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Women's Mental Rotation Abilities as a Function of Priming

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Abstract

This study examined how verbal priming of success or failure words influenced the Mental Rotation (MR) performance of women under stereotype threat. Women athletes and non-athletes (*N* = 67) completed several MR tasks after doing a word scramble that included positive or negative sports terms. The MR performance of athletes was diminished in relation to that of non-athletes when primed with negative sports-related actions. Negative primes also enhanced the performance of non-athletes in relation to their peers who had positive primes, but there were no differences in MR performances under positive priming. Thus, those who identified with a group experienced threat that negatively impacted performance, but non-athletes were unlikely to have been affected by evaluative performance concerns.

Keywords

Mental Rotation, Women's Cognitive Abilities, Stereotype Threat

1. Introduction

Individuals are often concerned about how their performance and behavior may reflect poorly on members of the groups with which they claim membership, a phenomenon termed *Stereotype Threat* (ST; Steele, 1997). In order for ST to occur people must associate themselves with a group and be aware of the group stereotype (Shapiro & Williams, 2012). People who belong to a group that is the target of stereotypes may fear that they will "confirm" the negative images of that group, often failing to perform to their abilities on various tasks (Shapiro & Williams, 2012). While threat can hinder cognitive performances among people for whom stereotypes are well-known (e.g., race, sex), threat can also diminish performance in athletics (Stone, Lynch, Sjomeling, & Darley, 1999), academics (Schmader, 2002), and with mental rotation (Brownlow, Valentine, & Owusu, 2008). Thoughts about being a failing representative of the group can prevent focus on the task in question (McIntyre,

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Paulson, & Lord, 2003), a problem that is likely compounded by an increase in physiological arousal (O'Brien & Crandall, 2003).

Many studies of ST have focused how ST impinges on women's ability with STEM-related tasks (Carr & Steele, 2009), particularly mathematics. Women often underperform in mathematics in relation to men, perhaps because people believe that men are superior to women in mathematics even though that is not the case (Else-Quest, Hyde, & Linn, 2010). Performance is improved when the threat is removed, and there are several ways that can be accomplished. For example, women can be directed to focus on the positive achievements of women like themselves (Gresky, Ten Eyck, Lord, & McIntyre, 2005; Schmader, Johns, & Forbes, 2008), reminded that they are superior research participants (McIntyre et al., 2003), told that others have purportedly found the tasks to be easy (Brownlow, Janas, Blake, Rebadow, & Mellon, 2011), or be led to think that a test is being used for non- diagnostic reasons (Gonzalez, Blanton, & Williams, 2002). In such cases, women perform on par with men, demonstrating that ST is a key factor in diminishing potential accomplishment.

Stereotype threat may also hinder performance on *Mental Rotation* (MR), a cognitive skill that involves the manipulation and transformation of three-dimensional objects in one's mind (Voyer, Voyer, & Bryden, 1995). Men, on average, rotate three-dimensional target objects more accurately than women (Cherney & Collaer, 2005; Maeda & Yoon, 2013). However, MR capability is not fixed, as several environmental and experiential factors negatively influence women's abilities. Factors that decrease successful MR performance include presumed experimenter evaluation (Brownlow et al., 2011), lack of reward (Kanoy, Brownlow, & Sowers, 2012), mentioning the phrase "rotation tasks" during recruitment (Sharps, Price, & Williams, 1994), a background deficient in relevant experience (Cherney, 2008; Uttal et al., 2013), and explicit directions to be accurate rather than to finish on time (Scali, Brownlow, & Hicks, 2000).

MR performance may also be enhanced by athletic experience. Athletic participation sharpens mental imagery because athletes need to locate current and future positions of objects, targets, and people, and then respond through kicking, shifting, throwing, batting and so forth (Ozel, Larue, & Molinaro, 2004). Moreover, regular practice routines for athletes necessitate use of imagery and rotation, skills that are used further during competition. Some research shows that athletes perform MR better (faster and more accurately) than others (Ozel et al., 2004), and that some athletes (especially "ball" sport players) are particularly adept with MR (Voyer & Isaacs, 1993). Despite the linked abilities, ST is sufficiently strong enough even in men athletes that they underperform *despite* this knowledge (Balentine & Brownlow, 2006), owing to the idea that they may be representing their group.

