .05$ (see Figure 1).[4] Simple effects analyses revealed that, as predicted, women trained to have a positive math attitude and expecting to taking a "diagnostic math test" spent more time on math problems on the effort task compared with their male counterparts, $F(1, 137) = 6.98$, $p < .01$, $\eta^2 = .05$, and compared with women with either a positive, $F(1, 137) = 1.98$, $p = .05$, $\eta^2 = .04$, or negative, $F(1, 137) = 3.09$, $p < .01$, $\eta^2 = .09$, math attitude completing a "problem solving task." Although women trained to like math spent somewhat more time on math problems compared with those trained to not like math under neutral conditions, $F(1, 137) = 1.24$, $p = .22$, $\eta^2 = .02$, this comparison did not reach significance. This effect might have been weaker in this second study as a result of our added efforts to make this condition as math-neutral as possible compared with the diagnostic math test condition.

Interestingly, comparisons among men yielded no significant differences between conditions. Men trained to like math taking the diagnostic math test spent similar amounts of time on the choice task compared with men trained to like math, $F(1, 137) = 0.52$, $p = .61$, $\eta^2 = .003$, or dislike math, $F(1, 137) = 0.59$, $p = .55$, $\eta^2 = .004$, while taking the problem-solving task. There were no differences between men trained to like or dislike math taking the problem-solving task as well, $F(1, 137) = 1.11$, $p = .27$, $\eta^2 = .01$. Furthermore, there were no differences between men and women in the two problem-solving task conditions, $F_{\text{like math}}(1, 137) = 1.22$, $p = .27$, $\eta^2 = .01$; $F_{\text{dislike math}}(1, 137) = 1.57$, $p = .21$, $\eta^2 = .01$.

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[3] The math test was included for exploratory purposes, and no specific hypotheses were made for actual test performance. Analyses revealed no significant effects on this measure (all *p*s $> .20$), and thus it is not discussed further.

[4] As in Study 1, time spent working on math was highly correlated with number of math problems chosen ($r = .51$) and answered ($r = .49$, *p*s $< .001$). There were no significant main effects or interaction on these coarser measures of motivation, however (all *F*s < 1.60, all *p*s $> .20$).

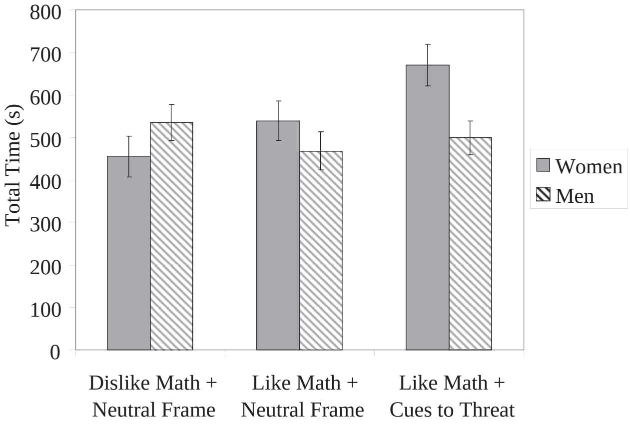

Figure 1. Study 2: Total time spent working on math problems as a function of gender, as well as attitude training and task description condition.

An additional 2 × 3 ANOVA performed on the total time participants spent working on RAT problems produced no significant main effects or interaction, $F_{\text{condition}}(1, 137) = 2.13$, $p = .12$, $\eta^2 = .03$; $F_{\text{gender}}(1, 137) = 1.67$, $p = .20$, $\eta^2 = .01$; $F_{\text{interaction}}(1, 137) = 1.18$, $p = .31$, $\eta^2 = .02$. As in Study 1, the effects of retraining were specific to math motivation.

Discussion

Results from this second study provide converging evidence that retraining positive attitudes toward math is causally linked to increased math motivation, especially when cues to stereotype threat are present, which further serves to boost women's motivation toward the domain. Men, on the other hand, are insensitive to these manipulations. Even when they know they are about to take a diagnostic test of their math intelligence, men show no increased motivation to engage with math tasks. This pattern is consistent with predictions derived from Brehm and Self's (1989) energization theory in that increasing a positive association or perceived value of a domain should maximize motivation on a task of moderate difficulty. Activating a stereotype-denoting domain inadequacy might create the sense among women that increased effort will be necessary for success. But benefiting from a stereotype denoting domain competency might activate among men the sense that they do not need to try hard to do well, even if it is a liked domain. If this explanation is valid, then we should be able to replicate this pattern observed among men in a sample of women trained to have a positive math attitude and a counterstereotype associated with their gender. This was one of the goals of Study 3.

Study 3

The results of Studies 1 and 2 suggest that having a positive associative attitude for an activity increases motivation to engage in that activity when confronted with stereotypes suggesting that one will do poorly. Recall, however, that in Study 1, this manipulation of liking did not improve women's working memory capacity or ability to derive strategies for solving math problems when cues to threat were present. In Studies 3 and 4, we return to the question of improving processing abilities under stereotype threat by examining the potential benefits of retraining gender stereotypes with math.

