Stereotype Threat Leads to Reduction in Number of Math Problems Women Attempt

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The arousal hypotheses of stereotype threat and a simple, instructional intervention first used by Johns, Schmader, and Martens (2005) to alleviate the effect in women's math performance were tested. 148 college students (69 women) provided salivary cortisol samples, completed GRE-Math items under stereotype threat activating, stereotype threat activating with alternate attribution instructions, or problem solving conditions, and then provided a second cortisol sample. Women in both stereotype threat conditions attempted fewer problems than men and fewer problems than women in the problem solving condition. By employing this strategy, women in the stereotype threat conditions were able to hold their performance accuracy (number correct divided by number attempted) at the level of men. No evidence for the arousal hypothesis or for the effectiveness of intervention was found.

Stereotype threat occurs when members of a negatively stereotyped group are placed in a situation where their performance on the assigned task may confirm the negative group stereotype (Steele & Aronson, 1995). In their seminal article, Steele and Aronson found that African Americans underperformed when told they were taking a test of intellectual ability. Additional studies have revealed negative stereotype threat effects for women in math (Ben-Zeev, Fein, & Inzlicht, 2005; O'Brien & Crandall, 2003; Spencer, Steele, & Quinn, 1999), and Caucasians in athletic performance when being compared to African Americans (Stone, Lynch, Sjomeling, & Darley, 1999). Coping strategies can reduce the effect (for a meta-analysis see Nguyen & Ryan, 2008).

The effects of stereotype threat have been shown to vary considerably by coping style. Some individuals use the stereotype as an excuse to reduce effort (Steele & Aronson, 1995). Others may avoid practice and use the lack of practice to justify poor performance (Stone, 2002). Denial also can cause a drop in performance on the designated task (von Hippel et al., 2005). However, some individuals invoke a defensive pessimism coping style when presented with a negative stereotype to increase their performance and thereby discredit the stereotype (Perry & Skitka, 2009).

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Furthermore, individuals who use humor to cope with a negative stereotype can reduce levels of anxiety while under stereotype threat conditions, resulting in better performance (Ford, Ferguson, Brooks, & Hagadone, 2004).

Although sex differences in math performance are negligible overall (Else-Quest, Hyde, & Linn, 2010; Hyde, Fennema, & Lamon, 1990), men tend to perform better than women on mathematical problem solving beginning in high school and college, as reflected in differences in SAT-Math scores (Hyde et al., 1990). A considerable amount of stereotype threat research has focused on the female math stereotype, revealing that women are able to improve performance on difficult mathematical tests when they identify with female role models who are strong in mathematics (Marx & Roman, 2002) or when they read about successful female role models (McIntyre, Paulson, & Lord, 2003). If a test is framed as potentially showing a strength, then women will perform better than if it is framed as potentially showing a weakness (Brown & Josephs, 1999). Thoman, White, Yamawaki, and Koishi (2008) found that whether the test emphasizes speed or power can determine how stereotype threat effects are revealed. Female participants who were placed in the stereotype condition attempted fewer items than male participants, but were able to achieve a higher ratio of correct answers. Instead of hindering overall performance, stereotype threat led women to adopt a strategy that emphasized accuracy over speed.

Women can potentially increase their performance while under stereotype threat conditions by being aware of the presented stereotypesphenomenon. Johns, Schmader, and Martens (2005) found that when women were told that stereotype threat would be present, and were also told that any anxiety they may experience while taking the exam is due to the stereotype threat, females' performance did not differ from males’ under the stereotype threat condition. Johns et al. (2005) suggested that these individuals were able to externally attribute their anxiety.

The conclusions of Johns et al. (2005) are based on arousal theory, which indicates that stereotype threat conditions increase physiological arousal, causing the difficulty of test items to increase for members of stereotyped groups (Ben-Zeev et al., 2005; Blascovich, Spencer, Quinn, & Steele, 2001; O'Brien & Crandall, 2003). A variety of stressful circumstances activate the sympathetic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis (Rhodes & Rubin, 1999). Conditions of stereotype threat are marked by the activation of the sympathetic nervous system, resulting in enhanced fight or flight responses and activation of the HPA axis (Vick, Seery, Blascovich, & Weisbuch, 2007). HPA axis activity is reflected peripherally by plasma concentrations of the adrenal cortical hormone, cortisol (Rhodes, O'Toole, Wright, Czambel, & Rubin, 2001). The accumulating effects of stress and associated increases in HPA activity are believed to contribute to increased hippocampal neuronal loss and memory impairment in the brain (Beck & Luine, 2002; Bowman, Beck, & Luine, 2003; Issa, Rowe, Gauthier, & Meaney, 1990; Luine, 1994, 2002; Luine, Villegas, Martinez, & McEwen, 1994).

