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The influence of sex and empathy on putting oneself in the shoes of others

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We tested whether putting oneself in the shoes of others is easier for women, possibly as a function of individuals' empathy levels, and whether any sex difference might be modulated by the sex of presented figures. Participants ($N = 100$, 50 women) imagined (a) being in the spatial position of front-facing and back-facing female and male figures (third person perspective (3PP) task) and (b) that the figures were their own mirror reflections (first person perspective (1PP) task). After mentally taking the figure's position, individuals decided whether the indicated hand of the figure would be their own left or right hand. Contrary to our hypothesis, results from the 3PP-task showed higher rotational costs for women than men, suggesting that mental rotation rather than social strategies had been employed. However, faster responding by women with higher empathy scores would appear to indicate that some women engaged social perspective taking strategies irrespective of the figures' position. Figures' sex was relevant to task performance as higher rotational costs were observed for male figures in the 3PP-task for both sexes and for female figures in the 1PP-task for women. We argue that these latter findings indicate that performance was facilitated and/or inhibited towards figures associated with specific social and emotional implications.

Taking the perspective of another person is an important interpersonal function, thought to reflect a social cognitive ability (Adolphs, 2001; Brothers, 1990). One form of social perspective taking is empathy, the 'response more appropriate to someone else's situation than to one's own' (Hoffman, 1987, p. 48). While empathy is frequently considered to concern the emotional situation of another person, independent accounts distinguish between three main forms of empathy that can be identified as emotional, cognitive (theory of mind, ToM), and motor (mirror system) empathy (Blair, 2005). Although differences between these forms of perspective taking have been outlined (Blair, 2005), common to all forms is the ability to compare one's own perspective with that of another person. Indeed, studies have emphasized that emotional empathy

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reflects a form of general perspective taking ability (Davis *et al.*, 2004; Vogeley & Fink, 2003) and neuroscientific findings have shown that different forms of perspective taking might depend on a partially common, overlapping brain network (Agnew, Bhakoo, & Puri, 2007; Apperly, Samson, Chiavarino, & Humphreys, 2004; Blanke *et al.*, 2005; Frith & Frith, 2006; Saxe & Wexler, 2005; Schulte-Ruther, Markowitsch, Shah, Fink, & Piefke, 2008 for recent accounts).

The present study is concerned with potential sex differences in perspective taking ability. It has been suggested that the understanding of others' thoughts and feelings is a 'female' trait (Unger & Crawford, 1992). Girls as compared to boys are more often raised in ways favouring the understanding and expressing of emotions (Brown, Donelan-McCall, & Dunn, 1996; Cervantes & Callanan, 1998; Leaper, Anderson, & Sanders, 1998). Also, girls use mental-state terms (e.g. know, think, pretend) at a higher frequency than boys (Hughes & Dunn, 1998). Girls score higher than boys on both social and self-understanding tasks (Bosacki, 2000), and show a weak advantage in false belief tasks (Charman, Ruffman, & Clements, 2002). Beyond young age, women as compared to men show better performance in ToM tasks such as the 'mind in the eyes', or 'social faux pas' task (Baron-Cohen & Hammer, 1997; Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Carroll & Yung, 2006; but see Jarrold, Butler, Cottington, & Jimenez, 2000; Russell, Tchanturia, Rahman, & Schmidt, 2007), and score higher on self-report empathy questionnaires (Baron-Cohen & Wheelwright, 2004; Rueckert & Naybar, 2008; Schulte-Ruther *et al.*, 2008), potentially mediated by the right cerebral hemisphere (Schulte-Ruther *et al.*, 2008). Finally, Galinsky, Magee, Inesi, and Gruenfeld (2006) argue that perceived power (a trait more highly associated with the male than the female sex) diminishes an individual's need to engage in perspective taking. In support of this notion, high-power participants – with an enhanced perception of their own power – showed impaired perspective-taking inclinations and abilities relative to low-power participants (Galinsky *et al.*, 2006). Taken together, much evidence suggests that women might be better at 'putting themselves in the shoes of others' (e.g. Davies & Stone, 1995) than men.

The present study tested the hypothesis that women would outperform men when mentally taking the visuospatial perspective of another person. More specifically, participants were required to make right–left judgments about a schematic human figure. In the third person perspective (3PP) taking condition, participants indicated whether the marked right or left hand of the depicted human figures (Figure 1) would be their own right or left hand if they were in the spatial position of these figures (Arzy, Thut, Mohr, Michel, & Blanke, 2006; Blanke *et al.*, 2005; Mohr, Blanke, & Brugger, 2006; Zacks, Rypma, Gabrieli, Tversky, & Glover, 1999). Importantly, this task was found to dissociate neuronally from a task measuring mental rotation of objects (Blanke *et al.*, 2005). In the first person perspective (1PP) taking condition, participants were also required to perform left–right judgments, but while imagining that the figures were their own reflection in a mirror (Arzy *et al.*, 2006). Accordingly, both tasks required participants to perform mental own-body transformations, but from different perspectives. In the 3PP-task, participants were required to carry out the task from the perspective of another (third person), and in the 1PP-task, from their own (first person) perspective. On the assumption that the 3PP-task is more strongly related to 'social' perspective taking (perspective of other) as compared to the 1PP-task (perspective of self), we expected women to outperform men in the 3PP-task, but not in the 1PP-task.

In addition, we investigated the influence of the sex that was depicted in the schematic figures, i.e. whether it depicted a male or a female figure, on performance in