According to existing theory, individuals underperform under stereotype threat not because they are unmotivated to do well but because the activated stereotype cues negative thoughts about one's performance and sets in motion other psychological processes that interfere with working memory (Beilock et al., 2007; Schmader et al., 2008). Thus, improving working memory in situations of stereotype threat necessitates a change in stereotypes, not a change in attitudes. To examine these questions in Study 3, we retrained both women's attitudes and their gender stereotypes toward math and measured the resulting effects on their motivation and working memory capacity.

In light of the findings from Study 2, we hypothesized that retraining women to like math should once again translate into greater math motivation, but only if they have simultaneously reinforced the stereotype that women are bad at math. Such a pattern would provide additional support for the energization hypothesis that motivation is maximized when a self-relevant group stereotype (i.e., "women are bad at math") suggests that it could be difficult to excel in a liked domain (i.e., "I like math"). As in Study 1, we do not expect that attitude retraining will benefit women's working memory. However, if stereotypes rather than attitudes are the key to processing impairments due to stereotype threat, then retraining women to associate their group with being good at math should directly increase their working memory capacity in a situation in which cues to stereotype threat have been shown to decrease cognitive processing (Schmader & Johns, 2003).

Method

Participants. Participants were 129 moderately math-identified women. Participants were excluded for not following directions on the tasks ($n = 5$), for correctly identifying the purpose of the study ($n = 2$), and due to computer failure ($n = 2$). Thus, 120 participants were included in the analyses.

Procedure and measures. The study followed the same procedure used in Study 1 with two notable exceptions. First, participants completed two training tasks during Session 1. In addition to the attitude-retraining pIAT, a stereotype-retraining IAT, counterbalanced in order, was also completed. Thus, this experiment was a 2 (attitude training: like math, dislike math) × 2 (stereotype training: stereotype reinforcement, counterstereotype retraining) factorial design. To conserve time, participants completed only the motivation task and the working memory task during Session 2.

To retrain women's stereotypes, we manipulated a traditional IAT in a manner identical to what was done for the attitude retraining in Study 1. Participants assigned to counterstereotype retraining saw the category labels *Women are good at* and *Math* together in the top left-hand corner of the computer screen and the labels *Men are good at* and *Language* in the top right-hand corner of the computer screen at all times during the training (the location was reversed every four blocks, but the pairings always remained the same). Conversely, participants assigned to the stereotype reinforcement training condition saw the labels *Women are good at* and *Language* in the right-hand corner of the screen and the labels *Men are good at* and *Math* in the left-hand corner of the screen.

Participants were then exposed to 12 blocks of 40 trials in which they had to classify a word that was either an idiosyncratic action or a math- or language-related concept. For the action words, they were told to press one button on the keyboard if they saw a word that they thought society perceives women to be good at (see Appendix for the complete list of words) and to press another button every time they saw a word they thought society perceives men to be good at. The idiosyncratic words themselves were chosen to represent basic actions that were generally gender-neutral. For the math/language concepts (the same math and language words used in Study 1), participants were instructed to correctly classify these words by domain. Thus, participants in the counterstereotype condition were continually mapping math-related words along with activities that society perceives women to be good at (and conversely mapping language-related words along with activities that society perceives men to be good at). In contrast, the mappings were stereotype-congruent for participants in the stereotype-reinforcement condition.

After completing the attitude- and stereotype-retraining tasks in Session 1, participants returned 24–30 hr later, were greeted by a female experimenter, and were asked to complete the choice task under the guise that it was a separate experiment (i.e., stereotype-neutral instructions). We chose not to introduce cues to stereotype threat during this motivation task, because we wished to test the effect of having reinforced the stereotype on motivation (rather than examine the effects of explicit stereotype cues on motivation as we did in Study 2). Participants were then informed by a recording of a male researcher that they would be completing a working memory task that would be followed by a math test that was diagnostic of their genuine math ability (Schmader & Johns, 2003). After the working memory task, participants were informed that due to time constraints they would not be completing the math test. At that point they were debriefed and thanked.

Results

Math motivation. A 2 × 2 ANOVA was conducted on the total time spent on math problems during the choice task. Although there was no main effect for attitude training, $F(1, 116) = 0.91$, $p = .34$, $\eta^2 = .01$, there was a significant interaction of attitude training and stereotype training, $F(1, 116) = 3.90$, $p = .05$, $\eta^2 = .03$, that also qualified a stereotype-training main effect, $F(1, 116) = 6.98$, $p < .02$, $\eta^2 = .05$ (see Figure 2).[5] Simple effects analyses revealed that women trained to like math spent significantly more time on math problems compared with women trained to dislike math, but only if they were also trained to reinforce the stereotype, $F(1, 116) = 4.35$, $p < .04$, $\eta^2 = .04$. When women were counterstereotypically retrained to associate math with women, attitude training had no effect on women's math motivation, $F(1, 116) = 0.51$, $p = .47$, $\eta^2 = .004$. Furthermore, among those trained to like math, women who were also trained to reinforce the stereotype spent more time working on math problems compared with women who were trained with the counterstereotype, $F(1, 116) = 9.63$, $p < .01$, $\eta^2 = .08$. There was no effect of stereotype training on math motivation among women trained to dislike math, $F(1, 116) = 0.11$, $p = .74$, $\eta^2 = .001$.[6]