In the short term, stereotype threat can inhibit working memory (Schmader & Johns, 2003). In animals, exposure to both chronic and acute stress has substantial effects on learning and memory (for reviews: Cahill & McGaugh, 1998; Kim & Diamond, 2002). The effects of acute stress on learning and memory are somewhat inconsistent, and sex differences vary depending on the task (Conrad et al., 2004). In humans, women respond to negative sex biases with a threatened motivational state, but men respond with a challenged state (Vick et al., 2007). Taken together, these results suggest that women under stereotype threat conditions will respond with a threatened motivational state, which is associated with increased HPA axis activity, which in turn reduces working memory capacity, thereby hindering performance on mathematical problem solving tests.

In a previous attempt to test the arousal hypothesis and to replicate Johns et al. (2005), we were unable to produce the basic effect (Rivardo, Rhodes, & Klein, 2008). Female participants unexpectedly reported higher SAT scores than men, and both male and female participants indicated that they did not believe there was a sex difference in mathematical ability, or that the experimenters present during the research believed that there was a sex difference in mathematical ability. Participants also indicated that they felt little anxiety during the course of the exam. A potential, contributing factor was that women were seldom in the minority in testing sessions; many more women than men volunteered to participate.

In the present study participants were tested individually by one of four male experimenters in a single-room research laboratory in the psychology department. They provided saliva samples that were used to extract salivary cortisol levels both before and after completion of the GRE-Math test items. Participants were assigned to the same three conditions employed by Johns et al. (2005): *problem solving, stereotype threat* (STT), and *stereotype threat with instructions* (STT with instructions).

Consistent with Johns et al. (2005), we predicted that the sex difference in GRE-Math performance would be greatest in the stereotype threat condition and that the problem solving and stereotype threat with instruction conditions would not differ. Second, we predicted that arousal, as measured by salivary cortisol, would vary between the three groups. We hypothesized that if the arousal model of stereotype threat was valid, then cortisol in the stereotype threat condition should be higher than in the problem solving and stereotype threat with instruction conditions. Johns et al. (2005) suggested that arousal was still experienced in both stereotype threat conditions, but that the instructions allowed participants to attribute that arousal to stereotype threat, and thereby reduce the response.

METHOD

Participants

One hundred forty-eight (69 women, 79 men) undergraduate students at a Catholic, liberal arts college who had passed or received advanced placement or transfer credits for Calculus I participated. Participants were paid $10 - $15 for their 50 to 60 minutes of participation, depending upon the semester in which they participated.

Materials & Procedures

Participants reported to the psychology research lab where they were tested by one of four male experimenters. Each participant was randomly assigned to one of three conditions similar to those of Johns et al. (2005): *problem solving*, *STT*, or *STT with instruction*. After granting their informed consent, participants received a testing packet and materials for saliva collection.

Salivary cortisol is a reliable indicator of the free cortisol in plasma, which is considered to be the biologically active hormone (Vining, McGinley, & Symons, 1983). Salivary cortisol increases within minutes in response to acute stressors and has a half-life of approximately 1 hour (HeUhammer, Kirschbaum, & Belkien, 1987). Eight to 10 minutes prior to the first sample collection, the participant thoroughly rinsed his or her mouth with water. Saliva was collected via the passive drool method, whereby saliva is allowed to flow down a 2-inch section of an ordinary household plastic straw and collected in a small microcollection tube and placed in a freezer. Following the experiment, saliva samples were centrifuged, quickly frozen at -80 °C, and stored until hormone analysis.

After completing demographic items, an audio file containing instructions for the appropriate condition was played on the lab computer. In the *problem solving* condition, instructions indicated that the upcoming test was a test of general problem solving ability. Instructions informed those in the *STT* group that they were about to take a math test on which men typically outperform women. Participants in the *STT with instruction* group were told that they were about to take a math test that typically shows gender differences, but they were also told about stereotype threat. The audio file also indicated that women in the latter group should follow these additional instructions, which are identical to those given by Johns et al. (2005):

> It's important to keep in mind that if you are feeling anxious while taking this test, this anxiety could be the result of these negative stereotypes that are widely known in society and have nothing to do with your actual ability to do well on the test (p. 176).

