Learning and Individual Differences xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Learning and Individual Differences

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

Maths anxiety in primary and secondary school students: Gender differences, developmental changes and anxiety specificity

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ARTICLE INFO

Article history:
Received 9 March 2015
Received in revised form 18 January 2016
Accepted 27 February 2016
Available online xxxx

Keywords:
Maths anxiety
Gender differences
Developmental changes
Maths performance
Anxiety specificity

ABSTRACT

Maths anxiety (MA) is a debilitating negative emotional reaction towards mathematics. However, MA research in primary and early secondary school is surprisingly sparse and inconsistent. Here we tested primary and secondary students' maths and reading performance and their maths and general anxiety (GA). We examined gender differences, developmental changes regarding the MA/maths performance link and investigated whether MA is linked to other academic domains (reading) and/or to other anxiety-types (GA). Results revealed that girls exhibited higher MA than boys at both educational levels. Whilst there was a reliable negative correlation between MA and secondary students' arithmetic performance, no such relationship was revealed in primary students. Finally, MA was moderately correlated with GA and, when GA was partialled out, MA remained significantly correlated with secondary students' arithmetic performance. MA was not related to reading performance when GA was controlled. It was concluded that the negative MA/maths performance link surfaces later in the educational timeline and MA appears to be both exclusively related to maths and independent of GA.

1. Introduction

Maths anxiety (MA) is a negative emotional response to current or prospective situation involving mathematics. The effects of MA are educationally debilitating; MA sufferers have decreased maths self-confidence, enjoy maths less and may even avoid maths altogether (Ashcraft, Kirk, & Hopko, 1998; Hembree, 1990; Maloney & Beilock, 2012). Nevertheless, the majority of studies have investigated MA in university and secondary school samples; MA research employing primary and early secondary school populations remains surprisingly sparse (Jackson & Leffingwell, 1999). Questions remain regarding MA gender differences amongst child and adolescent populations and it is unclear whether the MA/maths performance link seen in older students also presents in the younger age-range. A further question centres on the specificity of MA and whether MA is *only* related to maths or is a manifestation of general anxiety.

In response to these research gaps, here we had three objectives. Firstly, we examined gender differences in MA during primary and early secondary school. Secondly, we mapped developmental changes relating to MA and its link with maths performance in both primary and secondary school. Finally, we investigated whether MA is a maths specific anxiety-type and is independent of general anxiety.

1.1. Gender differences

Studies employing adult populations have consistently revealed women to have higher MA than men (e.g. Chang & Cho, 2013; Ferguson, Maloney, Fugelsang, & Risko, 2015; Miller & Bichsel, 2004; Woodard, 2004). Yet, far less is known about the development of MA gender differences in childhood and adolescence.

More researchers are beginning to investigate the incidence and effects of MA in primary samples (e.g. Galla & Wood, 2012; Vukovic, Kieffer, Bailey, & Harari, 2013; Wu, Barth, Amin, Malcarne, & Menon, 2012). However, such studies rarely report gender-related findings. Of the few which have, the majority found no gender MA differences (e.g. Gierl & Bisanz, 1995; Harari, Vukovic, & Bailey, 2013, Newstead, 1998; Punaro & Reeve, 2012; Ramirez, Gunderson, Levine, & Beilock, 2013; Young, Wu, & Menon, 2012). Nevertheless, the possibility that MA gender differences surface in primary school should not be ruled out. Some studies have reported primary-age girls' to have higher levels of MA than boys (e.g. Griggs, Rimm-Kaufman, Merritt, & Patton, 2013; Yüksel-Şahin, 2008) and Krinzinger, Wood, and Willmes (2012) revealed primary boys to have more positive attitudes towards maths

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http://dx.doi.org/10.1016/j.lindif.2016.02.006
1041-6080/

than girls. Further, Satake and Amato (1995) revealed that 5th and 6th grade girls reported higher levels of 'maths test anxiety' compared to male peers. Thus, it remains unclear as to whether girls experience higher MA than boys in primary education.

Data at the secondary level are more consistent with those revealed in adult populations. Although some studies have revealed no MA gender differences (e.g. Birgin, Baloğlu, Çatlıoğlu, & Gürbüz, 2010; Dede, 2008; Kyttälä & Björn, 2014), more have revealed higher MA in girls than boys (e.g. Devine, Fawcett, Szűcs, & Dowker, 2012; Frenzel, Pekrun, & Goetz, 2007; Jain & Dowson, 2009; Kvedere, 2012; Luo, Wang, & Luo, 2009; Primi, Busdraghi, Tommasetto, Morsanyi, & Chiesi, 2014).

Collectively, although null findings have been reported in both primary and secondary samples, the literature suggests girls experience more MA than boys at both educational levels. However, the evidence for a MA gender difference is considerably more extensive and conclusive amongst secondary samples. Although this may simply be due to a lack of research at the primary level, it may also indicate that the MA gender difference is more established and visible in secondary samples, and thus more likely to be reported by researchers. However, this is speculative and more research is required to ascertain whether MA gender differences are already present at the primary level or develop later. Hence, here we examined the presence and nature of MA gender differences in primary and early secondary school students.