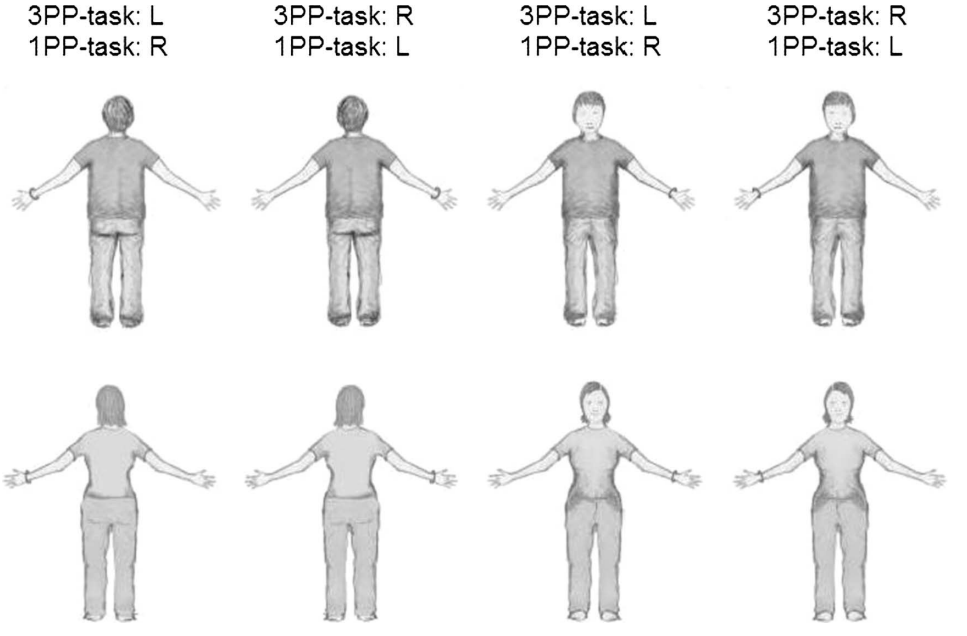

Figure 1. Male and female figures used in the mental own body transformation tasks. Always one hand is indicated by a black bracelet around the wrist. The correct answers are indicated with letters (R, right; L, left) for the 3PP-task and 1PP-task.

the 3PP- and 1PP-tasks. In face recognition tasks, some studies show women to perform better than men (Guillem & Mograss, 2005; Yonker, Eriksson, Nilsson, & Herlitz, 2003), in particular for female faces (Cellerino, Borghetti, & Sartucci, 2004; Ellis, Shepherd, & Bruce, 1973; Lewin & Herlitz, 2002; Rehnman & Herlitz, 2006), while others report a general same-sex advantage (Wright & Sladden, 2003). On the other hand, no same-sex advantage was reported in a study that tested memory for the appearance of others (Horgan, Mast, Hall, & Carter, 2004). The latter authors tested memory for appearance information of others, and found an overall advantage of female over male participants and an overall advantage for female over male figures. According to these findings, a same-sex advantage on the 3PP- and 1PP-tasks could be predicted, but also that women might have a general advantage in the processing of 'other' information, and that female figures might be more easily processed than male figures.

As a final question, we assessed participants' empathy with a validated empathy questionnaire (Baron-Cohen & Wheelwright, 2004). On the assumption that the 3PP-task is more related to social perspective taking than the 1PP-task, we expected that performance in the 3PP-task would improve with increasing empathy scores, and that this might be more pronounced for female as compared to male participants.

Method

Participants

One hundred healthy right-handed (Oldfield, 1971) undergraduate students (50 women) with a mean ($\pm SD$) age (in years) of 20.5 (2.9, range 18–39) took part in the study. None of the participants indicated (self-report) a previous neurological or psychiatric history.

Those who reported having consumed psychoactive substances within the last 2 months were excluded from the study. Prior to the experiment, which was approved by the local Ethical Committee of the University of Bristol, all participants provided written, informed consent. Participants were tested in groups of 5–10 participants in a classroom setting.

Empathy

Empathy was measured using the empathy quotient questionnaire (EQ; Baron-Cohen & Wheelwright, 2004). The EQ consists of 40 empathy and 20 filler items. Participants are instructed to respond on a four-point scale anchored from 'strongly disagree' to 'strongly agree'. Items include 'In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking' and 'It is hard for me to see why some things upset people so much'. Half of the target items are worded to elicit a 'disagree' response and the other half to elicit an 'agree' response when responding in an empathetic manner to avoid response biases. As done by Lawrence *et al.* (2004), we re-scored the 'disagree' items so that a higher overall EQ score indicated higher empathy.

Perspective taking task

The stimuli were modified versions of those used in previous mental imagery tasks on bodily perspective taking (Arzy *et al.*, 2006; Arzy, Mohr, Michel, & Blanke, 2007; Bailey, Papadopoulos, Lingford-Hughes, & Nutt, 2007; Blanke *et al.*, 2005; Mohr *et al.*, 2006; Zacks *et al.*, 1999). The eight figures faced either toward or away from the participant (Figure 1). Front- and back-facing figures had the same outline, and differed only in the rendering of the clothing of the figure, its shape (female, male) and the presence of a face (front-facing) or the back of a head (back-facing, Figure 1). The figures' hands were marked with a bracelet around the wrist on either the right or left hand (Figure 1).

Procedure

The general task of the participants was to judge whether the bracelet was on their right or their left hand when imagining themselves in the figure's position (3PP) or when imagining the figure to be their mirror reflection (1PP) (Arzy *et al.*, 2006, 2007; Blanke *et al.*, 2005; Mohr *et al.*, 2006). Participants made these right–left judgments about the figures (Figure 1) presented sequentially in the centre of a computer screen ($5.0° \times 6.1°$ of visual angle) until a response was provided. Right–left responses were indicated by button press on a keyboard. Left judgments (L, Figure 1) were indicated by a button press of the left index finger on the left SHIFT key, and right judgments (R, Figure 1) by a button press of the right index finger on the right SHIFT key. The inter-trial interval was 1,000 ms. Participants were instructed to respond as quickly and precisely as possible, but to always make the mental effort required to perform the 3PP-task or 1PP-task prior to giving their responses. Half of the participants started with the 3PP-task, and the remaining half with the 1PP-task. Each experimental block consisted of a total of 80 trials, within which each of the eight stimuli appeared 10 times in randomized order. For both task conditions, we calculated the percentage of correct responses as well as mean reaction times (RTs) for correct responses separately for the task conditions that required no additional spatial transformation (WITHOUT: front-facing figures in the 1PP-task and back-facing figures in the 3PP-task) and those that required an additional spatial transformation (WITH: back-facing figures in the 1PP-task and front-facing figures in the

3PP-task). Response latencies faster than 200 ms and slower than 5,000 ms were discarded from analysis (Harris, Harris, & Caine, 2002). After verbal and written instructions, the participants first performed 10 practice trials for each task condition before entering the actual experimental blocks.

