



Psychometric properties of the Abbreviated Math Anxiety Scale (AMAS) in Italian primary school children



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ABSTRACT

Given the widespread prevalence of mathematics anxiety (MA) and its detrimental long-term impact on academic performance and professional development, it is essential to develop standardized tools capable of identifying MA as early as possible. One of the scales most often used to assess MA is the Abbreviated Math Anxiety Scale (AMAS) (Hopko, Mahadevan, Bare, & Hunt, 2003). The first aim of the present study was to validate this tool in a large sample of Italian primary school children, to confirm the factor structure of the AMAS and to develop standardized norms that can be used in the clinical field. Moreover, as the relation between MA and gender has been extensively reported in adult samples, a second goal of the study was to test the invariance of the scale across genders.

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Emotional and motivational aspects have always played an important part in the literature on learning and cognition. Within this wide-ranging framework, special attention has been paid to math anxiety (MA) and its impact on mathematical learning: an ever-growing body of research has recognized that anxiety states and feelings of helplessness and worry experienced during math classes or related activities are significant factors with a negative influence on math learning and basic numerical abilities in both adults (Bursal & Paznokas, 2006; Jameson & Fusco, 2014; Maloney & Beilock, 2012; McMullan, Jones, & Lea, 2010; Pozehl, 1996; Swars, Daane, & Giesen, 2006) and children (Hill et al., 2016; Wu, Barth, Amin, Malcarne, & Menon, 2012). Referring to younger people in particular, MA has been identified as a prominent cause of math difficulties (Ashcraft & Krause, 2007): students with more severe MA, generally identified as feeling tense, fearful and apprehensive about mathematics (Richardson & Suinn, 1972; Tobias, 1993; Zeidner & Matthews, 2005), tend to fail in math tasks more frequently than students experiencing little or no MA (Hembree, 1990; Ma, 1999; Mammarella, Hill, Devine, Caviola, & Szűcs, 2015; Tobias, 1985). Students who suffer from MA during their early formal education also generally avoid mathematics courses as part of their higher education or career paths that demand competence in the mathematical domain. MA thus seems to have serious consequences, not only in the short term (on math performance at school), but also in the long term,

adversely influencing an individual's choice of career, type of occupation, and professional growth in adulthood (Ashcraft & Ridley, 2005; Beasley, Long, & Natali, 2001; Hembree, 1990; Ho et al., 2000).

The worrying phenomenon of MA has also been investigated in the most famous international comparison of student achievement in mathematics, the Programme for International Student Assessment (PISA), published by the Organization for Economic Co-operation and Development (OECD, 2013), which assessed the competencies of 15-year-olds students from 65 different countries. Across PISA countries in the 2012 survey, around 30% of students have reported feeling helpless or nervous when faced with math problems, and this finding is associated with a 34-point lower school performance (equivalent to a year of academic learning). In Italy, 43% of students reported experiencing high levels of MA, and this was associated with a 31-point lower score in mathematics.

1. Math anxiety in children

As previously stated, MA has become a subject of increasing interest in educational and clinical settings because of its consequences in limiting people's mastery of mathematics. An increasing number of researchers are beginning to investigate the incidence and effects of MA in primary samples (e.g. Galla & Wood, 2012; Karasel, Ayda, & Tezer, 2010; Wu et al., 2012), and its consequent influence on math achievement (Ramirez, Chang, Maloney, Levine, & Beilock, 2016). The majority of this extant research has been built with cross-sectional designs mainly involving students from fourth-fifth grades through the university

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(e.g., Baloğlu & Koçak, 2006; Birgin, Baloğlu, Çatloğlu, & Gürbüz, 2010; Newstead, 1998 and Suinn, Taylor, & Edwards, 1988).

Only few studies focused on younger samples (Harari, Vukovic, & Bailey, 2013; Krinzinger, Kaufmann, & Willmes, 2009; Ramirez, Gunderson, Levine, & Beilock, 2013) highlighting as initial signs of MA may emerge as early as 6 years-old (Aarnos & Perkkilä, 2012). Other studies investigated the developmental trajectory of MA (Vukovic, Kieffer, Bailey, & Harari, 2013) or tried to define a path from high MA to math performance, developmental dyscalculia, cognitive abilities or lower self-efficacy towards math learning. (e.g. Hoffman, 2010; Kesici & Erdogan, 2010; Maloney, Ansari, & Fugelsang, 2011; Rubinsten & Tannock, 2010): the final picture resulted in a complex puzzle in which MA represents a tough source of individual differences in children's mathematical performance in which also negative experiences with parents or teachers might worsen children's negative attitudes towards mathematics (e.g. Bekdemir, 2010).

2. Gender differences

Some studies found similar levels of anxiety in males and females (Birgin et al., 2010; Ma & Xu, 2004), but findings generally suggested that females suffer from MA more than males (see Else-Quest, Hyde, & Linn, 2010; and see Devine, Fawcett, Szucs, & Dowker, 2012, for a short review), and that women are consequently less likely to seek opportunities for math problem solving, and they tend to avoid math-related activities (Baloğlu & Koçak, 2006; Else-Quest et al., 2010; Jain & Dowson, 2009; McGraw, Lubienski, & Strutchens, 2006; Rubinsten, Bialik, & Solar, 2012). Studies on adult populations have consistently found that women have higher levels of MA than men (Ferguson, Maloney, Fugelsang, & Risko, 2015; Miller & Bichsel, 2004), but less is known about the development of gender-related differences in the levels of MA experienced in childhood and adolescence (Beilock, Gunderson, Ramirez, & Levine, 2010; Hill et al., 2016). Erturan and Jansen (2015) found gender differences related to MA and math performance tested on children sample of grades 3–8: only girls performed worse in mathematics due to their perceived math competence. Further research seem confirm this marked gender differences to the detriment of girls in the relation between MA, math achievement and other cognitive abilities, such as reading and fluid intelligence (Schleepen & Van Mier, 2016).