Mathematics performance gender differences are also of interest. Meta-analytic studies have demonstrated a male advantage in mathematics amongst secondary-age students (Hedges & Nowell, 1995; Hyde, Fennema, & Lamon, 1990). Nevertheless, this does vary across country (Else-Quest, Hyde, & Linn, 2010) and recent data suggest this gender gap is disappearing (Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Hyde & Mertz, 2009; Lindberg, Hyde, Petersen, & Linn, 2010). Further, Devine and colleagues showed no gender difference in arithmetic performance, despite girls reporting higher MA than boys (Devine et al., 2012). Thus, here we also compared girls' and boys' arithmetic performance to elucidate whether or not there a gender related mathematics attainment gap.

1.2. Developmental changes

Findings relating to the development of the MA/maths performance link are even less clear-cut than those focusing simply on MA incidence. In secondary school, MA has been found to be negatively correlated with mathematics performance, including term/exam grades and mathematics tests (Hembree, 1990; Ma, 1999; Resnick, Viehe, & Segal, 1982; Richardson & Suinn, 1972; Wigfield & Meece, 1988). However, evidence suggests that the MA/maths performance link typically seen in older students is not present in primary school. For instance, Thomas and Dowker (2000) found no association between MA and calculation ability in six- to nine-year-olds, prompting Dowker (2005) to suggest that MA only affects maths performance after fourth grade. Supporting this, Krinzinger, Kaufmann, and Willmes (2009) found no significant correlations between MA and maths ability in early primary school children.

Nevertheless, other researchers have revealed opposing evidence. For instance, Punaro and Reeve (2012) found a significant relation between nine-year-old children's maths worry ratings and their maths problem-solving judgments. Further, they revealed that a high maths-worry subgroup showed poorer maths performance than other subgroups (Punaro & Reeve, 2012). Similarly, Wu et al. (2012) discovered that 2nd and 3rd grade maths achievement was negatively associated with MA scores. Evidently, the findings lack consistency, with some finding an MA/maths performance relationship even in young children, and others suggesting that it develops later. Thus, here we tested both primary and early secondary school students to explore whether this relationship differs by education level.

1.3. Anxiety specificity

By definition, MA is exclusively related to maths (Hembree, 1990). However, an important issue concerning MA's specificity relates to whether MA is only linked to maths performance or whether it also has associations with other academic domains and skills. The vast majority of research on academic anxiety has focused on mathematics, yet research indicates that reading/literacy anxiety may also exist. For instance, children and adolescents with poor literacy have been shown to exhibit more language anxiety than their literate peers (Carroll, Maughan, Goodman, & Meltzer, 2005) and researchers have noted an association between reading difficulties and anxiety symptomology (Carroll & Iles, 2006). Furthermore, Punaro and Reeve (2012) revealed that nine-year-old children reported high levels of worry in a literacy judgement task corroborating the possibility that literacy can elicit anxiety. Consequently, here we measured maths and reading performance to explore whether MA is exclusively related to maths or whether it is also related to performance in literacy.

Nevertheless, Punaro and Reeve (2012) also discovered that, whilst the high maths-worry subgroup only reported a maths task to be worrisome and not a language task, the high language-worry subgroup reported *both* maths and language tasks to be worrisome. It may be that these children were worried about mathematics and about language simply because they were *generally anxious* children, with a disposition towards many forms of anxiety. General anxiety (GA) differs conceptually and in definition from MA in that it does not relate to a specific situation or activity, but rather refers to an individual's general disposition to worry about events, behaviours and personal abilities. However, evidence suggests that GA and MA may not be entirely independent; GA is moderately correlated with MA (Hembree, 1990) and, in a study exploring the genetic variance of MA, genetic and non-shared environmental factors associated with GA were found to influence MA, implicating GA in MA aetiology (Wang et al., 2014).

There is the further possibility that methodological issues are clouding the issue. Researchers have distinguished between trait and state anxiety (Bieg, Goetz, & Lipnevich, 2014; Goetz, Bieg, Lüdtke, Pekrun, & Hall, 2013). Trait anxiety refers to habitual emotions, whereas state anxiety relates to transitory, contextual worries elicited by real-life experiences. Self-report measures of state and trait anxiety can lead to different results (Porter et al., 2000) and findings reveal higher intensities of trait as compared to state emotions (Goetz et al., 2013). Yet, researchers typically employ self-report questionnaires measuring trait, rather than state, MA.

Whereas state MA reflects an individual's momentary anxiety levels in a given maths-based situation, trait MA reflects an individual's *typical* feelings towards maths, therefore making it more akin to general anxiety. Furthermore, unlike state MA, trait MA levels have been found to be influenced by dispositional and temperament-based factors such as subjective beliefs (Robinson & Clore, 2002) and competence beliefs (Goetz et al., 2013). Consequently, it is conceivable that typical self-report (i.e. trait) MA measures are influenced by GA levels. With this is mind, a pertinent (yet often overlooked) question relates to whether, and how, general and maths anxiety are associated. Are typical self-report MA measures simply highlighting *generally* anxious individuals rather than those *specifically* worried about maths? By utilising both a measure of GA and a typical self-report measure of trait MA we aimed to further explore relations between the two anxiety-types and whether controlling for GA would affect the relationship between students' MA and their maths performance.

1.4. The current study

In response to the abovementioned research gaps, here we had three objectives. Firstly, by testing both primary and secondary students, we further explored MA gender differences and investigated whether gender-related patterns are visible in secondary school, primary school

Please cite this article as: Hill, F., et al., Maths anxiety in primary and secondary school students: Gender differences, developmental changes and anxiety specificity, *Learning and Individual Differences* (2015), http://dx.doi.org/10.1016/j.lindif.2016.02.006