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# Working memory, worry, and algebraic ability

Kelly Trezise, Robert A. Reeve *

*Melbourne School of Psychological Sciences, University of Melbourne, Melbourne, VIC 3010, Australia*

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ABSTRACT

Math anxiety (MA)–working memory (WM) relationships have typically been examined in the context of arithmetic problem solving, and little research has examined the relationship in other math domains (e.g., algebra). Moreover, researchers have tended to examine MA/worry separate from math problem solving activities and have used general WM tasks rather than domain-relevant WM measures. Furthermore, it seems to have been assumed that MA affects all areas of math. It is possible, however, that MA is restricted to particular math domains. To examine these issues, the current research assessed claims about the impact on algebraic problem solving of differences in WM and algebraic worry. A sample of 80 14-year-old female students completed algebraic worry, algebraic WM, algebraic problem solving, nonverbal IQ, and general math ability tasks. Latent profile analysis of worry and WM measures identified four performance profiles (subgroups) that differed in worry level and WM capacity. Consistent with expectations, subgroup membership was associated with algebraic problem solving performance: high WM/low worry > moderate WM/low worry = moderate WM/high worry > low WM/high worry. Findings are discussed in terms of the conceptual relationship between emotion and cognition in mathematics and implications for the MA–WM–performance relationship.



## Introduction

Interest in the impact of emotional states on learning and cognition has a long history in developmental psychology (Fletcher, 1934; Mandler & Sarason, 1952). A widely held view is that emotional states (e.g., anxiety) are relatively stable within a learning domain (e.g., math) and affect problem

* Corresponding author.
*E-mail addresses:* kelly.trezise@gmail.com (K. Trezise), r.reeve@unimelb.edu.au (R.A. Reeve).

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solving similarly across the domain (i.e., emotion is a trait) (see Pnevmatikos & Trikkaliotis, 2013). In the context of math problem solving specifically, it has also been argued that math anxiety (MA) affects working memory (WM), which together affect math problem solving (Ashcraft & Krause, 2007). Nonetheless, others suggest that emotional states (anxiety), cognition, and learning relationships may differ within and across learning domains (i.e., emotion is a state) (Pnevmatikos & Trikkaliotis, 2013; Punaro & Reeve, 2012;). One difficulty in deciding between state/trait interpretations, as well as MA/WM relationships, in math is that previous relevant research has focused on arithmetic problem solving (Ashcraft & Faust, 1994; Friso-van den Bos, van der Ven, Kroesbergen, & van Luit, 2013; Miller & Bichsel, 2004; Raghubar, Barnes, & Hecht, 2010). It is possible that MA/WM problem solving relationships may differ as a function of math domain (e.g., algebra). In the current study, we investigated the relationships among 14-year-olds' algebraic anxiety/worry, algebraic WM, and algebraic problem solving abilities.

Although algebra is often considered as the generalization of arithmetic, it is also different from arithmetic cognitively. Algebra involves working with unknown values and requires a structural, rather than a procedural, understanding of mathematical expressions (Alibali, Knuth, Hattikudur, McNeil, & Stephens, 2007; Christou & Vosniadou, 2012; Humberstone & Reeve, 2008; Kieran, 1992; Knuth, Stephens, McNeil, & Alibali, 2006). The absence of research examining the relationship between WM and MA in algebra is problematic for at least three reasons. First, claims for a link between MA and problem solving may have been overstated (i.e., claims may be restricted to arithmetic). Second, we have little understanding of how anxiety and/or cognitive factors interact to affect problem solving in complex/abstract mathematical domains. Third, from an applied perspective, algebra is typically introduced early in high school, and failure to grasp its intricacies may be a stumbling block to the acquisition of higher level math (Alibali et al., 2007; Stacey & MacGregor, 1999).

### *Math anxiety*

Some studies that have examined the MA–arithmetic association found that individuals with high MA are less accurate and slower at solving problems compared with students with low MA (Ashcraft & Faust, 1994; Ashcraft & Kirk, 2001; Faust, Ashcraft, & Fleck, 1996), whereas other studies found no difference in problem solving accuracy between high and low MA groups (Cates & Rhymer, 2003). However, findings are difficult to reconcile because these studies used different MA and arithmetic problem solving measures. For example, Ashcraft and Faust (1994) used a true/false verification of addition, multiplication, and mixed arithmetic problems, Ashcraft and Kirk (2001) used solving addition problems within a dual task paradigm, and Cates and Rhymer (2003) required participants to solve complex arithmetic and simple algebraic equations. Indeed, the findings of Cates and Rhymer suggest that MA might not impair advanced mathematics problem solving. Moreover, Wu, Barth, Amin, Malcarne, and Menon (2012) examined math performance on a standardized general abilities test and found that MA has a pronounced effect on math reasoning but not on arithmetic computation subtasks. In sum, research suggests that MA may impair simple arithmetic performance; however, the relationship between MA and more advanced mathematics is unclear.

Nearly all indexes of MA are based on responses to questions about anxiety experienced solving math problems (e.g., "How stressed do you feel solving math problems?"; see Capraro, Capraro, & Henson, 2001) rather than the anxiety that occurs *while* solving math problems. The interpretation of questionnaire responses may be problematic for at least five reasons. First, assessing general perceptions of competence is open to influences (e.g., self-concept, gender stereotypes; see Bull, Espy, & Wiebe, 2008; Monti, Parsons, & Osherson, 2012). Second, commonly used MA measures (e.g., Mathematics Anxiety Rating Scale; Richardson & Suinn, 1972) assess math *test* anxiety and not MA per se. Third, items on MA scales focus on arithmetic referents and do not refer to more complex mathematical problems (e.g., algebraic problems) (Capraro et al., 2001). Fourth, few studies assess cognitive factors (e.g., memory, attention) that might affect self-reports. Fifth, MA questionnaires tend to tacitly assume that MA is an enduring anxiety (trait) rather than an anxiety state experienced solving particular problems. These limitations suggest that retrospective and global self-report measures should be interpreted with caution and that more proximal indexes of anxiety would be desirable (i.e., assessing anxiety while solving problems).