Statistical analyses

We performed two sets of repeated measures ANOVAs on (1) mean RTs for correct responses, and (2) accuracy; one set to facilitate comparability of the present results with those of previous ones (see also Arzy *et al.*, 2006; Easton, Blanke, & Mohr, 2009), and another set to directly test for sex differences in perspective taking. The first set considered the factors TASK (3PP-task, 1PP-task), and TRANSFORMATION (WITH, WITHOUT). The second set made use of mental transformation indices calculated for each individual separately (see below) to capture behavioural costs when participants' physical body position did not match the imagined body position. To do so, we made use of the transformation conditions WITH and WITHOUT (see above): for RTs indices, we used the formula RT index = (WITH − WITHOUT)/(WITH + WITHOUT) × 100 (Marshall, Caplan, & Holmes, 1975; Mohr *et al.*, 2005) to obtain a measure that was independent of individual differences in overall performance. For accuracy indices, we used the formula accuracy index = (WITHOUT – WITH)/(WITH + WITHOUT) × 100. In both instances, positive values reflect an advantage of the WITHOUT over the WITH condition, and negative values reflect an advantage of the WITH over the WITHOUT condition. These indices were individually calculated for each task (1PP-task, 3PP-task) and figure (female figure, male figure), and subjected to repeated measures ANOVAs with the factors TASK (3PP-task, 1PP-task), and FIGURES' SEX (male figure, female figure) as repeated measures, and PARTICIPANTS' SEX (men, women) as between-subject measure. Kolmogorov–Smirnov statistics showed that the dependent measures met criterion for normal distribution (all $d < .14$, all $p > .05$). *Post hoc* comparisons were performed using Tukey honestly significant difference (HSD) tests.

In order to test whether increasing empathy related to superior performance in the 3PP-task, but not 1PP-task (in particular in women), we performed Pearson correlations for each task and sex separately between EQ scores and (i) accuracy, (ii) RTs, and (iii) rotational cost indices. All p-values are two-tailed, and the significance level was set to $\alpha = .05$.

Results

Participants

While the mean age (in years) did not differ between women (20.1 ± 2.1) and men (20.8 ± 3.5; $t(98) = 1.07$, $p = .29$), EQ scores were higher in women (55.7 ± 9.3) than in men (49.5 ± 8.2, $t(98) = 3.54$, $p = .0006$).

General performance in the two perspective taking tasks

Reaction times

The ANOVA on RTs with TASK and TRANSFORMATION as within-subject measures revealed a significant main effect for TASK ($F(1, 99) = 64.51$, $p < .0001$; 3PP-task: 803.5 ± 179.4 < 1PP-task: 975.1 ± 225.1), and a significant main effect for

TRANSFORMATION ($F(1, 99) = 103.27, p < .0001$; WITHOUT: 808.5 ± 172.1 <WITH: 970.1 ± 212.5), but no significant interaction between TASK and TRANSFORMATION ($F(1, 99) = 0.53, p = .47$). These findings indicate that participants responded faster in the 3PP-task than 1PP-task, and faster in WITHOUT than WITH trials.

Accuracy

The ANOVA on accuracy revealed a significant main effect for TASK ($F(1, 99) = 20.99$, $p < .0001$; 3PP-task: 96.5 ± 4.4 > 1PP-task: 93.9 ± 5.9), a significant main effect for TRANSFORMATION condition ($F(1, 99) = 8.38$, $p = .005$; WITHOUT: 96.2 ± 5.0 > WITH: 94.2 ± 6.0), but no significant interaction between TASK and TRANSFORMATION condition ($F(1, 99) = 0.06$, $p = .81$). Again, these findings show that participants performed better in the 3PP-task than 1PP-task, and in WITHOUT than WITH trials.

Sex differences in the two perspective taking tasks

Reaction times

The ANOVA on RT indices (note that positive values indicate an advantage for the WITHOUT over the WITH condition and negative values an advantage for the WITH over the WITHOUT condition) with SEX as a between-subject measure and TASK and FIGURES' SEX as within-subject measures revealed significant main effects for SEX ($F(1, 98) = 11.41$, $p = .001$; women: 11.3 ± 7.5 > men: 6.8 ± 5.7) and TASK ($F(1, 98) = 7.65$, $p = .007$; 3PP-task: 10.3 ± 7.9 > 1PP-task: 7.7 ± 9.0, Figure 2). There were also significant interactions between TASK and FIGURES' SEX ($F(1, 98) = 68.05$, $p < .0001$) and TASK, FIGURES' SEX, and SEX ($F(1, 98) = 6.28$, $p = .01$, Figure 2). The remaining comparisons were not significant (*F*-values 3.33, $p > .07$). To explore this significant three-way interaction we conducted the same ANOVAs as before, but for the 3PP-task and 1PP-task separately. The ANOVA for

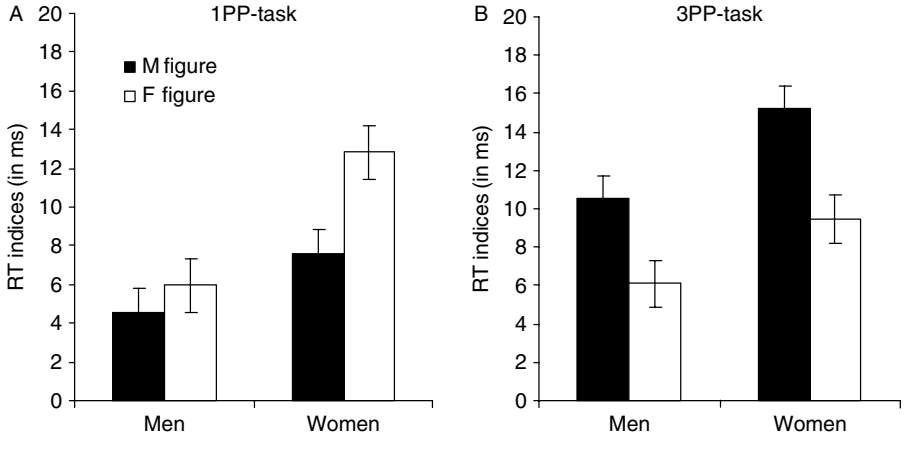

Figure 2. Mean RT indices in the 1PP-task (A) and the 3PP-task (B) as a function of PARTICIPANTS' and FIGURES' SEX (male figures, M figure; female figures, F figure). Vertical bars denote 1SE. Higher values denote increasing rotational costs, i.e. larger differences between the condition WITH and WITHOUT an additional mental transformation.