Because ST has a cognitive component, reducing ST about women's spatial skills may be a function of removing the disruptive cognitive component or by introducing a positive one. *Priming* can activate sets of beliefs and subsequent behaviors and do so implicitly, without the explicit cognitive understanding on the part of a primed target (Bargh, Chen, & Burrows, 1996). So, for example, people who are primed to think of elderly persons subsequently tend to walk slower; those who think of disabled persons tend to request help on tasks (Chambon, 2009). Moreover, priming people (both women and men) to think about stereotypical women's characteristics and behaviors results in lowered performance on spatial tasks (Ortner & Sieverding, 2008), and priming athletes with negative achievement-imagery can decrease motor-skill precision on well-rehearsed tasks (Ashford & Jackson, 2010).

In sum, priming can have a deleterious effect on performance, but priming may potentially lead to success. If people are primed to think about experiences that were successful, the chances of getting something right or doing it well may improve. We therefore examined the influence of positive- and negative-sports primes on the MR abilities of women athletes and non-athletes. We hypothesized that the MR ability of women athletes after positive priming would be higher in comparison to those athletes who were primed negatively.

2. Method

2.1. Participants and Design

Participants were 67 women, 32 of whom were on a sports roster at a NCAA Division II college at the time of the experiment. The athletes came from various sports (mostly "ball" sports: softball, volleyball, lacrosse, basketball, soccer). The 35 participants deemed "non-athletes" had never played college-level sports. Each either volunteered or received partial course credit for participation.

The athlete/non-athlete participants were primed with either positive- or negative words denoting spatial rota-

tional images (e.g., catch vs. fumble). The manipulations resulted in a 2 × 2 (Athlete Status × Priming) design. All provided informed consent before participation according to the research protocol approved by the Institutional Review Board.

2.2. Materials and Measures

Following the procedure of Bargh et al. (1996), participants unscrambled 25 six-word groups and then placed the words in a 5-word sentence. For 35 of the participants several positive words related to sports (e.g., gold, trophy, touchdown) appeared; for the remainder negative words (e.g., penalty, foul, bronze) were in the word groups.

Participants also completed two rotation tests: the Vandenberg and Kuse Mental Rotations Test (VKRT; Vandenberg & Kuse, 1978) and the Purdue Visualization Rotations Test (PVRT; Bodner & Guay, 1997). On the VKRT, a figure was shown with four possible rotations; two were correct; there were eight total rotations to complete. The PVRT showed a three-dimensional shape paired with a version of the shape rotated along *two* orientations (e.g., left and up). Another shape was shown and participants chose the analogous rotation from five options.

2.3. Procedure

We told participants that they were to complete tasks of various sorts. After obtaining consent, our participants completed the scrambled sentence tasks (the prime), taking as much time as they needed. Then, participants completed the rotations, which we presented in one of two counterbalanced orders across experimental conditions. Dependent measures were time to complete the tasks (in *s*) and correct rotations (termed *performance*), which was a count of number correct on the PVRT and the VKRT, minus the number of incorrect items to adjust for guessing (see Goldstein, Haldane, & Mitchell, 1990). After students finished their tasks they confirmed whether they had status on a roster for one of the College's sports teams.

2.4. Data Analyses

Both measures (performance and time) were normally distributed (Shapiro-Wilk's statistic for each was <1) and Levene's test indicated equality of variances for each, both *F*s (3, 63) < 1.10. Thus, each measure was separately entered in a 2 × 2 (Athlete Status × Priming) ANOVA to test the hypothesis. Level of significance was set *a priori* at $p \leq .05$.