A parallel analysis on time spent working on RAT items yielded no main effects or interaction, $F_{\text{attitude training}}(1, 116) = 0.45$, $p = .50$, $\eta^2 = .004$; $F_{\text{stereotype training}}(1, 116) = 0.13$, $p = .72$, $\eta^2 = .001$. These findings provide further evidence that it is the unique combination of positive domain attitudes and strong stereotypic associations that engender the greatest motivational response.[7]

Working memory. An additional 2 × 2 ANOVA conducted on participants' working memory scores revealed the predicted main effect for stereotype training, $F(1, 116) = 4.62$, $p < .04$, $\eta^2 = .04$ (see Figure 3). Women trained to associate women with being good at math ($M = 33.22$) had higher working memory scores than did women trained to associate men with being good at math ($M = 27.34$). Neither the main effect for attitude training nor the interaction was significant, $F_{\text{attitude training}}(1, 116) = 1.17$, $p = .28$, $\eta^2 = .01$; $F_{\text{interaction}}(1, 116) = 0.02$, $p = .88$, $\eta^2 = .00$. This finding provides direct evidence that it is the stereotype specifically that sets the stage for working memory depletion when women believe their math skills are being tested as opposed to their associated attitude toward the domain or some combination of the two.

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[5] As in Studies 1 and 2, the time spent working on math was highly correlated with the number of math problems chosen ($r = .63$) and answered ($r = .61$, ps $< .001$), but there were no significant main effects or interaction (all Fs < 1.04, all ps $> .31$).

[6] In Studies 1, 2, and 3, we examined the possibility that retraining a positive attitude might have been most effective for those who start out with a more negative association with math. Such an effect could provide an alternative account for why women were more affected by attitude training than were men in Study 2. To test this possibility, we first operationalized initial math attitude as each participant's average reaction time from the first four blocks of the training task, during which they paired things they liked with math-related words. We then examined within-cell correlations between these reaction time averages and math motivation among women trained to like math specifically. We found no correlation between these two variables in Study 1 ($r = -.19$, $p = .32$), Study 2 ($r = .00$, $p = .99$), or Study 3 ($r = -.10$, $p = .63$). Thus, there is no support for the premise that positive attitude training only worked on women who had a more negative math attitude at baseline.

[7] In Studies 1, 2, and 3, we also conducted a more direct test of the idea that attitude training only influenced motivation in the stereotyped domain (math) and not the alternative domain (language). Specifically, mixed factors analyses using math and language task type as a repeated measures variable along with the between-subjects variable(s) in each study yielded an interaction between attitude training and task type in Study 1 that approached significance, $F(1, 56) = 3.36$, $p = .07$, $\eta^2 = .06$; a three-way interaction between task type, condition, and gender in Study 2 that approached significance, $F(1, 137) = 2.74$, $p = .07$, $\eta^2 = .04$; and a three-way interaction between task type, attitude training, and stereotype training in Study 3 that approached significance, $F(1, 116) = 3.36$, $p = .08$, $\eta^2 = .03$. Furthermore, the predicted interaction of task type and attitude training was significant when the three data sets were combined to include relevant conditions in which attitude training effects were predicted (e.g., among all participants in Study 1; all women in Study 2, collapsing across the two conditions in which women were trained to like math; and women trained to reinforce the stereotype in Study 3), $F(1, 179) = 17.22$, $p < .001$, $\eta^2 = .09$. Simple effect analyses indicated that women trained to like math spent more time on math problems ($M = 463.08$ s) than did women trained to like language ($M = 331.19$ s), $F(1, 179) = 26.56$, $p < .001$, $\eta^2 = .13$. Training type did not affect time spent on language problems, $F(1, 179) = 0.85$, $p = .36$, $\eta^2 = .005$. Importantly, the three-way interaction between motivation domain, condition, and study was not significant, $F(1, 179) = 0.61$, $p = .54$, $\eta^2 = .007$, suggesting that this effect was not significantly different across study. These results provide strong evidence in support of the conjecture that attitude-training effects are only present in domains that are associated with an ingroup stereotype denoting domain inadequacy.

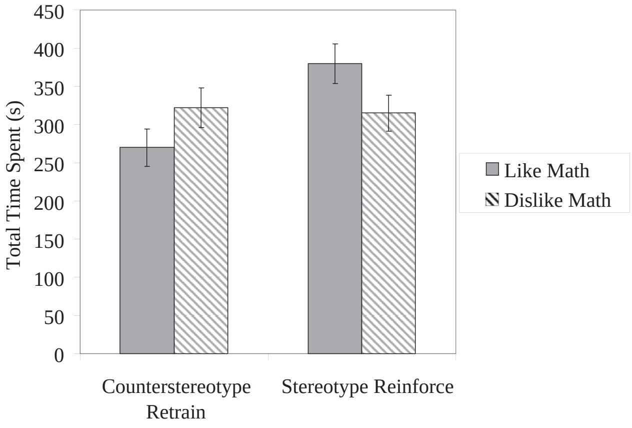

Figure 2. Study 3: Total time spent working on math problems as a function of attitude and stereotype training.