the 1PP-task showed significant main effects for SEX ($F(1, 98) = 79.95$, $p < .0001$; women: $10.2 \pm 9.4 >$ men: 5.2 ± 7.8), FIGURES' SEX ($F(1, 98) = 21.59$, $p < .0001$; female figure: $9.4 \pm 10.2 >$ male figure: 6.1 ± 9.2), and a significant interaction ($F(1, 98) = 7.18$, $p = .009$). *Post hoc* comparisons showed (see also Figure 2a) that women, when presented with female figures, revealed the largest rotational costs (higher indices) as compared to when male figures were presented to women ($p < .001$), or female ($p = .001$) and male ($p < .001$) figures were presented to male participants. The ANOVA for the 3PP-task showed significant main effects of SEX ($F(1, 98) = 6.94$, $p = .01$; women: $12.3 \pm 8.8 >$ men: 8.3 ± 6.3), and FIGURES' SEX ($F(1, 98) = 52.64$, $p < .0001$; male figure: $12.9 \pm 8.4 >$ female figure: 7.8 ± 8.9), but no significant interaction ($F(1, 98) = 0.84$, $p = .36$, Figure 2b).

Accuracy

The ANOVA on accuracy indices with SEX as a between-subject measure and TASK and FIGURES' SEX as within-subject measures revealed a significant interaction between TASK and FIGURES' SEX ($F(1, 98) = 9.26$,, $p = .003$). *Post hoc* comparisons were all non-significant ($p > .20$); only a trend indicated that rotational costs were lower for male (0.5 ± 7.3) as compared to female (1.8 ± 6.5) figures in the 1PP-task (3PP-task: male 1.5 ± 4.2; female 0.5 ± 4.4). The remaining main effects and interactions were all not significant ($F -$ values < 2.50, $p -$ values $> .12$).

Relationship between perspective taking performance and empathy scores

For male participants, none of the correlations between EQ scores and the behavioural measures were significant (Table 1). For female participants, increasing EQ scores were negatively correlated with RTs in the 3PP-task (Table 1). None of the remaining correlations for women were significant (Table 1).

Table 1. Pearson correlations (*p*-values in brackets) between EQ scores and behavioural measures for men ($N = 50$) and women ($N = 50$) separately

	3PP-task		1PP-task	
	RT/RT index	Acc/Acc index	RT/RT index	Acc/Acc index
Men	.12 (.41)/−.04 (.77)	−.18 (.21)/−.12 (.39)	−.07 (.66)/.22 (.13)	−.09 (.53)/−.02 (.88)
Women	−.29 (.04)/−.18 (.22)	.09 (.52)/−.07 (.62)	−.05 (.71)/−.03 (.84)	.18 (.22)/.18 (.22)

Note. Acc, accuracy.

Discussion

Herein we tested the role of participants' sex, figure's sex, and individuals' self-reported empathy on bodily perspective taking. Using the same stimuli, participants took a 3PP-task and a 1PP-task in a bodily perspective taking task. Behavioural differences in the two tasks with respect to participants' sex or figures' sex can thus not be explained by the stimuli used, but by the mental effort required to perform each task. Based on the earlier literature, we predicted an advantage (i) for women in the 3PP-task (in particular with increasing self-reported empathy scores), and (ii) for female or same-sex figures.

General performance in the two perspective taking tasks

Irrespective of participants' and figures' sex, we replicated previous findings showing that participants demonstrated an advantage (RT, accuracy) for figures matching the own body position. In more detail, participants performed better when figures required no additional mental bodily transformation (WITHOUT: front-facing figures in the 1PP-task, back-facing figures in the 3PP-task) as compared to those requiring an additional mental bodily transformation (WITH: back-facing figures in the 1PP-task, front-facing figures in the 3PP-task) (Arzy *et al.*, 2006, 2007; Blanke *et al.*, 2005; Easton *et al.*, 2009; Mohr *et al.*, 2006; Zacks *et al.*, 1999). These overall behavioural findings are in agreement with previous reports regarding the mental rotation of objects (Shepard & Metzler, 1971; Wohlschläger & Wohlschläger, 1998), body parts (Bonda, Petrides, Frey, & Evans, 1995; Cooper & Shepard, 1975; L. M. Parsons, 1987; Petit, Pegna, Mayer, & Hauert, 2003; Seurinck, Vingerhoets, de Lange, & Achten, 2004), and perspective taking tasks (e.g. Kaiser *et al.*, 2008; Rilea, 2008): RTs are longer when the position of a stimulus (or own current body position) does not match that of the target stimulus (the WITH figures in the current study).

Rotational costs

The increase in RTs and the decrease in accuracy when the own current body position did not match that of the target stimulus was used to determine rotational costs (numerically expressed as an index, see statistical analysis section). A larger difference between the two body positions reflects higher rotational costs, and is represented numerically by higher indices. Results on these indices showed that (1) women revealed higher rotational costs than men in both perspective taking tasks, (2) for the 1PP-task, highest rotational costs were observed in women when presented with same-sex figures, (3) rotational costs were higher for female figures in the 1PP-task, and for male figures in the 3PP-task, and (4) women, but not men, showed faster responding in the 3PP-task with increasing EQ scores.

Sex differences

One of our major hypotheses was based on previous reports of a female advantage in emotional and social perspective taking (Baron-Cohen & Hammer, 1997; Baron-Cohen & Wheelwright, 2004; Baron-Cohen *et al.*, 1997; Hughes & Dunn, 1998; Rueckert & Naybar, 2008; Schulte-Ruther *et al.*, 2008; Unger & Crawford, 1992). Assuming that the 3PP-task might capture some form of social perspective taking, we hypothesized that women might outperform men in this task. The present findings, however, showed the opposite. Previous studies comparing the sexes on comparable versions of the 3PP-task showed no sex difference (Mohr *et al.*, 2006; Rilea, 2008), pointed to a male advantage (Ofte, 2002), in particular when of young age (Ofte & Hugdahl, 2002), did not test for sex differences (Arzy *et al.*, 2006, Expt 2; Bailey *et al.*, 2007; Blanke *et al.*, 2005; Easton *et al.*, 2009), or tested only male participants (Arzy *et al.*, 2006, Expt 1, 2007; Zacks *et al.*, 1999). So, although most relevant studies either did not find or did not examine sex differences, the two that did point to a male advantage in the 3PP-task; in line with the present findings. This conclusion would imply that the 3PP-task is unrelated to social perspective taking, casting doubt on the idea of a partially overlapping neural network for physical and social perspective taking (at least, as tested here; Agnew *et al.*, 2007; Apperly *et al.*, 2004; Blanke *et al.*, 2005; Frith & Frith, 2006; Saxe & Wexler, 2005;

Schulte-Ruther *et al.*, 2008 for recent accounts). This conclusion would likewise imply that the 3PP-task might capture spatial/mental rotation abilities, for which a male advantage has repeatedly been reported (Harris & Gitterman, 1978; Parsons *et al.*, 2004; Voyer, Voyer, & Bryden, 1995; but see Jordan, Wustenberg, Jaspers-Feyer, Fellbrich, & Peters, 2006).