Participants had 20 minutes to complete 30 quantitative items taken from different sections of a GRE practice test (ETS, 2001). At the end of the 20-minute testing period, participants were asked to record their score on the quantitative portion of the Scholastic Aptitude Test (SAT) and to indicate their level of agreement on five Likert scale items regarding belief in a sex difference in mathematical ability, perceived belief of the experimenter about a sex difference in mathematical ability, and level of anxiousness experienced during the test. Then a second saliva sample was collected via the passive drool method.

Saliva samples were analyzed in duplicate for cortisol by a highly specific enzyme immunoassay (EIA) kit for salivary cortisol (Salimetrics, State College, PA). Inter- and intra-assay coefficients of variation were less than 5%, and the minimum detectable cortisol concentration was 0.25 ng/ml. All reported cortisol concentrations are ng/ml.

RESULTS

Math performance was measured by dividing the total number of problems correct by the number of problems attempted, a measure known as performance accuracy (Inzlicht & Ben-Zeev, 2000; Schmader & Johns, 2003; Steele & Aronson, 1995). A 2(sex) X 3(condition) ANCOVA was conducted with self-reported SAT as the covariate and performance accuracy as the dependent measure. Self-reported SAT was a significant covariate, $F(1, 121) = 54.41$, $p < .001$, $\eta_p^2 = .310$. The main effects of condition, $F(2, 121) = .65$, $p = .525$, $\eta_p^2 = .011$, and sex, $F(1, 121) = 2.96$, $p = .088$, $\eta_p^2 = .024$, and the interaction of sex and condition were not significant, $F(2, 121) = 2.21$, $p = .114$, $\eta_p^2 = .035$. However, planned comparisons revealed that women's performance accuracy in the problem solving condition was lower than in the STT ($p = .011$) and STT with instructions ($p = .036$) conditions. See Table 1 for descriptive statistics.

A 2(sex) X 3(condition) ANOVA found a significant interaction of sex and condition on the number of problems attempted, $F(2, 141) = 6.74$, $p = .002$, $\eta_p^2 = .087$. As shown in Table 2, women attempted fewer problems in the STT and STT with instruction conditions than in the problem solving condition (both ps < .01), and women attempted fewer problems than men in the STT with instructions condition (p = .006). Neither the main effects of condition, $F(2, 141) = 1.87$, $p = .16$, $\eta_p^2 = .026$, nor sex, $F(1, 141) = 0.43$, $p = .52$, $\eta_p^2 = .003$, were significant. Men (M = 19.65, SE = .69) and women (M = 18.99, SE = .73) did not differ in the number of problems attempted, nor did number attempted in the problem solving (M = 20.64, SE = .91), STT (M = 18.20, SE = .90), and STT with instructions (M = 19.12, SE = .80) conditions differ.

TABLE 1 Performance Accuracy by Sex and Condition.

	Sex								
	Male			Female			Total		
Condition	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
STT	60.99	19.10	26	58.91	20.89	15	60.23	19.54	41
Problem solving	59.78	20.86	15	44.59	11.86	24	50.43	17.36	39
STT with instructions	57.32	21.61	27	54.91	22.01	21	56.27	21.58	48
Total	59.27	20.27	68	51.78	18.97	60	55.76	19.95	128

A 2(sex) X 3(condition) MANOVA was conducted on items addressing participants beliefs about sex differences in math performance, their perceptions of the experimenter’s beliefs, and feelings

TABLE 2 Number Attempted by Sex and Condition

	Sex								
	Male			Female			Total		
Condition	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
STT	19.39	6.62	28	17.00	5.24	18	18.46	6.17	46
Problem solving	18.39	6.34	18	22.89	6.17	27	21.09	6.56	45
STT with instructions	21.16	6.31	32	17.08	4.35	24	19.41	5.88	56
Total	19.88	6.45	78	19.33	6.01	69	19.63	6.23	147

of anxiousness. Anxiousness was lower in the STT with instructions condition (M = 2.86, SD = 1.26) than in the problem solving condition (M = 3.49, SD = .97), but neither differed from the STT condition (M = 3.20, SD = 1.17), $F(1, 141) = 3.20$, $p = .044$, $\eta_p^2 = .043$. The interaction of condition and sex was also significant, $F(2, 141) = 3.55$, $p = .03$, η_p^2 = .048. Compared to all other groups, men were least anxious in the STT with instructions condition (all ps < .01). No other effects were reliable, all ps > .10.

