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Mental rotation, targeting ability and Baron-Cohen's Empathizing–Systemizing Theory of Sex Differences

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ABSTRACT

Sex differences on such tasks as Vandenberg's mental rotation and skilled targeting are well established with men showing performance advantages compared to women. Baron-Cohen's Empathizing–Systemizing Theory of Sex Differences (E/S theory) suggests that male and female brains adopt different cognitive biases with male brains 'systemizing' and female brains 'empathizing'. We explored the relation between abilities that typically demonstrate male advantages and performance on Systemizing Quotient (SQ), Empathizing Quotient (EQ) and 'Reading the Mind in the Eyes' (RMET). We hypothesized men should demonstrate superior performance on targeting, MROT and SQ task/questionnaire and that women should demonstrate superior performance on EQ and RMET. Significant sex differences were found for SQ, EQ, targeting and MROT, but not for RMET. Regression indicated that MROT was significantly predicted by higher SQ, lower EQ and unexpectedly, higher RMET scores. Regression indicated that individuals high in EQ and low in SQ were less accurate on the targeting task with their dominant hand, although high SQ individuals tended to be more accurate on targeting with their non-dominant hand. No relation between targeting and RMET scores was found. Thus, the E/S theory provides predictive power for spatial tasks that typically show male advantages.

1. Introduction

Humans exhibit large male advantages on some tasks of spatial ability, such as mental rotation (e.g. Collins & Kimura, 1997; Vandenberg & Kuse, 1978) or those measuring the ability to hit targets with a projectile, or 'targeting' (Watson & Kimura, 1991). The male advantage in mental rotation (MROT) and targeting is large, with effect sizes often approaching a full standard deviation (Voyer, Voyer, & Bryden, 1995). There are numerous theories as to why these differences occur, including differences in exposure to sex hormones *in utero* (e.g. Manning, 2002), differences in selection pressures in human prehistory (e.g. Darlington, 1975), and fundamental differences in approach to understanding the environment (e.g. Baron-Cohen, 2003).

The 'Empathizing–Systemizing Theory of Sex Differences' (E/S theory) hypothesizes that male and female brains adopt different approaches to understand the world (Baron-Cohen, 2003). Male brains 'systemize' and are driven to understand the basic rules and laws that govern a system. Female brains 'empathize' and are driven to understand and predict emotions in another person. These tendencies may reflect evolutionary pressures that humans faced during prehistory, including division of labour between the sexes for hunting/navigation and childcare (Baron-Cohen, 2008; Ecuyer-Dab & Robert, 2004).

Several different measures assess the degree to which individuals empathize or systemize, including the Systemizing Quotient (SQ) (Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003; Wheelwright et al., 2006) and the Empathizing Quotient (EQ) (Baron-Cohen & Wheelwright, 2004). Both the EQ and SQ have high internal consistency and factor analyses confirm that they are independent (Wakabayashi et al., 2006). Typically, men score more highly on SQ than women, whereas women score more highly on the EQ than men (Voracek & Dressler, 2006; Wakabayashi et al., 2007), although we note that these are group differences and that individuals may score highly on either regardless of sex. The sex differences in EQ and SQ performance are observed cross-culturally (e.g. Baron-Cohen et al., 2003; Berthoz, Wessa, Kedia, Wicker, & Grezes, 2008; Wakabayashi et al., 2007), suggesting that these are stable measures.

If performance on SQ reflects an approach to understanding the world that is consistent with a male brain, then perhaps high SQ individuals may perform better on tasks that exhibit a male advantage, such as MROT and targeting. Similarly, if performance on EQ reflects an approach to understanding the world that is consistent with a female brain, then high EQ individuals may perform more poorly on these same tasks. We note that although targeting and rotation both exhibit male advantages and both are presumed to

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reflect sexual selection pressure faced by males (e.g. Ecuyer-Dab & Robert, 2004), Voyer et al. (1995) observed that these tasks measure different aspects of spatial ability. Thus, performance on rotation and targeting were tested and considered separately.

Baron-Cohen and colleagues have also developed a secondary questionnaire called 'Reading the Mind in the Eyes' (RMET) that assesses how well an individual can judge the emotional quality of different expressions by looking at the eyes only (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). The ability to judge the emotional state in another is a component of empathizing, with a positive relationship between RMET and EQ scores (Lawrence, Shaw, Baker, Baron-Cohen, & David, 2004; Voracek & Dressler, 2006). Women sometimes outperform men on this questionnaire (Voracek & Dressler, 2006), although this is not always observed (e.g. Baron-Cohen et al., 2001, 2006). Thus, this measure was included to investigate possible relations between performance on this questionnaire, EQ, SQ and the two spatial tasks.

2. Experiment 1: Rotation

2.1. Rationale

Baron-Cohen's E/S theory (2003) suggests that male and female brains exhibit different biases that reflect the means by which they solve problems and interact with the world (Wakabayashi et al., 2006). As MROT is a male-advantaged task, this experiment sought to examine whether performance on MROT (Vandenberg & Kuse, 1978) was predicted by EQ, SQ and RMET. We hypothesized that high scores on the SQ questionnaire should predict good MROT performance and that high scores on the EQ and RMET questionnaires should predict poorer MROT. We predict that EQ will be positively related to RMET and that the typically observed sex differences will be observed for each of the individual tasks/questionnaires.