However, the significantly faster RTs of women in the 3PP-task with increasing EQ scores seems to support our original hypothesis, albeit the correlation is only modestly significant ($p = .04$). Also, no significant correlations were observed between EQ scores and rotational cost indices indicating that faster responding occurred for front-facing and back-facing figures alike. On this basis, we only cautiously propose that the 3PP-task could, at least for some women, entail social perspective taking components, and that this might depend on task expectancies (see also Massa, Mayer, & Bohon, 2005; Wraga, Helt, Jacobs, & Sullivan, 2007). The sexes have been reported to apply different problem solving strategies in spatial tasks (Butler *et al.*, 2006; Kaiser *et al.*, 2008; Pena, Contreras, Shih, & Santacreu, 2008; Seurinck *et al.*, 2004; Weiss *et al.*, 2003). Also, spatial abilities as a function of participants' sex depend on variables such as gender role belief (Massa *et al.*, 2005; Moe & Pazzaglia, 2006), gender stereotype (Wraga *et al.*, 2007), time contraints (Peters, 2005), guessing tendencies (Voyer & Saunders, 2004), and stimulus complexity (Parsons *et al.*, 2004; Rilea, 2008). In more detail, women's imagined self-rotations improved or deteriorated after having been exposed to a positive or negative stereotype, respectively (Wraga *et al.*, 2007). Massa *et al.* (2005) observed that women with masculine gender role beliefs performed better when a spatial test was introduced as a spatial ability task, and women with feminine gender role beliefs performed better when the test was supposed to measure empathy. Although our instruction neither manipulated stereotype nor empathic abilities, the 3PP-task might naturally have triggered social perspective taking in some of our female participants, facilitating responding with increasing EQ scores. Men, on the other hand, might be more likely to use a spatial perspective taking strategy. Indeed, Kaiser *et al.* (2008) showed that women more frequently apply egocentric perspective transformations and men object-based perspective transformations. Moreover, these authors reported that half of their male sample performed a 3PP-task without even taking the perspective of a presented virtual avatar into consideration, applying an object-based approach to both a 1PP-task and a 3PP-task.

Participants' and figures' sex interaction

The finding that the highest rotational costs were for women observing same-sex figures in the 1PP-task (and not 3PP-task) suggests that this task is not merely a spatial task, but might engage visual or social perspective taking components. This suggestion receives further support from the observation that rotational costs in the 3PP-task were higher for male as compared to female figures. When asked to recognize faces, a female advantage (Guillem & Mograss, 2005; Yonker *et al.*, 2003), in particular for female faces (Cellerino *et al.*, 2004; Ellis *et al.*, 1973; Lewin & Herlitz, 2002; Rehnman & Herlitz, 2006) has been reported, while another study found evidence for a same-sex advantage (Wright & Sladden, 2003). On the other hand, Horgan *et al.* (2004) found no same-sex advantage for the appearance of others in a memory task, but an overall advantage of female over male participants and an overall advantage for female over male figures. Accordingly, we expected a female advantage with regards to female participants and/or female figures. Admittedly, the present study did not target face recognition memory for

the figures or their appearance, but still lends credence to the view that men and women might process body- or sex-relevant information differently (Fischer *et al.*, 2004; Proverbio, Brignone, Matarazzo, Del Zotto, & Zani, 2006 for evidence from face processing).

Explaining the current findings would appear challenging. In particular, why should rotational costs be higher for male figures in the 3PP-task, and for female figures in the 1PP-task (specifically for female participants)? The simplest explanation would be that front-facing female figures are the easiest to process, and accordingly are recognized quicker and better than the other figures. This would result in higher rotational costs for female figures in the 1PP-task, and in lower rotational costs in the 3PP-task (because rotational costs are calculated as *back minus front* and *front minus back*, respectively). While this suggestion could account for the finding that female figures associated with higher rotational costs in the 1PP-task and male figures in the 3PP-task, it does not explain the different treatment of front-facing female figures or why rotational costs for female figures were most pronounced in women. Accordingly, we present some conjectural, social psychological explanations, that are not only relevant to the present findings, but also to future research.

These social psychological explanations would suggest that inhibition and facilitation of physical perspective taking for male and female figures, respectively, might relate to associated social and emotional roles / abilities of the sexes in the 3PP-task, and that enhanced rotational costs for women in the 1PP-task might relate to social comparison processes. In the 3PP-task it seems that mentally taking the spatial position of a third person might be inhibited for male figures and/or facilitated for women figures. Mentally taking the physical perspective of a woman might be facilitated by the image of a woman. Semantic priming tasks, for instance, have demonstrated that the stereotype 'woman' has a number of associates, including that of nurturance towards others, and that these associations are automatically activated when presented with female images or even the word 'woman' (Macrae, Bodenhausen, Milne, Thorn, & Castelli, 1997; Martin & Macrae, 2007). Women are thought to have more highly developed emotional skills, superior ToM, and to be more understanding, and empathic than men (Baron-Cohen & Hammer, 1997; Baron-Cohen & Wheelwright, 2004; Baron-Cohen *et al.*, 1997; Brown *et al.*, 1996; Cervantes & Callanan, 1998; Hughes & Dunn, 1998; Leaper *et al.*, 1998; Rueckert & Naybar, 2008; Schulte-Ruther *et al.*, 2008; Unger & Crawford, 1992). On the other hand, the male 'stereotype' of striving for power (Connell, 2005), being aggressive and competitive (Cohen, Bowdle, Nisbett, & Schwarz, 1996; see also Pound, Penton-Voak, & Surridge, 2009) might inhibit mentally taking the physical perspective of a man (see also Galinsky *et al.*, 2006).