Cortisol concentrations were analyzed with a 2(sample time) x 2(sex) x 3(condition) repeated measures ANOVA. Only the main effect of time was significant. Post instruction cortisol levels (M = 2.53, SD = 2.98) were higher than pre instruction levels (M = 2.12, SD = 1.68); $F(1, 141) = 4.76$, $p = .031$, $\eta_p^2 = .033$.

DISCUSSION

Although we intended to replicate Johns et al. (2005), the way we activated the stereotype was different in one condition. Johns et al. only asked participants in the two STT conditions to explicitly indicate their gender, but we asked all participants to report their gender prior to completing the test. As a result, participants in the problem solving condition may have experienced implicit STT activation and participants in the other two conditions received both explicit and implicit STT activation. Nguyen and Ryan (2008) found that although the difference was small, subtle STT activation resulted in greater effects than explicit activation for women in the math domain. Our findings appear to be consistent with their conclusion if we assume that the explicit activation would override the implicit activation in the two STT conditions. Similarities in women's self reported anxiousness and cortisol levels across all three conditions are also consistent with the notion that STT may have been activated for women in all three conditions although an argument based upon null results is weak[1]. It is unlikely that women in both STT conditions exhibited the defensive pessimism coping style (Perry & Skitka, 2009) and reacted to discredit the stereotype because belief that the experimenter thought there was a sex difference was neutral or negative across all conditions.

The standard STT effect was not found: women did not perform worse in the STT conditions than the problem solving condition when traditional measures of performance accuracy (e.g. Inzlicht & Ben-Zeev, 2000; Schmader & Johns, 2003; Steele & Aronson, 1995) were used. However, women attempted fewer problems in the STT conditions,

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[1] We thank an anonymous reviewer for pointing out this methodological difference and its implications.

resulting in a similar proportion correct across both STT conditions, but worse performance in the problem solving group, potentially because STT was implicitly activated in that condition. Thoman et al. (2008), and Steele and Aronson (1995, experiment 4) found similar reduction in the number of problems attempted, although others have not (e.g. Johns et al., 2005). Many have not reported this measure (e.g. Aronson et al., 1999; Ben-Zeev et al., 2005; Blascovich et al., 2001; Inzlicht & Ben-Zeev, 2000; Inzlicht & Ben-Zeev, 2003) and used methods where such a measure could not be obtained (e.g. Aronson, Fried, & Good, 2002; Inzlicht et al., 2006; Spencer et al., 1999; Stone, 2002). The explicit STT conditions may have activated effort-based coping whereby the women attempted fewer problems but spent more time on each problem. It is unclear whether the implicit STT activation in the problem solving condition led women to attempt more problems than they otherwise would have because there was no true control condition; one that did not include STT activation.

Specific selection criteria, a supportive environment, and the low stakes associated with the test may have weakened the effects of stereotype threat in this experiment. Participants were restricted to students who had already completed Calculus I or received advanced placement credit for the course, following the suggestion of previous research to limit participation to those who value or are highly skilled in math ability (Aronson et al., 1999; Ben-Zeev et al., 2005; Inzlicht, Aronson, Good, & McKay, 2006; Inzlicht & Ben-Zeev, 2003; Spencer et al., 1999). However, since this project was conceptualized Nguyan and Ryan (2008) have cautioned against the use of restrictive samples because STT may affect moderately math-identified women more than those who were highly math-identified, because the high identifiers may exhibit STT reactance (Kray, Thompson, & Galinsky, 2001). The data were collected at a small (approximately 1800 students), Catholic, liberal arts college. The atmosphere at the college is of a supportive close-knit community, which may counter STT effects in much the same way as positive role models can (McIntyre et al., 2003). The stakes of the test were low; students participated for extra credit and a modest monetary payment, but no incentives were tied to their actual performance. Unlike during a class exam, only social pressure to perform well in front of a single, male student research assistant and pressure imposed by the recorded instructions were present at testing.

Although overall the results were not consistent with the majority of previous findings, we did find an effect of STT on the number of math problems attempted by the female participants, despite relatively low levels of arousal. Because so few researchers have reported the number of problems and others use methodologies that do not allow for this measure, the prevalence of such an effect is unknown. These findings suggest that even when the threat does not produce the typical effect, behavior can still be affected. Depending upon the demands of the task presented, attempting fewer problems may hinder overall performance; few classroom tests are scored as the number correct divided by the number attempted. Instead, points are awarded for the number of problems correctly completed and students who do not complete the test lose points for the problems they did not have time to attempt. When feasible, future researchers should attend to the number of problems completed as another outcome measure for determining the influence of stereotype threat on performance.

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