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Are males always better than females in mental rotation? Exploring a gender belief explanation

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Abstract

Males outperform females in the Mental Rotation Test (MRT) for biological, strategic and cultural reasons. The present research tested a motivational explanation with the hypothesis that females could do better when induced to have positive beliefs and expectations. All-female and all-male samples were divided into six groups, each having listened to different instructions: 1. men are better than women at this task; 2. women are better than men; 3. control instructions with no gender reference. Each group was further allocated to either the easy or the difficult task expectations condition. Experimental manipulation affected performance differently in relation to gender. Women's performance was affected by positive instructions about gender. Men were affected by instructions about the task difficulty. Women improved performance and reached men's scores in the MRT when they were led to believe they were better than men.

Keywords: Mental rotation; Stereotyped attitudes; Gender beliefs

1. Introduction

Mental rotation is a spatial task that involves the ability to mentally retain an object and rotate it in space. This ability is important for academic achievement given its supposed ability to predict success in topics such as geometry, mathematics, chemistry and physics; and for everyday spatial activities, such as orientation in unfamiliar places or finding a route on a map (Casey, 1996; Linn & Petersen, 1986).

The most frequently used assessment questionnaire is the mental rotation test (MRT) developed by Vandenberg and Kuse (1978). This consists of twenty graphic representations of a target three-dimensional object on the left (a 10-block figure with three angles); two rotated versions; and two distractors on the right (e.g. Fig. 1). The participants have to select in a limited time period the two correct answers, i.e. the rotations corresponding to the target object.

A male superiority has been extensively demonstrated in this task, greater than that observed in other spatial tasks (for a review see Voyer, Voyer, & Bryden, 1995). It emerges very early and is stable across life (Linn & Petersen, 1985).

Many explanations have been proposed.

The first explanation is biological. Gender differences in mental rotation could depend on hormonal factors or on hemispheric specialization and brain organization. Research showed that finger-length ratios, a measure of prenatal androgen levels exposure, correlate with MRT scores (Burton, Henninger, & Hafetz, 2005), whereas the effect appears to be significant in men, but not in women (Sanders, Bereczkei, Csatho, & Manning, 2005). The levels of circulating testosterone affect the performance in spatial tasks (Driscoll, Hamilton, Yeo, Brooks, & Sutherland, 2005) following an inverted-U shape function, where a high performance correlates with high testosterone levels in women and low testosterone levels in men (e.g. Geschwind & Galaburda, 1987; McKeever & Deyo, 1990; Nyborg, 1983). Moreover, using an fMRI technique differences in activation have been found between males (Alivisatos & Petrides, 1997) and females (Richter, Ugurbil,

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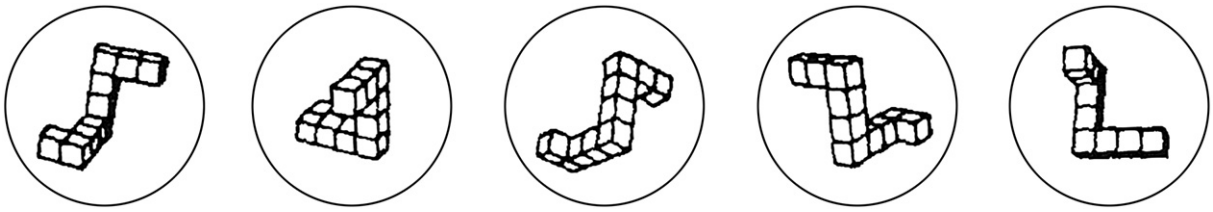

Fig. 1. A sample Mental Rotation item. Correct answers: the first and third.

Georgopoulus, & Kim, 1997). In performing mental rotation tasks there is evidence of an activation in the motor area, but women show bilateral processing both in verbal and in spatial tasks such as mental rotation (Howard, Fenwick, Brown, & Norton, 1992).