Discussion

Results from Study 3 provide additional evidence of the different effects of attitude and stereotype retraining for women's motivation and cognitive capacity to do math. We again found that women retrained to like math are motivated to pursue a math task, but only in the face of stereotypes saying that they are not good at math. Interestingly, when women are trained to associate their gender with math, the attitude retraining ceases to affect motivation. This pattern is strikingly similar to that of men in Study 2, who were also unaffected by the attitude-retraining manipulation. It seems that benefiting from a stereotype of superior ability could cue a sense that one doesn't need to try hard in that domain in order to do well, regardless of whether it is a liked domain.

This interactive pattern is consistent with an energization hypothesis according to which motivation is maximized when stereotypes suggest that one might struggle to excel in a liked and valued domain. It is also consistent with Steele's (1997) original vanguard hypothesis that assumed that those who value a domain would be most threatened by the suggestion that their group lacks ability in it. In these studies, we see that these processes operate at a basic level in response to associative mappings.

Although women with an associative liking for math and stereotypic association between their gender and math inadequacy might be especially motivated to persist on math-related activities, ironically the stereotype might be cuing processes that tax the cognitive resources they would need to perform optimally (Schmader et al., 2008). As results from Study 3 indicate, women reinforced with stereotypic associations about women's math inadequacy exhibited lower working memory capacity than did women who were trained to associate their gender with being good at math. If cognitive capacity is integral for successful performance on many difficult performance tasks (Schmader et al., 2008), then it may not matter how much one likes the domain if ingrained cultural stereotypes do not link one's group to doing well in it.

Study 4

The results from Study 3 are informative, but several open questions about stereotype retraining remain. First, we assume that having the counterstereotype about women and math is specifically beneficial when cues to stereotype threat are present. However, because cues to threat were present for all participants while assessing their working memory capacity in Study 3, this parameter remains to be tested. Without a comparison with a neutral condition, it is difficult to ascertain whether counterstereotype retraining mimics performance in a threat-free environment or actually results in stereotype lift (Walton & Cohen, 2003).

In addition, we have shown effects on working memory but have not shown that counterstereotype retraining can improve actual performance. Thus, Study 4 focused exclusively on counterstereotype retraining as a means to improve women's math performance, as mediated by an increase in working memory capacity, when cues to stereotype threat are present. To examine these questions, we trained women to reinforce either the stereotype that women are bad at math or the counterstereotype that women are good at math. In a second session, women then completed a working memory task and a difficult math test, under neutral or stereotype-threatening conditions. Because our focus in this study was on stereotype retraining, we did not manipulate attitude retraining in this design.

Method

Participants. In this study, 190 women participated for course credit. Because attitudes were not being retrained this time, we did not select individuals on the basis of any predetermined characteristics such as math identification. Of the 190 participants, nine were excluded for not following directions in either the training or working memory task and four were excluded for correctly identifying the purpose of the study. Thus, 177 participants were included in the analyses.

Procedure. This study was a 2 (stereotype training: stereotype reinforcement, counterstereotype retraining) × 2 (task description: diagnostic math test, problem-solving task) factorial design. Participants completed the same stereotype-retraining task described in Study 3 during Session 1 and returned 24–30 hr later, at which time they were greeted by a female experimenter and asked to complete our two dependent variables: the same working memory measure used in Studies 1 and 3 and a 20-min math test composed

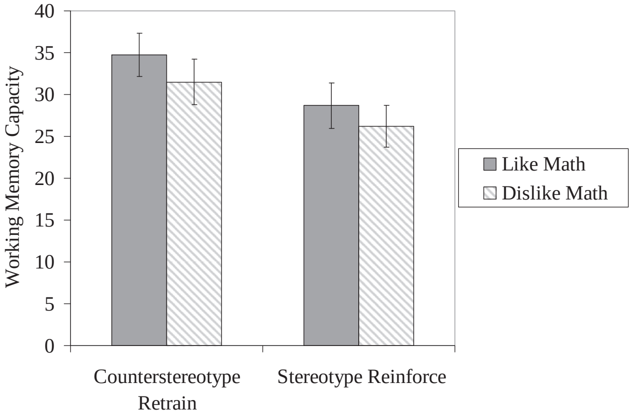

Figure 3. Study 3: Working memory scores as a function of attitude and stereotype training.

of 30 moderately difficult math problems taken from the GRE (Schmader & Johns, 2003; Study 3). Before participants completed these two measures, which were described as separate experiments, we manipulated stereotype threat for half of the sample. In the stereotype threat condition, participants were informed by an audio recording of a male researcher that they would be completing a diagnostic measure of their natural mathematical ability after the working memory task. They were also asked to mark their gender on a demographic questionnaire. Participants in the control condition were informed that they would be completing problem-solving tasks, and their demographic questionnaire did not include gender. All participants were then given four moderately difficult math problems taken from the GRE that served as an example of the type of problems they would be asked to solve later. After completing both measures, participants were debriefed and compensated.

