The interplay between affective and cognitive factors in shaping early proficiency in mathematics

Published Version:
Cargnelutti, E., Tomasetto, C., Passolunghi, M.C. (2017). The interplay between affective and cognitive factors in shaping early proficiency in mathematics. TREN DS IN N EURO SCIEN CE AN D EDUCATIO N , 8-9, 28-36 [10.1016/j .tine.2017.10.002].

Availability:
This version is available at: https://hdl.handle.net/11585/614734 since: 2022-02-23

Published:
DOI: http://doi.org/10.1016/j.tine.2017.10.002

This is the final accepted version of the manuscript:
Cargnelutti, E., Tomasetto, C., & Passolunghi, M. C. (2017). The interplay between affective and cognitive factors in shaping early proficiency in mathematics. *Trends in Neuroscience and Education, 8*, 28-36. doi: 10.1016/j.tine.2017.10.002

The Interplay Between Affective and Cognitive Factors in Shaping Early Proficiency in Mathematics.

Cargnelutti, Elisa[1], Tomasetto, Carlo[2], and Passolunghi, Maria Chiara*[3]

[1] Department of Life Sciences–Psychology Unit "Gaetano Kanizsa", University of Trieste, via Weiss 21, 34128, Trieste (TS), Italy; e-mail address: eli.cargnel@gmail.com; phone number: + 39 040 558 8866

[2] Department of Psychology, University of Bologna, Piazza Aldo Moro, 90, 47521, Cesena (FC), Italy; e-mail address: carlo.tomasetto@unibo.it; phone number: +39 0547 339 847

[3] Department of Life Sciences–Psychology Unit "Gaetano Kanizsa", University of Trieste, via Weiss 31, 34128, Trieste (TS), Italy; e-mail address: passolu@units.it; phone number: +39 040 558 8866

Affiliation where the research was conducted: Department of Life Sciences–Psychology Unit "Gaetano Kanizsa", University of Trieste, Italy

*Corresponding Author: Passolunghi Maria Chiara, Department of Life Sciences–Psychology Unit "Gaetano Kanizsa", University of Trieste, via Weiss 21, 34128, Trieste (TS), Italy (e-mail:passolu@units.it)

Acknowledgment: This work was supported by the Grant Beneficentia, 2016 to Maria Chiara Passolunghi

Performing math tasks is a complex process that requires the recruitment of many cognitive and affective factors. Research on the interplay between cognitive and affective factors

associated with math ability is surprisingly scarce in primary school children. In the present study, we examined the contribution of both general and math-specific anxiety to math performance in a large sample of second-grade schoolchildren, and also their relation with different measures of both domain-general (i.e., spatial and verbal working memory, intelligence) and domain-specific cognitive correlates of math ability (i.e., different skills tapping the approximate number system, ANS). Results revealed a negative relation between general anxiety (but not math anxiety) and math performance, beyond the contribution of the cognitive abilities. Importantly, specific components of both verbal working memory (i.e., digit span) and ANS (i.e., approximate addition) mediated the relation between general anxiety and math performance. The educational implications of these findings are discussed.

Keywords: general anxiety; math anxiety; working memory (WM); approximate number system (ANS); cognitive precursors; numerical cognition

Learning a discipline such as mathematics is a complex process to which many different factors concur. Also for this reason, in this domain there is a high prevalence of learning difficulties (see Barbaresi, Katusic, Colligan, Weaver, & Jacobsen, 2005), which lead to negative effects that reverberate not only on the academic success or future career expectations (see McCloskey, 2007 for a review), but also on the individual's well-being (e.g., Grolnick & Ryan, 1990). It is therefore not surprising that intensive research (e.g., Cirino, 2011; De Smedt et al., 2009; Fuchs et al., 2010; Xenidou-Dervou, De Smedt, van der Schoot, & van Lieshout, 2013) is devoted to the detection of the cognitive factors that prompt math proficiency, or, when deficient, underlie math learning disabilities (MLD).