In the 1PP-task it seems that mentally matching a female figure with oneself is inhibited in women, and social comparison might contribute to this finding. Female bodies are more often displayed in various media than male bodies (Pope, Olivardia, Borowiecki, & Cohane, 2001), with a frequent depiction of attention-grabbing and idealized body shapes (Pope *et al.*, 2001; Yang, Gray, & Pope, 2005). Studies like these are closely related to those showing that women as compared to men are much more concerned with body shape, and having an ideal, attractive body (Davison & McCabe, 2006; Unterhalter, Farrell, & Mohr, 2007), and that women exhibit social and appearance comparison more regularly than men (Davison & McCabe, 2005; Jones, 2001, 2004) with associated harmful consequences (e.g. Groesz, Levine, & Murnen, 2002). Thus, higher rotational costs for female figures in women might be explained by such social comparison processes.

Conclusions

The present study investigated whether participants' sex, figure's sex, and empathy would influence task performance in two mental bodily perspective taking tasks. The finding that rotational costs were higher in women than men in both tasks would argue against the idea that the 3PP-task engages social perspective taking abilities, and that both tasks might assess mental rotation abilities for which a male advantage has frequently been reported. On the other hand, observing (i) highest rotational costs in women for female figures in the 1PP-task, (ii) higher rotational costs for male than female figures in the 3PP-task, and for female than male figures in the 1PP-task, and (iii) faster responding of women with increasing EQ scores in the 3PP-task would suggest that some social perspective taking processes are active when performing not only the 3PP-task but also the 1PP-task. In particular, it has been conjectured that the 3PP-task might mainly engage spatial (e.g. mental rotation) perspective taking strategies, but that some individuals (mainly women) might spontaneously apply a social perspective taking strategy. Also, the modulating influence of figures' sex might reflect processing advantages for female figures, social comparison processes (women for female figures in the 1PP-task), and sex-specific emotional and social associations (perspective taking facilitation for the female sex and inhibition for the male sex). While the presented explanations are conjectural, they provide a new avenue to explore individual differences in perspective taking and the different responses that bodily stimuli might elicit from each sex. Thus, with special reference to our findings, future studies should present the current tasks in an empathetic and spatial context, and assess individuals' gender role beliefs, social comparison, and problem solving strategies.

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References

Adolphs, R. (2001). The neurobiology of social cognition. *Current Opinion in Neurobiology*, *11*(2), 231–239.

Agnew, Z. K., Bhakoo, K. K., & Puri, B. K. (2007). The human mirror system: A motor resonance theory of mind-reading. *Brain Research Reviews*, *54*(2), 286–293.

Apperly, I. A., Samson, D., Chiavarino, C., & Humphreys, G. W. (2004). Frontal and temporo-parietal lobe contributions to theory of mind: Neuropsychological evidence from a false-belief task with reduced language and executive demands. *Journal of Cognitive Neuroscience*, *16*(10), 1773–1784.

Arzy, S., Mohr, C., Michel, C. M., & Blanke, O. (2007). Duration and not strength of activation in temporo-parietal cortex positively correlates with schizotypy. *Neuroimage*, *35*(1), 326–333.

Arzy, S., Thut, G., Mohr, C., Michel, C. M., & Blanke, O. (2006). Neural basis of embodiment: Distinct contributions of temporoparietal junction and extrastriate body area. *Journal of Neuroscience*, *26*(31), 8074–8081.

Bailey, J. E., Papadopoulos, A., Lingford-Hughes, A., & Nutt, D. J. (2007). D-Cycloserine and performance under different states of anxiety in healthy volunteers. *Psychopharmacology*, *193*(4), 579–585.

Baron-Cohen, S., & Hammer, J. (1997). Is autism an extreme form of the male brain? *Advances in Infancy Research*, *11*, 193–217.

Baron-Cohen, S., Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another advanced test of theory of mind: Evidence from very high functioning adults with autism or Asperger syndrome. *Journal of Child Psychology and Psychiatry*, *38*, 813–822.

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: An investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, *34*(2), 163–175.

Blair, R. J. (2005). Responding to the emotions of others: Dissociating forms of empathy through the study of typical and psychiatric populations. *Consciousness and Cognition*, *14*(4), 698–718.

Blanke, O., Mohr, C., Michel, C. M., Pascual-Leone, A., Brugger, P., Seeck, M., *et al.* (2005). Linking out-of-body experience and self processing to mental own-body imagery at the temporoparietal junction. *Journal of Neuroscience*, *25*(3), 550–557.

Bonda, E., Petrides, M., Frey, S., & Evans, A. (1995). Neural correlates of mental transformations of the body-in-space. *Proceedings of the National Academy of Sciences USA*, *92*(24), 11180–11184.

Bosacki, S. (2000). Theory of mind and self-concept in preadolescents: Links with gender and language. *Journal of Educational Psychology*, *92*, 709–717.

Brothers, L. (1990). The social brain: A project for integrating primate behaviour and neurophysiology in a new domain. *Concepts in Neuroscience*, *1*, 27–51.

Brown, J. R., Donelan-McCall, N., & Dunn, J. (1996). Why talk about mental states? The significance of children's conversations with friends, siblings, and mothers. *Child Development*, *67*(3), 836–849.

Butler, T., Imperato-McGinley, J., Pan, H., Voyer, D., Cordero, J., Zhu, Y. S., *et al.* (2006). Sex differences in mental rotation: Top-down versus bottom-up processing. *Neuroimage*, *32*(1), 445–456.

Carroll, J. M., & Yung, C. K. (2006). Sex and discipline differences in empathising, systemising and autistic symptomatology: Evidence from a student population. *Journal of Autism and Developmental Disorders*, *36*(7), 949–957.

Cellerino, A., Borghetti, D., & Sartucci, F. (2004). Sex differences in face gender recognition in humans. *Brain Research Bulletin*, *63*(6), 443–449.

Cervantes, C. A., & Callanan, M. A. (1998). Labels and explanations in mother–child emotion talk: Age and gender differentiation. *Developmental Psychology*, *34*(1), 88–98.

