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# Arts versus science — Academic background implicitly activates gender stereotypes on cognitive abilities with threat raising men's (but lowering women's) performance

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ABSTRACT

There is ongoing debate as to whether "innate" cognitive sex differences contribute to the underrepresentation of women in science and engineering careers. Decades of gender research have revealed good evidence that both biological (e.g. sex hormones) and socio-cultural factors (e.g. gender stereotypes) contribute significantly to cognitive sex differences. Research on gender stereotypes has revealed that priming gender can have adverse or beneficial effects on cognitive performance, depending on whether primed participants appraise the testing situation as threatening or challenging. Several contextual factors have been investigated in this respect. Despite the debate on women in STEM disciplines, however, surprisingly little attention has been paid to academic discipline as a potentially relevant contextual factor. The present study investigated whether gender stereotypes affect cognitive sex differences differently in STEM (chemistry, engineering) and arts (English, philosophy) students. In Experiment 1, male and female arts and science students were tested on two sex-sensitive cognitive tests (mental rotation and verbal fluency) after gender stereotypes were activated. In Experiment 2, arts versus science stereotypes were activated. It was hypothesized that beliefs linked to gender and academic discipline are strongly associated (science = male, arts = female) with similar cognitive effects. Regardless of which identity is primed, it was hypothesized that female arts students would be particularly vulnerable to stereotype threat and would show the lowest performance of all groups in a male cognitive domain (i.e., mental rotation). Due to men's higher confidence in their cognitive abilities, it was hypothesized that primed men would show a performance increase in both spatial (stereotype lift) and verbal abilities (stereotype reactance). The results supported these hypotheses. The two experiments suggest that prompting participants' academic discipline implicitly activated gender stereotypes with considerable negative consequences for women's cognitive test performance. The results also suggest that the well-known sex difference in mental rotation (with men outperforming women) primarily occurs when negative stereotypes about women's spatial abilities are implicitly primed.



## 1. Introduction

The number of women in science, technology, engineering, and mathematics (commonly abbreviated as STEM) has significantly increased over the past years. However, women still remain the minority in STEM disciplines and the disparity widens along the educational–vocational continuum, starting at school and gradually increasing during professional (academic) life (Halpern et al., 2007). There is an ongoing debate as to the source of this disparity and there seems to be a tenacious belief that "innate" sex differences in cognitive abilities may partly account for it, or at least that these differences can partly

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explain why significantly fewer females than males appear at the upper end of higher cognitive abilities that are required in STEM areas (e.g. Summers, 2005, January 14).

Although cognitive performance of both sexes overlaps to a large extent, several meta-analyses have revealed that, on average, men perform better than women in specific spatial task abilities (Linn & Petersen, 1985; Masters & Sanders, 1993; Voyer, Voyer, & Bryden, 1995), particularly in mental rotation (Peters et al., 1995; Vandenberg & Kuse, 1978). In contrast, women perform better, on average, in specific aspects of verbal abilities, such as verbal fluency or verbal memory (Hyde & Linn, 1988; McGlone, 1980). The origins of these cognitive sex differences are still not fully understood (Halpern, 2000). Although there is no doubt that sex hormones and sexual brain dimorphisms contribute to sex differences in specific cognitive abilities, it is also clear that social priming, and especially gender stereotypes can significantly affect men's and women's cognitive performance (e.g. Hausmann, Schoofs, Rosenthal, & Jordan, 2009; Hirnstein, Freund, & Hausmann, 2012). In fact, gender stereotypes might be a central variable in environmental influences on sex differences in intelligence (Halpern & LaMay, 2000).

There is broad evidence that social priming can automatically affect individual's behavior, regardless of whether participants are aware of the potential influence of the priming event on their behavior or not (e.g., Bargh, Chen, & Burrows, 1996). An important field of research has investigated the effects of primed stereotypes, usually related to race and gender, on cognitive behavior, such as quantitative skills, spatial cognition, and verbal abilities.