Taking a look at the PISA data assessed in 2012, although Italy is one of the countries showing more significant improvements in performance in both mathematics and science (particularly between 2006 and 2009), the results showed a much greater discrepancy between boys and girls than the average 11-point gap for OECD countries as a whole: Italian adolescent males outperformed females by 18 points in mathematics. Similar results emerged in the latest PISA survey (OECD, 2016) which reports a 20-point discrepancy between gender. Italian girls also tended to report being less confident in their ability to learn mathematics, and more MA than boys (48.5% of the girls reported high levels of MA vs. 37.8% of the boys; OECD, 2013). These data highlighted an important aspect of the issue of MA, i.e., gender-related differences.

3. Measures of math anxiety

The first attempt to develop a tool for measuring MA was made by Dreger and Aiken (1957), who added 3 math-related items to an existing general anxiety scale (the Taylor Manifest Anxiety Scale; Taylor, 1953), but the first really innovative and complete instrument for measuring MA – the Mathematics Anxiety Rating Scale (MARS) – was published in 1972 by Richardson and Suinn. The good psychometric properties of the MARS prompted the development of several shorter versions: the Fennema-Sherman Mathematics Anxiety Scale (MAS; Fennema & Sherman, 1976); the Sandman Anxiety Toward Mathematics Scale (ATMS; Sandman, 1980); the Math Anxiety Rating Scale-

Revised (MARS-R; Plake & Parker, 1982); the Abbreviated Math Anxiety Rating Scale (sMARS; Alexander & Martray, 1989); the Abbreviated Math Anxiety Scale (AMAS; Hopko, Mahadevan, Bare & Hunt, 2003); the Mathematics Anxiety Scale-UK (MAS-UK; Hunt, Clark-Carter, & Sheffield, 2011); and the Single Item Math Anxiety Scale (SIMA; Núñez-Peña, Guilera, & Suárez-Pellicioni, 2014). Compared with the original version, all these scales are less time-consuming to administer, and that is why many of them have been translated into different languages (Cipora, Szczygieł, Willmes, & Nuerk, 2015; Núñez-Peña, Suárez-Pellicioni, Guilera, & Mercadé-Carranza, 2013; Primi, Busdraghi, Tomasetto, Morsanyi, & Chiesi, 2014).

Other MA measures tailored to older children and adolescents were subsequently developed, including: the adapted MARS for middle and high school students (Suinn & Edwards, 1982); the MARS-E with items more appropriate for elementary school children in grades 4 to 6 (Suinn et al., 1988); the Mathematics Anxiety Scale for Children (MAS-C; Chiu & Henry, 1990); the Math Anxiety Questionnaire (MAQ; Thomas & Dowker, 2000) for assessing 6- to 9-year-olds; the Mathematics Anxiety Survey (MAXS; Gierl & Bisanz, 1995); the Scale for Early Mathematics Anxiety (SEMA; Wu et al., 2012); the Child Math Anxiety Questionnaire (CMAQ; Ramirez et al., 2013); and, more recently, the Revised Child Math Anxiety Questionnaire (CMAQ-R; Ramirez et al., 2016).

One of the most often used questionnaires for examining MA is the Abbreviated Math Anxiety Scale (AMAS) developed by Hopko et al., 2003. It consists of nine items scored on a Likert-type scale from 1 to 5 (higher scores indicating more severe math anxiety), and considers two main factors, math *learning* and math *testing* (anxiety). Hopko et al. (2003) identified the methodological limitations of previous studies, such as small sample size, lack of test-retest analyses (e.g. Plake & Parker, 1982), and data validity issues (e.g. Alexander & Martray, 1989), and developed their scale using a large, representative sample. A confirmatory factor analysis showed that the items could be grouped under two meaningful subscales: math learning anxiety, which relates to anxiety about the process of learning (e.g., listening to a lecture in a math class); and math testing anxiety, which relates more to assessment situations (e.g., thinking about a math test scheduled for the next day). Good internal consistency estimates were reported for both subscales (Learning: Cronbach's $\alpha = .78$; Testing: Cronbach's $\alpha = .79$), as well as for the total scale (Cronbach's $\alpha = .83$).

The AMAS was adapted successfully to different cultures: the Iranian (Vahedi & Farrokhi, 2011), Italian (Primi et al., 2014), and Polish (Cipora et al., 2015) adaptations of the AMAS provided further evidence of the tool's construct validity and reliability, confirming its suitability for testing MA in various linguistic settings. The factor structure of the AMAS also remained unchanged and showed no gender-related differences. A modified version of the AMAS, with the addition of two more items, was applied to Australian students (Gyuris, Everingham, & Sexton, 2012), producing a similar pattern of results (though they cannot be compared directly with the findings of other studies because of the modifications introduced by the authors).

4. The present study

All the above-mentioned findings are difficult to compare because studies (especially those on younger populations) used different MA assessment tools and different mathematical tasks. Some researchers developed non-standardized ad-hoc questionnaires (Thomas & Dowker, 2000; Wren & Benson, 2004; Wu et al., 2012). Others assessed MA in children using tools adapted from scales applied to adults, with inadequate psychometric properties. Some studies have methodological weaknesses, such as small sample sizes, no test-retest analyses or confirmatory procedures to assess the reliability and dimensionality of the scales adopted, and an overall lack of normative data (Eden, Heine, & Jacobs, 2013; Harari et al., 2013). A measure of MA to be considered suitable for children, should not only have acceptable psychometric

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