Charman, T., Ruffman, T., & Clements, W. (2002). A gender difference in false belief development. *Social Development*, *11*(1), 1–10.

Cohen, D., Bowdle, B. F., Nisbett, R. E., & Schwarz, N. (1996). Insult, aggression, and the southern culture of honor: An 'Experimental ethnography'. *Journal of Personality and Social Psychology*, *70*(5), 945–960.

Connell, R. W. (2005). Change among the gatekeepers: Men, masculinities, and gender equality in the global arena. *Journal of Women in Culture and Society*, *30*(3), 1801–1825.

Cooper, L. A., & Shepard, R. N. (1975). Mental transformations in the identification of left and right hands. *Journal of Experimental Psychology: Human Perception and Performance*, *104*, 48–56.

Davies, M., & Stone, T. (1995). *Mental simulation: Evaluations and applications*. Oxford: Blackwell Publishers.

Davis, M. H., Soderlund, T., Cole, J., Gadol, E., Kute, M., Myers, M., *et al.* (2004). Cognitions associated with attempts to empathize: How do we imagine the perspective of another? *Personality and Social Psychology Bulletin*, *30*(12), 1625–1635.

Davison, T. E., & McCabe, M. P. (2005). Relationships between men's and women's body image and their psychological, social, and sexual functioning. *Sex Roles*, *52*(7–8), 463–475.

Davison, T. E., & McCabe, M. P. (2006). Adolescent body image and psychosocial functioning. *Journal of Social Psychology*, *146*(1), 15–30.

Easton, S., Blanke, O., & Mohr, C. (2009). A putative implication for fronto-parietal connectivity in out-of-body experiences. *Cortex*, *45*, 216–227.

Ellis, H., Shepherd, J., & Bruce, A. (1973). The effects of age and sex upon adolescents' recognition of faces. *Journal of Genetic Psychology*, *123*(1st Half), 173–174.

Fischer, H., Sandblom, J., Herlitz, A., Fransson, P., Wright, C. I., & Backman, L. (2004). Sex-differential brain activation during exposure to female and male faces. *Neuroreport*, *15*(2), 235–238.

Frith, C. D., & Frith, U. (2006). The neural basis of mentalizing. *Neuron*, *50*(4), 531–534.

Galinsky, A. D., Magee, J. C., Inesi, M. E., & Gruenfeld, D. H. (2006). Power and perspectives not taken. *Psychological Science*, *17*(12), 1068–1074.

Groesz, L. M., Levine, M. P., & Murnen, S. K. (2002). The effect of experimental presentation of thin media images on body satisfaction: A meta-analytic review. *International Journal of Eating Disorders*, *31*(1), 1–16.

Guillem, F., & Mograss, M. (2005). Gender differences in memory processing: Evidence from event-related potentials to faces. *Brain and Cognition*, *57*(1), 84–92.

Harris, I. M., Harris, J. A., & Caine, D. (2002). Mental-rotation deficits following damage to the right basal ganglia. *Neuropsychology*, *16*, 524–537.

Harris, L. J., & Gitterman, S. R. (1978). University Professors' self-descriptions of left–right confusability: Sex and handedness differences. *Perceptual and Motor Skills*, *47*(3 Pt 1), 819–823.

Hoffman, M. L. (1987). *The contribution of empathy to justice and moral judgment*. Cambridge: Cambridge University Press.

Horgan, T. G., Mast, M. S., Hall, J. A., & Carter, J. D. (2004). Gender differences in memory for the appearance of others. *Personality and Social Psychology Bulletin*, *30*(2), 185–196.

Hughes, C., & Dunn, J. (1998). Understanding mind and emotion: Longitudinal associations with mental-state talk between young friends. *Developmental Psychology*, *34*(5), 1026–1037.

Jarrold, C., Butler, D. W., Cottington, E. M., & Jimenez, F. (2000). Linking theory of mind and central coherence bias in autism and in the general population. *Developmental Psychology*, *36*(1), 126–138.

Jones, D. C. (2001). Social comparison and body image: Attractiveness comparison to models and peers among adolescent girls and boys. *Sex Roles*, *45*, 645–664.

Jones, D. C. (2004). Body image among adolescent girls and boys: A longitudinal study. *Developmental Psychology*, *40*(5), 823–835.

Jordan, K., Wustenberg, T., Jaspers-Feyer, F., Fellbrich, A., & Peters, M. (2006). Sex differences in left/right confusion. *Cortex*, *42*(1), 69–78.

Kaiser, S., Walther, S., Nennig, E., Kronmuller, K., Mundt, C., Weisbrod, M., *et al.* (2008). Gender-specific strategy use and neural correlates in a spatial perspective taking task. *Neuropsychologia*, *46*(10), 2524–2531.

Lawrence, E. J., Shaw, P., Baker, D., Baron-Cohen, S., & David, A. S. (2004). Measuring empathy: Reliability and validity of the empathy quotient. *Psychological Medicine*, *34*(5), 911–919.

Leaper, C., Anderson, K. J., & Sanders, P. (1998). Moderators of gender effects on parents' talk to their children: A meta-analysis. *Developmental Psychology*, *34*, 3–27.

Lewin, C., & Herlitz, A. (2002). Sex differences in face recognition – women's faces make the difference. *Brain and Cognition*, *50*(1), 121–128.

Macrae, C. N., Bodenhausen, G. V., Milne, A. B., Thorn, T. M. J., & Castelli, L. (1997). On the activation of social stereotypes: The moderating role of processing objectives. *Journal of Experimental Social Psychology*, *33*(5), 471–489.

Marshall, J. C., Caplan, D., & Holmes, J. M. (1975). The measure of laterality. *Neuropsychologia*, *13*(3), 315–321.

Martin, D., & Macrae, C. N. (2007). A face with a cue: Exploring the inevitability of person categorization. *European Journal of Social Psychology*, *37*(5), 806–816.

Massa, L. J., Mayer, R. E., & Bohon, L. M. (2005). Individual differences in gender role beliefs influence spatial ability test performance. *Learning and Individual Differences*, *15*, 99–111.

Moe, A., & Pazzaglia, F. (2006). Following the instructions! Effects of gender beliefs on mental rotation. *Learning and Individual Differences*, *2006*, 369–377.

Mohr, C., Blanke, O., & Brugger, P. (2006). Perceptual aberrations impair mental own-body transformations. *Behavioral Neuroscience*, *120*(3), 528–534.