Results

Working memory. A 2 × 2 ANOVA conducted on participants' working memory scores revealed a main effect for stereotype training that approached significance, $F(1, 173) = 3.48$, $p = .06$, $\eta^2 = .02$, and that was qualified by the predicted interaction, $F(1, 173) = 6.50$, $p < .02$, $\eta^2 = .04$ (see Figure 4). The main effect for task description was not significant, $F(1, 173) = 0.66$, $p = .42$, $\eta^2 = .004$. Simple effects analyses revealed a pattern in the diagnostic condition that replicated the result from Study 3. Specifically, women who received counterstereotype retraining exhibited greater working memory capacity when taking a diagnostic math test compared with women who received stereotype reinforcement training, $F(1, 173) = 9.20$, $p < .01$, $\eta^2 = .05$. However, when the situation was stereotype-neutral, stereotype retraining had no effect on working memory capacity, $F(1, 173) = 0.25$, $p = .62$, $\eta^2 = .001$. Furthermore, among women who received counterstereotype retraining, working memory was higher in the diagnostic math test condition compared with the problem-solving task condition, $F(1, 173) = 5.46$, $p < .03$, $\eta^2 = .03$. In contrast, women trained to reinforce the stereotype did not show significantly lower working memory when they believed they would be taking a diagnostic math test compared with those who believed they would be working on a problem-solving task, $F(1, 173) = 1.56$, $p = .21$, $\eta^2 = .01$.

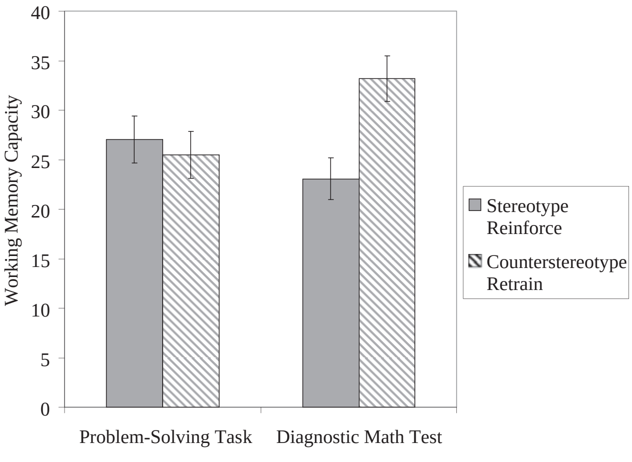

Figure 4. Study 4: Working memory scores as a function of stereotype training and condition: Stereotype Training (stereotype reinforcement, counterstereotype retraining) × Task Description (diagnostic math test, problem-solving task).

Math test performance. A 2 × 2 ANOVA conducted on participants' math test accuracy yielded only the predicted interaction, $F(1, 173) = 3.96$, $p < .05$, $\eta^2 = .02$ (see Figure 5). The main effects were not significant, $F_{\text{stereotype training}}(1, 173) = 2.54$, $p = .11$, $\eta^2 = .01$; $F_{\text{task description}}(1, 173) = 2.25$, $p = .14$, $\eta^2 = .01$. Consistent with the working memory findings, simple effects analyses indicated that women who thought they were taking a diagnostic math test performed better on the math test when they were retrained with the counterstereotype—women are good at math—than when the traditional stereotype was reinforced, $F(1, 173) = 6.06$, $p < .02$, $\eta^2 = .03$. Stereotype retraining had no effect on accuracy in the problem-solving condition; women retrained with the counterstereotype performed comparably to women who reinforced the stereotype, $F(1, 173) = 0.08$, $p = .77$, $\eta^2 = .00$. Furthermore, although women who thought their math ability was being assessed did not underperform those in the problem-solving condition when the stereotype was reinforced, $F(1, 173) = 0.12$, $p = .72$, $\eta^2 = .001$, they did outperform their problem-solving counterparts when they were retrained to associate math with things women are good at, $F(1, 173) = 5.88$, $p < .02$, $\eta^2 = .03$.

Mediated moderation analyses. To determine whether the interactive effects observed on performance are mediated by those on working memory, we tested for mediated moderation by carrying out a series of regression analyses as per the guidelines of Muller, Judd, and Yzerbyt (2005). In the first analysis, training type (0 = *counterstereotype retraining*, 1 = *stereotype reinforcement*), task diagnosticity (0 = *diagnostic math test*, 1 = *problem-solving task*), and the interaction term was entered into a model predicting working memory. Consistent with the ANOVA results described previously, only the interaction was significant ($\beta = .34$, $p < .02$, $R^2 = .04$). A parallel analysis on math test accuracy yielded the same interaction pattern ($\beta = .27$, $p < .05$, $R^2 = .02$).

A final regression analysis revealed that when working memory was added to the second model, it was a significant predictor of math test accuracy ($\beta = .21$, $p < .01$, $R^2 = .04$), and the interaction predicting test performance became nonsignificant ($\beta = .20$, $p = .14$, $R^2 = .01$). A Sobel (1990) test for the indirect pathway was significant ($z = 1.80$, $p < .04$; one-tailed). These results are consistent with the hypothesis that counterstereotype retraining can increase women's performance under stereotype threat because it increases their working memory capacity.