3. Results

MR performance was entered as the dependent measure in a 2 × 2 (Athlete Status × Priming) ANOVA, the means and *SD*s from which are located in **Table 1**. Neither main effect was significant, both *F*s (1, 63) < 1, *ns*. The interaction effect from the ANOVA on MR correct was significant and produced a small effect, F (1, 63) = 3.97, p = .05, η_p^2 = .06. Post-hoc Tukey tests (alpha = .05) revealed that, contrary to the hypothesis, athletes performed similarly regardless of type of priming; however, non-athletes performed similarly to athletes under positive priming, but negatively-primed athletes (M = 2.93, SD = 7.92) performed significantly worse than negatively-primed non-athletes (M = 8.71, SD = 8.21). Additionally, non-athletes under negative priming also outperformed their non-athlete peers under positive priming (M = 3.11, SD = 7.55).

Table 1. Means and SDs for MR performance measures as a function of priming procedure.

	Stereotype Threat Priming Condition		
	Positive	Negative	Total
MR score—athlete	5.53 (9.71)	2.93_a (7.92)	4.31 (8.87)
MR score—nonathlete	3.11_a (7.55)	8.71_b (8.21)	5.83 (8.27)
MR score—total	4.29 (8.62)	6.00 (8.47)	
Time in sec.—athlete	607.47 (221.78)	660.53 (181.91)	632.34_a (204.65)
Time in sec.—non-athlete	534.89 (168.47)	491.06 (164.61)	513.60_b (165.64)
Time in sec.—total	570.14 (198.61)	570.50 (190.56)	

Note: Means with different subscripts within each dependent measures are significantly different, $p < .05$.

A 2 × 2 (Athlete × Prime Type) ANOVA on time-to-complete the task (measured in *s*) revealed a main effect for athletic status, F (1, 63) = 7.02, p = .013, η_p^2 = .10. Athletes (M = 632.34, SD = 204.65) took longer at the MR task than did non-Athletes (M = 513.60, SD = 165.64). No other effects (main, interaction) were significant, Fs (1, 63) ≤ 1.13, all ps ≥ .29.

4. Discussion

The results indicated that the priming manipulation did not lead to different MR performances in women athletes, but that non-athletes outperformed athletes when negatively primed and also outperformed their peers who were positively primed. Regardless of whether the athletic terms were positive or negative, words relating to athletics may have made salient athletic identity for the athletes and thus providing important meaning for them that resulted in poor performance (as in Brownlow et al., 2008). Low performance for the athletes may have been a function of evaluation apprehension or intrusive thoughts about letting their group down (McIntyre et al., 2003). Athletes may have experienced self-imposed self-concept and group threat when faced with a difficult but possible task (Shapiro & Williams, 2012), even though the positive terms should have reminded them about the positive aspects of their group-related abilities (see Schmader et al., 2008). Thus, any sports cues may have created a threat in the air for athletes.

Athletes and non-athletes did not perform differently when they were primed with positive sports cues, but non-athletes performed better when primed with negative sports cues. Perhaps challenge, rather than threat, was present for non-athletes when primed negatively; they had no reason to feel stereotype threat. Research has shown that in order for stereotype threat to occur people must associate themselves with a group and be aware of a group stereotype (Shapiro & Williams, 2012). Consequently, when people become a part of a group, the group becomes a part of their self-concept which may result in self-concept threat and group threat when exposed to stereotypic conditions. The findings on time to complete the task suggest that the athletes did notice the manipulation. Overall, athletes took longer to complete MR tasks than non-athletes, concurrent with past research that indicated that time to complete tasks is a crucial component in measuring the inhibiting effects on performance of stereotype threat (Stone et al., 1999). Athletes may identify so strongly with their group that they draw conclusions about their ability to complete MR based on their athletic experiences. When expectations and performance are not in synch the athletes may experience distress that leads to a poorer performance (McIntyre et al., 2003).

5. Conclusion

While the results add to our knowledge of how ST can influence performance under certain conditions, the effect was only a small one, and then not in the predicted direction. It is possible that some of those classified as non-athletes had exposure to sports at some point in their lives, and may have been athletes previously or they may have considered themselves athletic. Thus, the manipulation of college athletic status may not be a key to showing effects priming on ST-based performances. Future research should delineate more clearly athletic status as a part of the self-concept in order to examine how sports-related priming of any sort may be beneficial or detrimental to spatial performances.

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