Mohr, C., Michel, C. M., Lantz, G., Ortigue, S., Viaud-Delmon, I., & Landis, T. (2005). Brain state-dependent functional hemispheric specialization in men but not in women. *Cerebral Cortex*, *15*(9), 1451–1458.

Ofte, S. H. (2002). Right–left discrimination: Effects of handedness and educational background. *Scandinavian Journal of Psychology*, *43*(3), 213–219.

Ofte, S. H., & Hugdahl, K. (2002). Right-left discrimination in male and female, young and old subjects. *Journal of Clinical and Experimental Neuropsychology*, *24*(1), 82–92.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia*, *9*(1), 97–113.

Parsons, L. M. (1987). Imagined spatial transformation of one's body. *Journal of Experimental Psychology: General*, *116*(2), 172–191.

Parsons, T. D., Larson, P., Kratz, K., Thiebaux, M., Bluestein, B., Buckwalter, J. G., *et al.* (2004). Sex differences in mental rotation and spatial rotation in a virtual environment. *Neuropsychologia*, *42*(4), 555–562.

Pena, D., Contreras, M. J., Shih, P. C., & Santacreu, J. (2008). Solution strategies as possible explanations of individual and sex differences in a dynamic spatial task. *Acta Psychologica (Amsterdam)*, *128*(1), 1–14.

Peters, M. (2005). Sex differences and the factor of time in solving Vandenberg and Kuse mental rotation problems. *Brain and Cognition*, *57*(2), 176–184.

Petit, L. S., Pegna, A. J., Mayer, E., & Hauert, C. A. (2003). Representation of anatomical constraints in motor imagery: Mental rotation of a body segment. *Brain and Cognition*, *51*, 95–101.

Pope, H. G., Olivardia, R., Borowiecki, J. J., & Cohane, G. H. (2001). The growing commercial value of the male body: A longitudinal survey of advertising in women's magazines. *Psychotherapy and Psychosomatics*, *70*(4), 189–192.

Pound, N., Penton-Voak, I. S., & Surridge, A. K. (2009). Testosterone responses to competition in men are related to facial masculinity. *Proceedings of the Royal Society B*, *276*, 153–159.

Proverbio, A. M., Brignone, V., Matarazzo, S., Del Zotto, M., & Zani, A. (2006). Gender differences in hemispheric asymmetry for face processing. *BMC Neuroscience*, *7*, 44.

Rehnman, J., & Herlitz, A. (2006). Higher face recognition ability in girls: Magnified by own-sex and own-ethnicity bias. *Memory*, *14*(3), 289–296.

Rilea, S. L. (2008). A lateralization of function approach to sex differences in spatial ability: A reexamination. *Brain and Cognition*, *67*(2), 168–182.

Rueckert, L., & Naybar, N. (2008). Gender differences in empathy: The role of the right hemisphere. *Brain and Cognition*, *67*(2), 162–167.

Russell, T. A., Tchanturia, K., Rahman, Q., & Schmidt, U. (2007). Sex differences in theory of mind: A male advantage on Happe's 'Cartoon' task. *Cognition and Emotion*, *21*, 1554–1564.

Saxe, R., & Wexler, A. (2005). Making sense of another mind: The role of the right temporo-parietal junction. *Neuropsychologia*, *43*(10), 1391–1399.

Schulte-Ruther, M., Markowitsch, H. J., Shah, N. J., Fink, G. R., & Piefke, M. (2008). Gender differences in brain networks supporting empathy. *Neuroimage*, *42*(1), 393–403.

Seurinck, R., Vingerhoets, G., de Lange, F. P., & Achten, E. (2004). Does egocentric mental rotation elicit sex differences? *Neuroimage*, *23*(4), 1440–1449.

Shepard, R. N., & Metzler, J. (1971). Mental rotation of three-dimensional objects. *Science*, *171*(972), 701–703.

Unger, R., & Crawford, M. (1992). *Women and gender: A feminist psychology*. New York: McGraw-Hill.

Unterhalter, G., Farrell, S., & Mohr, C. (2007). Selective memory biases for words reflecting sex-specific body image concerns. *Eating Behaviors*, *8*(3), 382–389.

Vogeley, K., & Fink, G. R. (2003). Neural correlates of the first-person-perspective. *Trends in Cognitive Sciences*, *7*(1), 38–42.

Voyer, D., & Saunders, K. A. (2004). Gender differences on the mental rotations test: A factor analysis. *Acta Psychologica (Amsterdam)*, *117*(1), 79–94.

Voyer, D., Voyer, S., & Bryden, M. P. (1995). Magnitude of sex differences in spatial abilities: A meta-analysis and consideration of critical variables. *Psychological Bulletin*, *117*(2), 250–270.

Weiss, E., Siedentopf, C. M., Hofer, A., Deisenhammer, E. A., Hoptman, M. J., Kremser, C., *et al.* (2003). Sex differences in brain activation pattern during a visuospatial cognitive task: A functional magnetic resonance imaging study in healthy volunteers. *Neuroscience Letters*, *344*(3), 169–172.

Wohlschläger, A., & Wohlschläger, A. (1998). Mental and manual rotation. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 397–412.

Wraga, M., Helt, M., Jacobs, E., & Sullivan, K. (2007). Neural basis of stereotype-induced shifts in women's mental rotation performance. *Social Cognitive and Affective Neuroscience*, *2*(1), 12–19.

Wright, D. B., & Sladden, B. (2003). An own gender bias and the importance of hair in face recognition. *Acta Psychologica (Amsterdam)*, *114*(1), 101–114.

Yang, C. F. J., Gray, P., & Pope, H. G. (2005). Male body image in Taiwan versus the West: Yanggang Zhiqi meets the Adonis complex. *American Journal of Psychiatry*, *162*(2), 263–269.

Yonker, J. E., Eriksson, E., Nilsson, L. G., & Herlitz, A. (2003). Sex differences in episodic memory: Minimal influence of estradiol. *Brain and Cognition*, *52*(2), 231–238.

Zacks, J., Rypma, B., Gabrieli, J. D., Tversky, B., & Glover, G. H. (1999). Imagined transformations of bodies: An fMRI investigation. *Neuropsychologia*, *37*(9), 1029–1040.

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