Supplementary analyses. It is notable that the effect of our diagnosticity manipulation on working memory and performance was more of a performance lift effect for those trained with a counterstereotype than a performance impairment effect for those reinforced with the stereotype. The lack of clear impairment due to threat could be due to the fact that our sample was composed of women of all levels of math identification, whereas prior research has suggested that stereotype threat effects should be most pronounced among those who most value or most identify with the domain (Aronson et al., 1999; Spencer, Steele, & Quinn, 1999; Stone, Lynch, Sjomeling, & Darley, 1999). Consistent with this assumption, within-cell correlations revealed that among women taking the diagnostic math test, those who received counterstereo-

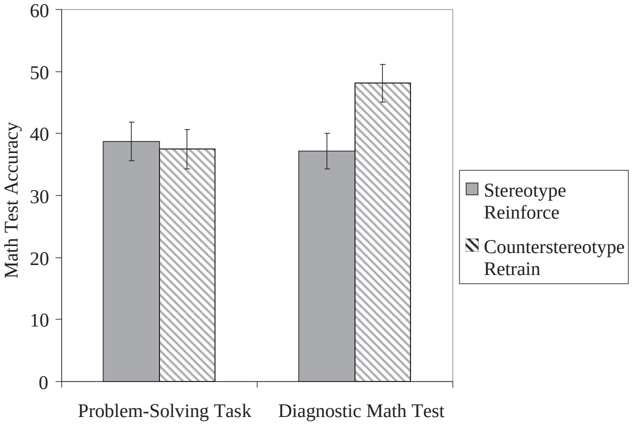

Figure 5. Study 4: Math accuracy scores as a function of stereotype training and condition: Stereotype Training (stereotype reinforcement, counterstereotype retraining) × Task Description (diagnostic math test, problem-solving task).

type retraining had a significant positive relationship between an earlier mass survey measure of math identification and working memory ($r = .34$, $p < .04$, $R^2 = .12$), but this pattern was significantly reversed among those trained to reinforce the stereotype ($r = –.32$, $p < .05$, $R^2 = .10$; $z = –2.92$, $p < .01$). There was no relationship among these variables for women taking a problem-solving task (both *r*s $< |.01|$).

Parallel analyses with math performance, however, revealed that pretest math identification was generally positively related to math performance for all conditions (*r*s range from .20 to .44) and was not significantly different between conditions. Given that measures of math identification are likely to be conflated with past math experience, the domain-general measure of working memory capacity might have been a more sensitive way to detect how identification with the domain exposes one to stereotype threat.

Discussion

Results from Study 4 indicate that retraining women to have counterstereotypic associations between their gender and math can actually enhance their working memory capacity and performance on a difficult math test when they are put in situations that normally induce stereotype threat. Elsewhere, we have argued that stereotypes that denote domain competency can generally create stereotype lift effects on performance by minimizing the capacity-absorbing processes (e.g., stress arousal, performance monitoring, emotional suppression) that could lead anyone to perform below his or her potential (Schmader et al., 2008). Here is evidence that retraining a counterstereotype that denotes domain competency does in fact increase working memory capacity, and this enhancement in turn mediated the relationship between counterstereotype retraining and math test performance. Importantly, these benefits for cognitive processing and performance are not some general reaction to pairing women with math; these effects were only observed when the task was described in a stereotype-relevant way.

It is interesting that women trained to reinforce the stereotype did not show overall decrements in working memory capacity or performance when they believed they were taking a diagnostic math test compared with women who believed they were working on a problem-solving task. Given the nature of our sample, which was composed of women who exhibited various levels of math identification, this was not entirely surprising. More detailed analyses revealed that women who had reinforced the stereotype did exhibit less working memory capacity to the extent they were identified with math and that this relationship was significantly different from their counterstereotype-retrained counterparts. Although domain identification makes one susceptible to the impairments of stereotype threat, the moderating effect of identification on stereotype lift is rather weak (Walton & Cohen, 2003). This might imply that domain identification is less of a prerequisite for stereotype lift, enabling us to observe the performance benefits of retraining a positive stereotype even though we did not find performance impairments from reinforcing a negative stereotype.

General Discussion

It has always been a core tenet of stereotype threat theory that those who care most about succeeding in a domain are the ones who should be most threatened and cognitively impaired by a stereotype suggesting that their group lacks the ability to perform well there (Steele, 1997). The implication of this assertion is that both motivation and cognitive capacity are important elements to this phenomenon, but prior research has not sought to directly measure these within the same program of research. The studies presented here are the first to provide a clear distinction between the boost to motivation that comes from a positive association to a domain in which one is stereotyped to perform poorly and the simultaneous effect of those stereotypes on cognitive capacity. Evidence in support of increased motivation alongside impaired capacity is important, given that stereotype threat effects are sometimes misinterpreted as stemming from a lack of motivation (Sackett, Borneman, & Connelly, 2008) or as involving no role of reduced capacity (Jamieson & Harkins, 2007).

