



Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp



On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies



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ARTICLE INFO

Article history:

Received 8 March 2015

Revised 20 July 2015

Keywords:

Math anxiety

Math performance

Arithmetic strategies

Working memory

Strategy development

Processing efficiency

ABSTRACT

Even at young ages, children self-report experiencing math anxiety, which negatively relates to their math achievement. Leveraging a large dataset of first and second grade students' math achievement scores, math problem solving strategies, and math attitudes, we explored the possibility that children's math anxiety (i.e., a fear or apprehension about math) negatively relates to their use of more advanced problem solving strategies, which in turn relates to their math achievement. Our results confirm our hypothesis and, moreover, demonstrate that the relation between math anxiety and math problem solving strategies is strongest in children with the highest working memory capacity. Ironically, children who have the highest cognitive capacity avoid using advanced problem solving strategies when they are high in math anxiety and, as a result, underperform in math compared with their lower working memory peers.

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Introduction

Early quantitative skills, including the ability to perform basic arithmetic operations and to fluently use a variety of problem solving strategies, are important to children's future success in the classroom (Clements & Sarama, 2011; Duncan et al., 2007; Geary, 2013; Hiebert & Carpenter, 1992; National Mathematics Advisory Panel, 2008; Star & Rittle-Johnson, 2009). Although young children vary in the problem solving strategies they use to solve arithmetic problems (Carr, Hettinger-Steiner, Kyser, & Biddlecomb, 2008; Jordan, Huttenlocher, & Levine, 1994; Jordan & Levine, 2009; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2011), we know little about the affective factors that may contribute to this variation. In a large field study, we show, for the first time, that first and second graders' math anxiety (i.e., a fear or apprehension about math) negatively predicts their use of advanced problem solving strategies, which in turn relates to their math achievement. This work opens a new window into understanding the interplay between affective factors and performance in mathematics in young children.

Mathematics anxiety as constraint of math achievement

During recent years, anxiety about the prospect of doing mathematics has been recognized as a significant factor shaping math learning, math performance, and basic numerical abilities of adults in the classroom (Maloney & Beilock, 2012), workplace (Bursal & Paznokas, 2006; McMullan, Jones, & Lea, 2010; Pozehl, 1996; Swars, Daane, & Giesen, 2006), and consumer decisions they make (Jones, Childers, & Jiang, 2012; Suri, Monroe, & Koc, 2013). Math anxiety has been found to be negatively related to math achievement both because it leads to avoidance of math and because it disrupts the working memory resources students use to solve difficult math problems in the moment (Ashcraft, 2002; Ashcraft & Kirk, 2001; Hembree, 1990; Lyons & Beilock, 2012; Park, Ramirez, & Beilock, 2014). Working memory (WM) is an important cognitive construct involved in maintaining relevant information in a highly active state and inhibiting interfering information (Engle, 2002). Unfortunately, math anxiety can cause negative thoughts and ruminations that co-opt the WM resources that individuals rely on to maintain superior performance in math. Evidence consistent with this hypothesis comes from behavioral studies (Ashcraft & Kirk, 2001; Park et al., 2014) and studies using brain imaging. For instance, functional magnetic resonance imaging (fMRI) studies have found that math anxiety is associated with reduced activity in WM-related brain regions (dorsolateral prefrontal cortex: Young, Wu, & Menon, 2012) as well as hyperactivity in brain regions associated with the processing of negative emotions and pain (right amygdala: Young et al., 2012; bilateral dorsal posterior insula: Lyons & Beilock, 2012).

Even though much the literature on math anxiety has focused mainly on adults, there is evidence that the detrimental effects of math anxiety start early. Recent work suggests that some children report experiencing math anxiety as early as first and second grades. Paradoxically, those with higher WM show the most pronounced negative relation between math anxiety and math achievement (Organization for Economic Cooperation & Development, 2013; Ramirez, Gunderson, Levine, & Beilock, 2013; Vukovic, Kieffer, Bailey, & Harari, 2013). The current work explores *why* math anxiety relates to poor math performance at the start of elementary school and *why* children with higher WM are particularly vulnerable to the deleterious effects of math anxiety. We argue that the math anxiety–achievement relationship might be mediated by less frequent use of the developmentally advanced problem solving strategies (described below) that predict superior math performance in young children.

Math problem solving strategies

Most children initially rely on rudimentary problem solving strategies such as finger counting to solve basic arithmetic problems at the beginning of formal schooling. With repeated use of rudimentary problem solving procedures, children develop strong problem–answer associations (e.g., they associate the answer 4 with the problem $2 + 2$) that enable them to transition to more advanced

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