Spatial Ability, Spatial Anxiety, and Working Memory in Early Elementary School

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Many adults have anxieties about mathematics and these anxieties, over and above actual math ability, can negatively impact math performance (Ashcraft, 2002). Prior work has revealed that math anxiety disrupts the working memory (WM) that individuals need to carry out difficult mathematical computations. Working memory can be thought of as a short-term memory system involved in the control, regulation, and active maintenance of a limited amount of information immediately relevant to the task at hand (Miyake & Shah, 1999). If the ability of WM to maintain task focus is disrupted, performance may suffer (Ashcraft & Krause, 2007).

Working memory can not only be thought of as a general cognitive construct. It can also be thought of as an individual difference variable – meaning that some people have more of it than others. Usually, the higher one's WM the better one's performance on academic tasks ranging from reading comprehension to mathematical problem solving (Engle, 2002). However, it has been shown that individuals who are relatively high in WM (i.e. high span individuals) are most susceptible to poor math performance in anxiety-provoking situations (Beilock & Carr, 2005). This is because situation-induced anxieties compete for the WM resources that individuals with high WM capacity normally rely on for their superior performance (Beilock, 2008). As a result, math anxiety may serve to push the math performance of those higher in WM down to the level of their lower WM counterparts.

Though the findings outlined above have added much to our understanding of the negative impact of math anxiety on performance, less is know about whether there are other domain-relevant anxieties that can impact performance. In particular, while spatial ability is important for students' success in math and science, little work has been done to investigate the relation between students' spatial anxiety and their spatial abilities (Delgado & Prieto, 2004; Govier & Feldman, 1999). Because individual differences in spatial ability begin to appear as young as kindergarten, we chose to investigate the possibility that spatial anxieties also emerge and impact children's abilities at a young age (Levine, Huttenlocher, Taylor & Langrock, 1999).

For these reasons, the current work explored the relation between spatial anxiety (e.g., anxiety about performing spatial tasks in an evaluative context) and spatial ability (as measured via mental rotation ability) at the early elementary school level, where it is unknown whether spatial anxiety even exists. Specifically, we (1) explored the existence of spatial anxiety in young children and (2) examined how spatial anxieties related to young children's spatial abilities as a function of individual differences in WM.

Measures of spatial anxiety, spatial ability, and working memory were obtained for 160 first and second grade students in the Chicago Public Schools during the first three months of the school year. Spatial anxiety was measured using a questionnaire adapted for 1st and 2nd graders from the Mathematics Anxiety Rating Scale for Elementary school students (Suinn, Taylor & Edwards, 1988). Spatial ability was assessed using the Thurstone mental rotation subtest. WM

was measured using the total digit span which consists of forward and backward digit span (WISC III). Span scores averaged across the two tests ranged from 2-20. We took the bottom quartile to represent low WM students (M = 6.80, SE = .254), and the top quartile to represent high WM students (M = 13.25, SE=.250).

As seen in Figure 1, the relation between spatial anxiety and mental rotation ability was very different for lower WM and higher WM children. For lower WM children, there was no relation between spatial anxiety and mental rotation ability (r=-.02, *n.s.*). In contrast, for higher WM children, the higher one's spatial anxiety, the lower one's mental rotation ability (r=-.32, p<.04). Put another way, spatial anxiety was related to lower spatial ability, but only in children who were high in WM. High WM children with low spatial anxiety outperformed their low WM counterparts. However, high WM children with high spatial anxiety performed just like their low WM counterparts.

The significance of these results is heightened by the fact that spatial ability is thought to be an important component of early mathematical processing (Casey, Kersh & Young, 2004; Casey, Nuttall & Pezaris, 2001; Kyttälä, Aunio, Lehto, Van Luit & Hautamäki, 2003). If high WM children with spatial anxiety have lower spatial abilities than they are capable of achieving, this may carry consequences for their success in math and related disciplines. These results suggest the importance of examining spatial anxieties as well as spatial abilities in young children as both have the potential to impact achievement in the STEM disciplines.

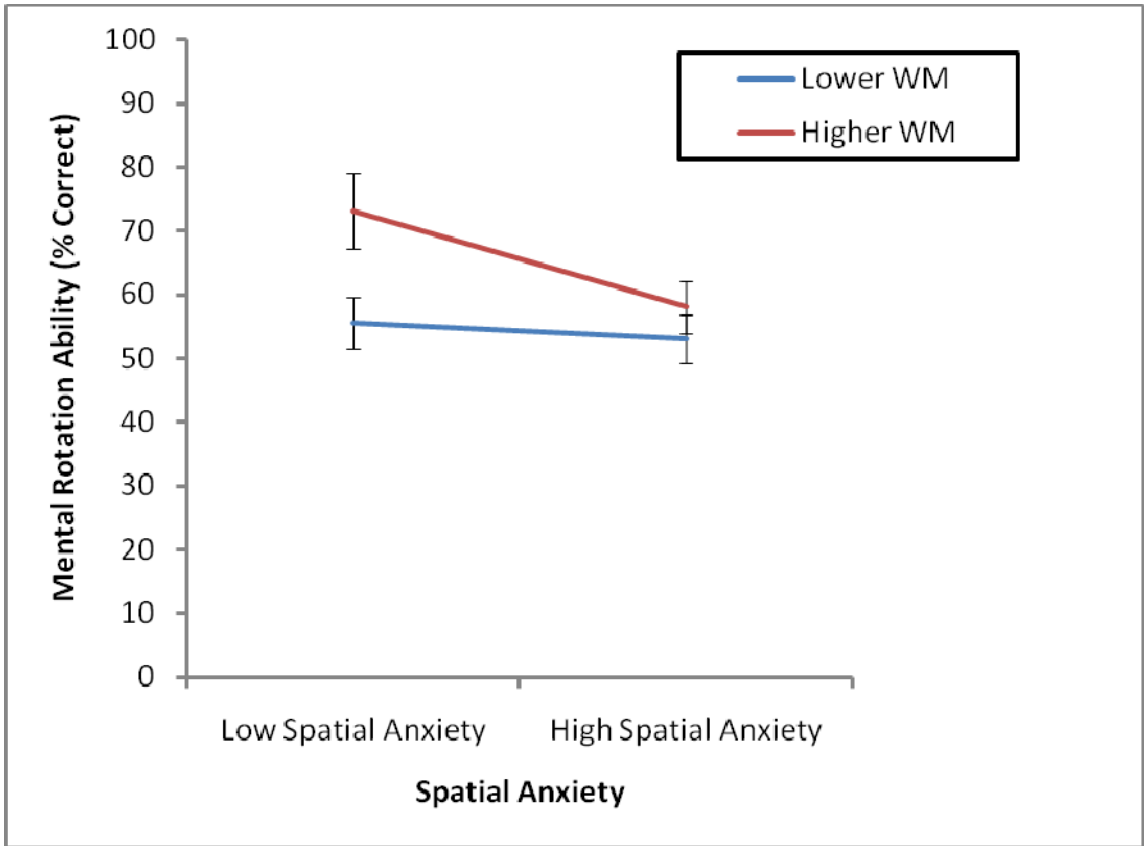

Figure 1. Students' spatial ability scores as a function of their WM and Spatial Anxiety

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