Results from three of our experiments reveal that retraining women to have more positive math attitudes increased their math motivation in general (Study 1), specifically when stereotypes had either been primed subtly (Study 2) or reinforced (Study 3). Men, and women trained with a counterstereotype, showed no effect of attitude training on motivation. Thus, in an extension of recent work by Kawakami and colleagues (2008), we found that positive attitudes toward a domain are particularly motivating in the context of being stereotyped to perform poorly. This finding supports Steele's (1997) vanguard hypothesis of stereotype threat, but it can also be understood in terms of Brehm and Self's (1989) energization hypothesis. According to that framework, motivation is maximized when the value of a domain is high (and thus success is a goal) and the task is perceived to be moderately difficult (and thus requiring concerted effort). Although this classic idea is usually examined with explicit measures of perceived value and difficulty, here we saw a similar pattern of maximized motivation when a positive attitude toward a domain is associatively retrained (i.e., imbuing the domain with value) in the context of an ingroup stereotype denoting domain inadequacy (i.e., cuing effort needed to disconfirm it; Jamieson & Harkins, 2007). What is equally interesting, however, is the suggestion that benefitting from a stereotype denoting domain competency might cue the sense that added effort, even in a liked domain, isn't necessary.

Whereas retraining women with positive math attitudes enhanced their motivation to work on basic math problems, these new associations appeared to contribute little to enhance women's cognitive capacity in a stereotype-threatening context. Instead, cognitive capacity improved only when stereotypes were retrained. After being retrained to associate their gender with being good at math, women exhibited increased working memory capacity (Studies 3 and 4) and increased math performance (Study 4) in a situation that has previously been shown to impair performance (Schmader & Johns, 2003). Mediational analyses confirmed that the enhanced performance that resulted from the counterstereotype training was mediated by the boost to cognitive resources.

These results are consistent with Schmader et al.'s (2008) process model of stereotype threat, which suggests that the activation of self-relevant stereotypes can prime a cognitive imbalance where the suggestion "women are bad at math" conflicts with the simultaneously activated cognitions "I am a woman" and "I am good at math." As a result of this cognitive imbalance, a cascade of motivational and cognitive processes are initiated to make sense of this inconsistency, resolve it, and cope with the negative thoughts and emotions that are likely to result (Forbes et al., 2008; Johns et al., 2008; Schmader et al., 2009). It is because these processes are cognitively demanding that working memory resources that are otherwise critical for optimal performance become depleted and performance suffers.

However, no such imbalance is present if the stereotype has been changed to associate women with math, and in fact women in this situation in Studies 3 and 4 seemed to benefit from the same stereotype lift effect that boosts performance for groups labeled with a stereotype denoting domain competency (Walton & Cohen, 2003). Prior studies have shown these kinds of performance benefits in response to explicit presentations of positive female exemplars (Marx & Roman, 2002; McIntyre, Paulson, & Lord, 2003), which at a basic level provides a forum for forming positive associations between members of one's group and a stereotyped domain. But this is the first study to show that simple retraining of the cognitive association can have the same positive effect on performance—an effect that is mediated by enhanced working memory capacity. We would argue that the balance created by retraining women with a counterstereotype increased working memory and performance by reducing any likelihood of cognitively taxing mental processing or self-doubt that could lead participants to perform lower than their potential (Schmader et al., 2008). We note, however, that this doesn't preclude the possibility that being the beneficiary of a stereotype denoting domain competency can also have motivational consequences by engaging challenge appraisals and cuing a specific kind of motivational orientation that could facilitate better performance.

Implication for Performance

The primary goal of these studies was to examine the unique and interactive effects that attitude and stereotype retraining have for motivation and cognitive capacity. However, we assume that performance in real-world contexts can be affected by both of these component processes. Study 4 provided evidence that women's math performance can in fact be increased when they have been trained to associate their group with being good at math. The role of attitudes and motivation in performance, however, is less clear. On the one hand, our attempt to measure the effect of attitude retraining on a math test (Studies 1 and 2) and working memory measure (Studies 1 and 3) produced null results, but this doesn't preclude any effect of motivation on performance. Other programs of research have explored important distinctions between different kinds of achievement goals (Dweck & Leggett, 1988; Elliot & Church, 1997; Smith et al., 2007), motivational orientations (Keller, 2007; Seibt & Förster, 2004), and effort-based strategy biases (Jamieson & Harkins, 2009) that are no doubt important for performance.

Our focus on motivation, in contrast, was to isolate and measure a basic tendency to approach the domain due to a positive association with that domain. We did not attempt to examine more complex aspects of goal types or framing effects. However, an approach tendency stemming from the kind of attitude retraining used here might motivate persistence to combat stereotype-induced cognitive impairments. Such motivated persistence in the face of reduced capacity might not translate to improved performance when tasks are timed (e.g., in a testing context) but could allow for compensation effects on untimed tasks (e.g., homework or take-home tests). Perhaps this is why gender differences in math performance are most pronounced in test scores but not in course grades (Kimball, 1989). Future research is needed to connect these component processes of motivation and capacity to different types of performance contexts.