The second explanation is strategic. MRT can be performed using either holistic–spatial (e.g. rotate the target until it overlaps with the alternative stimulus) or analytic–verbal (e.g. counting blocks) strategies (Shepard & Metzler, 1971). Holistic strategies are more effective and preferred by males as demonstrated by using a selective interference paradigm (Pezaris & Casey, 1991) and more recently with an fMRI technique (Jordan, Wuestenberg, Heinze, Peters, & Jaencke, 2002). Given that females use less effective strategies than males, they attempt fewer items (Peters, 2005). When time pressure is stressed females attempt to resolve a higher number of items, but their accuracy does not improve, suggesting they are guessing (Cherney & Neff, 2004). In fact, guessing is defined by a high number of items containing a wrong response, while reluctance to guess is defined by a high proportion of blank responses (Voyer, Rodgers, & McCormick, 2004; Voyer & Saunders, 2004). Consequently, when more items are attempted but there is no increase in accuracy it is possible to argue that participants are guessing. When given unlimited time to finish the task, females perform as well as males (Scali, Brownlow, & Hicks, 2000), but this result is controversial. For instance, recently Peters (2005) found that, when the standard time allowed is doubled, females solve more problems, but the same is true for males, so the magnitude of the gender difference, measured through Cohen *d*, is not reduced.

The third explanation lies in the spatial experience. The role of prior exposure to spatial tasks (computer, video-games, and some sports) is important (Cherney & Neff, 2004). Prior performance of spatial tasks may have increased women's self-confidence and the knowledge of effective strategies for mental rotation (Casey, Nuttall, & Pezaris, 1997). Ginn and Pickens (2005) found that experience with spatial activities (e.g. participating in basket-ball, volleyball or being music performance majors or engaged in artistic activities) increases the mental rotation performance. Richardson (1994) found that gender differences in mental rotation performance can be reduced by educational experience. Casey, Nuttall, and Pezaris (1999) proposed a biological environmental interaction model following which only girls with a biological aptitude for spatial thinking, given by an inherited right-shift factor rs + −, i.e. right-handed with at least one first-degree relative left-handed or ambidextrous (Annett, 1995), improve their spatial abilities with experience.

Recently, a motivational explanation based on a stereotype threat effect has been put forward (Moè & Pazzaglia, 2006). The stereotype threat is the fear of confirming a stereotype about the group to which one belongs (Steele, 1997; Steele & Aronson, 1995). When a negative gender belief is aroused by the test instructions or by presenting the test as diagnostic of specific abilities, participants tend to under perform. This can be due to fear of failure (Steele, 1997), disengagement, intrusive thoughts (Cadinu, Maass, Rosabianca, & Kiesner, 2005), anxiety (Osborne, 2001), negative expectations (Cadinu, Maass, Frigerio, Impigliazzo, & Latinozzi, 2002), reduced working memory capacity (Schmader & Johns, 2003), increased mental load (Croizet et al., 2004) or heightened arousal (Ben-Zeev, Fein, & Inzlicht, 2005).

Research has found a number of mediators of the stereotype threat effect (for a review see Maass & Cadinu, 2003). Among these, in the present research, expectations about the difficulty of the task will be considered. A task presented as difficult can create a challenging situation that can motivate, or be a threat to one's abilities, thereby decreasing motivation and performance depending on perceived abilities, goals, and achievement motivation (e.g. Atkinson, 1964; Dweck, 1999). In the stereotype context it is possible that a task presented as difficult can create an additional pressure and hence produce a decrement in performance or, alternatively, following an attributional perspective, encourage the subject ('It isn't my fault: the task is difficult') (Weiner, 1985).

Stereotype threat effects on performance can be reduced by shaping an incremental theory of intelligence (Aronson, Fried, & Good, 2002) or through self-affirmation in an unrelated domain (Martens, Johns, Greenberg, & Schimel, 2006). Self-affirmation consists in affirming a valued characteristic that is not under threat before taking the test (Steele & Liu, 1983). Providing that the stereotype threat comes from a threat to self-integrity, self-affirmation can reduce the stereotype threat through an increase in self-esteem, boosting the sense of competence, integrity and self-worth and by reducing the fear of failure (Koole, Smeets, van Knippenberg, & Dijkesterhuis, 1999).

Positive effects due to stereotyping, known as stereotype lift (Walton & Cohen, 2003) or stereotype susceptibility (Shih, Ambady, Richeson, Fujita, & Gray, 2002; Shih, Pittinsky, & Ambady, 1999) has also been found. Stereotype lift occurs when an out-group is explicitly negatively stereotyped (e.g. men are told than women do worse) causing an enhancement in performance, probably due to an increase in self-efficacy (Bandura, 1997). It focuses on non-stereotyped groups (e.g. men for spatial abilities). Stereotype susceptibility is the performance boost caused by activation of a positive in-group stereotype (e.g. men are instructed men do better). The magnitude of the stereotype lift, measured through Cohen *d*, is half that of the stereotype susceptibility, probably because stereotype lift works by