Whether stereotype priming has adverse or beneficial effects on cognitive performance depends on whether participants appraise the testing situation as threatening or challenging. For example, when women were told that a math test consistently shows pronounced sex differences, women's test performance declined, while the same test did not reveal sex differences when introduced as gender-neutral (Spencer, Steele, & Quinn, 1999). Similarly, several studies found that women scored lower in mental rotation tests when they were told that men perform generally better in spatial abilities than women (Moè, 2012; Moè & Pazzaglia, 2006; Wraga, Helt, Jacobs, & Sullivan, 2007). In contrast, cognitive performance improved when participants were confronted with either positive stereotypes about their own group identity or negative stereotypes about the group to which they were compared (e.g., Shih, Pittinsky, & Ambady, 1999; Walton & Cohen, 2003). For example, women showed enhanced performance in mental rotation tests, when they were told that these tests measure perspective-taking abilities in which they were superior to men (Heil, Jansen, Quaiser-Pohl, & Neuburger, 2012; Moè, 2009; Wraga, Duncan, Jacobs, Helt, & Church, 2006; Wraga et al., 2007).

Adverse and beneficial effects of stereotype priming even occurred when the priming cue to group identity was less salient. Shih et al. (1999) investigated the effects of implicit stereotype priming in Asian American female undergraduates. The researchers primed negative stereotypes related to gender (e.g., women have inferior quantitative skills compared with men) and positive stereotypes related to ethnic identity (e.g., Asians have superior quantitative skills compared to other cultures) by asking participants whether they preferred single-sex floors in their college, and whether their grandparents spoke any language other than English. The results revealed that participants' quantitative skills were altered in the direction predicted by the stereotype associated with gender and ethnic identity.

However, participants' cognitive performance after stereotype priming does not always follow the direction predicted by the stereotype. Many studies have struggled to replicate the 'classic' stereotype threat or reported effects opposite to the direction predicted by the stereotype (e.g., Picho, Rodriquez, & Finnie, 2013, for a review). The diverse effects of stereotype priming can be summarized as follows: If individuals are afraid of confirming a negative stereotype, cognitive performance can decline — a phenomenon called 'stereotype threat' (Steele & Aronson, 1995). In contrast, if confronted with a positive stereotype about the individual's group identity, cognitive performance can improve slightly ('stereotype lift'; Walton & Cohen, 2003) or significantly ('stereotype boost'; Shih, Ambady, Richeson, Fujita, & Gray, 2002; Shih et al., 1999). Cognitive performance can also improve when confronted with a negative stereotype about an out-group ('stereotype susceptibility', Walton & Cohen, 2003), or when a negative stereotype about the in-group is appraised as challenging—termed 'stereotype reactance' (Kray, Thompson, & Galinsky, 2001). Stereotype reactance was found especially when stereotypes were explicitly primed. "When a negative stereotype is blatantly and explicitly activated, it might be perceived by the test taker as a limit to their freedom and ability to perform, thereby ironically invoking behavior that is inconsistent with the stereotype" (Nguyen & Ryan, 2008, p. 1315).

Underlining the highly situational character of stereotype threat (Steele, 1997), it has been shown that degree and direction of stereotype priming effects can be mediated by various psychological factors (e.g., gender identification, Schmader, 2002; stigma consciousness, Brown & Pinel, 2003) and contextual factors (e.g., sex composition, Hirnstein, Andrews, & Hausmann, in press; Inzlicht & Ben-Zeev, 2003; Murphy, Steele, & Gross, 2007; type of priming, Bargh, 1997; test difficulty, Inzlicht & Ben-Zeev, 2003; domain identification, Cadinu, Maass, Frigerio, Impagliazzo, & Latinotti, 2003; academic domain (STEM vs. non-STEM, Crisp, Bache, & Maitner, 2009; Werhun, 2007). Two recent meta-analyses estimated the effect sizes of these contextual factors on stereotype threat and found that on average, women under stereotype threat performed nearly a quarter of a standard deviation ($d = -0.24$, Picho et al., 2013; $d = -0.21$, Nguyen & Ryan, 2008) below their non-stereotyped counterparts on math tests. While this effect size was only marginally affected by, for example, sex composition (i.e., same-sex groups: $d = -0.22$, mixed-sex groups: $d = -0.26$) and type of priming (implicit: $d = -0.28$; explicit: $d = -0.23$), Picho et al. (2013) revealed that academic domain had differential stereotype threat effects on quantitative skills in STEM ($d = 0.06$) vs. non-STEM undergraduate students ($d = -0.25$). However, only a very few studies have looked at academic domain as a mediating factor. This is surprising given the ongoing debate on the underrepresentation of women in science disciplines, and attempts to enhance women's performance in STEM disciplines. One of these studies (Crisp et al., 2009) investigated the effect of negative stereotype priming on quantitative skills in 39 female psychology and engineering majors. This study found that whereas female undergraduate psychology students