Limitations and Future Directions

Intriguing ramifications arise out of the finding that retraining positive attitudes does not boost motivation when one is the beneficiary of stereotypes denoting domain competency (men in Study 2, women in the counterstereotyping condition of Study 3). If a stereotype denoting domain competency implies that a group should have an inherent ability to do well in that domain, this could diminish the perception that extra motivation is needed for success. Such an interpretation should depend, however, on one's lay theories of ability for that domain. Research by Dweck, Chiu, and Hong (1995) points to individual differences in the degree to which individuals view intelligence and related constructs as stable and uncontrollable entities or as a skill that can be incrementally strengthened with added effort and motivation. From this perspective, those who are the beneficiaries of stereotypes denoting domain competency might still show motivational effects of attitude retraining if they have a more incremental theory of ability in that domain (i.e., where having ability does not imply exerting less motivation). Such a hypothesis, which awaits future research, could have important implications for how and when students from advantaged social groups exert effort in academic domains.

Furthermore, given our focus on understanding the potential benefits of positive attitudes and counterstereotypes, our studies (e.g., Study 2) lacked a condition that examined the motivational consequences of having a negative attitude and being primed with stereotype threat. Given the assumption that only those who care about performance in a domain would be motivated to disconfirm the stereotype about their group, we assume that motivation in such a condition would be low. However, it is possible that certain situations of stereotype threat (e.g., when group identification is high, the group is thought to like the domain, and/or performance is public) could cue a desire to disprove the stereotype even if the individuals have no personal liking for that domain. Future research is needed to test these boundary conditions.

Although the goal of these studies was to examine the causal effects of retraining associations, it is still an open question as to whether this type of retraining exclusively changed implicit and not explicit attitudes and stereotypes. On the one hand, past research has used similar training methods to alter what are argued to be implicit attitudes (Ebert et al., 2009), and in Studies 1 through 3, our attitude-retraining manipulation had no significant effects on self-reported liking of math. Thus, we suspect that this kind of associative training adds new implicit associations to the target construct. On the other hand, however, one could also argue that using the same response key to categorize math alongside other liked things could evoke an explicit association that simply was not adequately measured in these studies. Thus, the need to firmly establish that such retraining uniquely affects attitudes, at least initially, at an implicit level is still necessary.

Furthermore, we do not rule out the possibility that even if our retraining manipulation initially altered only implicit associations, these could eventually translate to explicit attitudes and beliefs. Such predictions would be consistent with Gawronski and Bodenhausen (2006), who suggested that implicit attitudes form the basis through which explicit attitudes are derived. For instance, if positive attitude associations motivate individuals to engage with a domain, they might experience more success particularly in those contexts where working memory resources are unlikely to be compromised. With these observations of success and time spent in the domain, individuals can eventually form the explicit attitude that they must like the domain (via a self-perception mechanism; Bem, 1967). However, we have also seen that the repeated experience of stereotype threat can impair cognitive resources and performance, the perception of which might only reinforce a woman's explicit belief that she can't do math or that women can't do math. Those women who repeatedly experience increased motivation (perhaps stemming from a positive attitude) alongside decreased capacity and performance (perhaps stemming from a gender stereotype denoting inadequacy) might be drawn toward a consistent cognition that would suggest they must have to try so hard because they lack the ability.

Finally, we note that the patterns we observed due to associative training of attitudes and stereotypes might also be evidenced by manipulations that seek to directly change explicit attitudes and stereotypes. Despite evidence that the effects of retraining on motivation and cognitive capacity were unique from those based on explicit math attitudes and stereotypes, we do not try to argue that there is something unique about modifying attitudes and stereotypes using this more implicit training technique. Nevertheless, we would assert that these retraining methods constitute a convenient, effective, and subtle means of manipulating attitude and stereotype associations to understand their effects on performance and behavior. Indeed, it is almost shocking to think that having someone pair a basic activity, such as walking, with math would be sufficient to both alter the nature of a stereotype and free up subsequent working memory resources when performing in the domain. Future research is needed to investigate how long-lasting and stable these effects are, but evidence suggests that simple training manipulations such as these can intensify over the course of multiple days (Kawakami et al., 2000).

In sum, directly manipulating associative pairings led to results that highlight how retraining attitudes and stereotypes can distinctly predict motivation and cognitive capacity in stereotype-threatening contexts. Such findings inform what kind of steps need to be taken to promote greater involvement of underrepresented groups in educational and organizational contexts. Programs and interventions that foster a positive orientation toward the domain can take us only so far; stereotypic associations need to be changed to really offset the cognitive impairments that stereotype threat can create. In short, positive attitudes might lead a woman to math, but stereotypes could still make it hard for her to think.

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Appendix

Math, Language, and Idiosyncratic Stimuli Used in the Different Training Tasks

Table A1

Math items (Studies 1–4)	Language items (Studies 1–4)	Idiosyncratic items (Studies 1–3)	Idiosyncratic actions (Studies 3–4)
addition	adjectives	airplanes	acting
algebra	crosswords	beer	advising
calculating	English	caves	biking
calculus	grammar	Clinton	eating
computation	letters	coffee	hiking
equations	literature	country music	laughing
formulas	paragraphs	disco	memorizing
fractions	pronouns	football	napping
geometry	reading	fraternities	perceiving
math	spelling	garlic	playing
multiplying	verbal	houses	recalling
quantifying	verbs	jogging	relaxing
statistics	vocabulary	Monday	skipping
subtracting	words	motorcycles	sleeping
variables	writing	opera	studying
		romance	swimming
		spinach	talking
		storms	typing
		television	walking
		tequila	working

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