2.2. Materials and methods

2.2.1. Participants

For this experiment, 97 participants were enrolled in the study (52 women). Participants who were taking psychoactive medication or who did not speak English as their first language were excluded ($n = 9$, 6 women). The remaining 88 participants were predominantly right-handed (81 were right-handed; 42 women); 7 were left-handed (3 women). The mean age of the participants was 22.220 (s.d. = 5.672 years, range 17–37 years). All had normal or corrected to normal vision. Participants were undergraduates at the University of Lethbridge and received compensation (either $5 CAD or course credit) for taking part in the experiment. The University of Lethbridge Human Subjects Research Committee approved this study.

2.2.2. Systemizing Quotient (SQ)

The SQ questionnaire consisted of 75 statements (Baron-Cohen et al., 2003; Wheelwright et al., 2006), to which participants responded using a 4-point Likert scale ('strongly disagree', 'slightly disagree', 'slightly agree', and 'strongly agree'). Participants received 2 points for displaying a 'strongly' systemizing response and 1 point for 'slightly' displaying a systemizing response (maximum score = 150; minimum score = 0).

2.2.3. Empathizing Quotient (EQ)

The EQ questionnaire consisted of 60 statements (Baron-Cohen & Wheelwright, 2004), to which participants responded using the same 4-point Likert scale as the SQ questionnaire. Participants received 2 points for displaying a 'strongly' empathizing response and 1 point for 'slightly' displaying an empathizing response (maximum score = 80; minimum score = 0).

2.2.4. Reading the Mind in the Eyes Test (RMET)

The RMET questionnaire (Baron-Cohen et al., 2001) consisted of 36 pictures of the eye region of the face. Participants selected one word from a list of four that 'best describes what the person in the picture is thinking or feeling'. Participants could consult a glossary that defined the words on the questionnaire. Participants received one point for each correct item, with no penalty for guessing (maximum score = 36; minimum score = 0).

2.2.5. Mental Rotations Test (MROT)

In this task, participants chose two of four 3-dimensional figures that matched a target figure (Vandenberg & Kuse, 1978). The four alternatives were rotated, thus participants had to covertly rotate the target to determine a match. There were 12 items and participants had 4 min to complete the task. For each item, participants received one point for correct choices and a 1 point penalty for incorrect choices (maximum score = 24; minimum score = 0).

2.2.6. Procedure and statistical analysis

Participants provided informed consent and then completed a demographic questionnaire that assessed handedness (Elias, Bryden, & Bulman-Fleming, 1998), languages spoken, medications currently taken, year and area of study. The order of the remaining tasks/questionnaires was randomly assorted among participants. Statistical analyses were carried out using SPSS 17.

2.3. Results

2.3.1. Sex differences

As predicted, men had significantly higher scores than women on MROT, $t(86) = 2.477$, $p = .015$, $1 - \beta = .688$, $d = .543$ and SQ, $t(86) = 3.514$, $p < .0001$, $1 - \beta = .935$, $d = .712$, whereas women had significantly higher scores on EQ, $t(86) = -4.501$, $p < .0001$, $1 - \beta = .994$, $d = .983$ (Table 1). Although the means were in the direction predicted, no significant sex differences were found for the RMET, $t(86) = -1.327$, $p = .188$, $1 - \beta = .259$, $d = .269$ (Table 1).

2.3.2. Regression and partial correlation analyses

A forced regression was performed using the MROT performance as the criterion and RMET, SQ and EQ scores as predictors. The overall model was significant, $R^2 = .267$, $F(3, 84) = 10.191$, $p < .0001$, with scores on EQ, $\beta = -.354$, $t(84) = -3.553$, $p < .001$, SQ, $\beta = .235$, $t(84) = 2.482$, $p < .05$, and RMET, $\beta = .473$, $t(84) = 4.795$, $p < .0001$, as significant predictors.

Considering the strong sex difference on mental rotation ability, the forced regression was also conducted separately for each sex. For men, the model was significant, $R^2 = .388$, $F(3, 38) = 8.016$, $p < .0001$, and performance on the EQ, $\beta = -.313$, $t(38) = -2.138$, $p = .039$, and RMET $\beta = .620$, $t(38) = 4.751$, $p < .0001$, were significant predictors. The regression model was not significant for

Table 1
Means (s.d.) for the performance on the EQ, SQ, RMET questionnaires and MROT task.

Task/questionnaire	Men	Women
Mental rotation score*	12.070 (5.973)	8.910 (5.977)
Empathizing Quotient*	40.740 (10.205)	49.800 (8.679)
Systemizing Quotient*	66.690 (17.429)	53.200 (18.490)
Reading the Eyes in the Mind Test score	26.140 (3.771)	27.260 (4.101)

* Indicates a significant sex difference, $p < .05$.