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A note on sex differences in mental rotation in different age groups

Christian Geiser [a,*], Wolfgang Lehmann [b], Michael Eid [a]

[a] Faculty of Educational Sciences and Psychology, Free University of Berlin, Habelschwerdter Allee 45, 14195 Berlin, Germany
[b] University of Magdeburg, Germany

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Abstract

A large number of studies have reported average performance differences in favor of males in mental rotation tasks. However, it is still unclear to what extent the magnitude of the sex differences varies across age, and whether the differences increase with age. In this study, we reanalyzed data from a cross-sectional investigation of $N=1624$ German students who were tested with the Peters et al. [Peters, M., Laeng, B., Lathan, K., Jackson, M., Zaiouna, R., & Richardson, C. (1995). A redrawn Vandenberg and Kuse Mental Rotations Test: Different versions and factors that affect performance. Brain and Cognition, 28, 39–58.] version of the Mental Rotations Test [MRT; Vandenberg, S.G., & Kuse, A.R. (1978). Mental rotations, a group test of three-dimensional spatial visualisation. Perceptual and Motor Skills, 60, 343–350.]. Sex differences in favor of males were found for all age groups (9–23 years), with *d* values ranging from .52 to 1.49. Structural equation analyses revealed that overall, sex alone accounted for 16.1% of the variance in latent MRT scores. Furthermore, mental rotation scores increased with age for both genders ($\Delta R^2=.126$). The increase was stronger for males than for females as indicated by a small but significant interaction between sex and age ($\Delta R^2=.003$). Our findings thus suggest a slight increase in the sex differences as a function of age.

Keywords: Mental rotation; Sex differences; Development; Age

Mental rotation problems are among the cognitive tasks for which the largest sex differences in favor of males are found. In their influential meta-analysis, Linn and Petersen (1985) reported a mean weighted effect size of $d=.73$ (95% confidence interval .50–.96) for mental rotation tasks. Ten years later, Voyer, Voyer, and Bryden (1995) conducted an extended meta-analysis and found a mean weighted effect size of $d=.56$. Among different mental rotation tests, the Vandenberg and Kuse (1978) Mental Rotations Test (VMRT) appears to show the largest sex differences in favor of males. Masters and Sanders (1993) reported a mean weighted effect size of $d=.90$ for college students and young adults (below 26 years of age) for this test. They found that the sex difference in the VMRT remained stable from 1975 to 1992. Voyer et al. (1995) also found no evidence for decreasing sex differences in the VMRT, and reported mean effect sizes of $d=.70$–.94 for this test given that conventional scoring methods were employed.

Although the finding of robust sex differences in mental rotation in favor of males is well-established, there is still an uncertainty as to the age when the sex differences first emerge and whether the magnitude of the differences is constant over the life span. There is at

* Corresponding author. Tel.: +49 30 838 55719; fax: +49 30 838 55629.
E-mail address: christian.geiser@fu-berlin.de (C. Geiser).

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least one reason why one might expect the sex difference to increase with age. It has been hypothesized that the male advantage in mental rotation performance may be explained by males having more experience with activities requiring spatial cognition (Baenninger & Newcombe, 1989, 1995). For example, males have been found to play certain computer games more often than do females (Quaiser-Pohl, Geiser, & Lehmann, 2006). Some computer games require spatial cognition and seem to be beneficial for mental rotation ability (Feng, Spence, & Pratt, 2007; Okagaki and Frensch, 1994). The effects of differential experience with environmental spatial tasks are likely to increase as individuals grow older, possibly leading to an increase in the score differences found for mental rotation tasks.

The relevant meta-analyses do not provide an unequivocal answer to the question of whether the sex difference in mental rotation increases over the life span. Linn and Petersen (1985) found that "there were no changes in effect size with age over the ages studied" and "Sex differences are detected as soon as mental rotation could be measured" (p. 1488). However, in their meta-analysis, no studies were included that used the VMRT with children younger than 13. In contrast to Linn and Petersen (1985), Voyer et al. (1995) found a significant increase in the magnitude of the sex differences as a function of age for the VMRT. However, in the studies included in their meta-analysis, the VMRT had only been administered to children older than 14. Vederhus and Krekling (1996) administered a modified version of the Vandenberg and Kuse task to 9–10 year old children and found an effect size of $d=.56$ in favor of boys. It thus seems likely that a reliable sex difference in performance on the conventional version of this test can already be found in children below 13 years of age. However, it remains unclear whether the magnitude of the sex difference in the original VMRT is comparable to the effect size found for older participants.

The contribution of the present study is as follows. In order to shed more light on (1) the question of whether the sex differences in mental rotation differ for different age groups and (2) the question of whether these differences increase with age, we reanalyzed data from a large cross-sectional investigation of students (Geiser, Lehmann, & Eid, 2006) who were tested with the a redrawn version of the VMRT (Peters et al., 1995; Vandenberg & Kuse, 1978). In this study, the test had been administered to individuals who were nine years of age and older. To test whether the sex difference in mental rotation differs across age, we calculated and compared the effect sizes for 15 different age groups (9–23 years). Second, we investigated whether there was a positive relation between the magnitude of the sex differences and the age of our participants. In particular, we tested the following hypotheses:

(1) We expected sex differences in favor of males for all age groups.
(2) We hypothesized that mental rotation performance would increase as a function of age for both males and females.
(3) We expected that sex differences in mental rotation performance would increase as a function of age. In other words, we expected that the increase in mental rotation performance with age would be stronger for males than for females.

1. Materials and methods

1.1. Participants

Data from $N=1624$ students (818 females) from the German Bundesland Sachsen-Anhalt were reanalyzed in the present study. The original sample had been recruited from 2000 to 2002 to conduct a detailed psychometric analysis of the MRT items and consisted of $N=1695$ individuals. The main findings of the item analysis conducted by Geiser et al. (2006) were that different MRT item types are prone to different solution strategies. In particular, it was found that not all items require a mental rotation strategy. Some of the items can obviously be solved more easily by using analytic feature comparison strategies. Females tended to use analytic strategies more often than did males. For the present reanalysis, we included only participants who had provided information on their age. Furthermore, we considered only those age groups for which more than ten females and more than ten males were available. This resulted in 15 different age groups (9–23 years) for which sufficient data were present. (The sample sizes for each age group are given in Table 4.) The younger age groups consisted of high school students who went to a German Sekundarschule or Gymnasium. The older participants (20–23 years) were mainly undergraduate students at the University of Magdeburg (Germany). Therefore, it is likely that the younger participants (i.e., the high school students) in our sample were more representative for the total population with respect to general intelligence than were the older participants, who represented a selected sample.

1.2. Material and procedure

The redrawn version A of the Vandenberg and Kuse (1978) VMRT developed by Peters et al. (1995) was used (hereafter referred to as PMRT). This paper-and-pencil