Similarly, a growing amount of studies has also stressed the importance of the affective factors as determinants of math achievement, with a prevailing focus on the role of anxiety (e.g., Carey, Devine, Hill, Szűcs, 2017; Hembree, 1990; Owens, Stevenson, Hadwin, & Norgate, 2012). However, only a few studies to date have jointly investigated the role of both cognitive and affective factors associated with math ability, and even fewer have focused on young children (e.g., Gómez-Velázquez, Berumena, & González-Garrido, 2015; MacKinnon McQuarrie, Siegel, Perry, & Weinberg, 2014; Ramirez, Chang, Maloney, Levine, & Beilock, 2016; Ramirez, Gunderson, Levine, & Beilock, 2013; Vukovic, Kieffer, Bailey, & Harari, 2013). To address this gap in the literature, in the present study we examined the interplay between both domain-general and domain-specific cognitive and affective factors at the basis of math ability in a young sample of second-grade schoolchildren.

Cognitive Correlates of Math Proficiency

Domain-General Components: Working Memory.

The domain-general cognitive correlates of math include the cognitive abilities, such as memory and intelligence, that support the individuals' proficiency not only in math, but also in a variety of other domains including language (e.g., Fuchs, Geary, Fuchs, Compton, & Hamlet, 2016;

Passolunghi & Lanfranchi, 2012). It is generally assumed, for instance, that intelligence is a relevant domain-general math correlate (e.g., Geary, 2011; Krajewski & Schneider, 2009; Passolunghi, Cargnelutti, & Pastore, 2014; Passolunghi, Lanfranchi, Altoè, & Sollazzo, 2015). However, it should be noted that the intellectual profile of children with math disabilities is not compromised: Individuals affected by MLD have by definition intelligence levels within the normal range (see DSM-V, American Psychiatric Association, 2013).

Beyond general intelligence, memory is probably the most studied domain-general correlate of math. Consistent with the widely accepted Baddeley's model (Baddeley, 1986; Baddeley & Hitch, 1974; see also Gathercole & Alloway, 2006), memory systems may be subdivided in a more passive component, essentially devoted to transient information retention and precisely expressed in terms of *short-term memory* (STM), and in a more active component, defined as working memory (WM) in *stricto sensu,* and additionally involved in information elaboration. According to this model, STM is represented by the two stores of the phonological loop and of the visuo-spatial sketchpad, whereas WM coincides with the so called central executive. Whereas WM is almost unanimously viewed as a key contributor of math proficiency (e.g., Bull, Espy, & Wiebe, 2008; Gathercole & Alloway, 2006; Jarvis & Gathercole, 2003; Passolunghi et al., 2014; Peng, Namkung, Barnes, & Sung, 2016), the relative importance of specific verbal and visuo-spatial memory components is still debated (see Cornoldi & Vecchi, 2003). Although both components appear related to math proficiency, it remains unclear whether verbal and visuo-spatial components may differently contribute to the diverse math domains (e.g., calculation vs. geometry; for recent meta-analyses, see Friso-Van den Bos, van der Ven, Kroesbergen, & van Luit, 2013; Peng et al., 2016), and whether their relation with math proficiency may vary according to the children's stage of development (see Holmes & Adams, 2006; McKenzie, Bull, & Gray, 2003; Meyer, Salimpoor, Wu, Geary, & Menon, 2010). Importantly, not only the WM domain, but also the content of the tasks used to assess verbal WM may influence the relation with math skills. Namely, it has been suggested that a stronger association with math proficiency may appear when tasks involving numbers are used to assess verbal WM (typically, backward digit recall; Andersson & Lyxell, 2007; Nosworthy, Bugden, Archibald, Evans, & Ansari, 2013; Passolunghi & Cornoldi, 2008; Peng et al., 2016). Several works attempted to control for this potential confound by using both digit and word (or letter) recall tasks to assess verbal WM. However, results are not conclusive: Whereas some findings with children with math difficulties demonstrated specific impairments in WM tasks involving numerals (e.g., Geary, Hoard, Byrd-Craven, & DeSoto, 2004; Hitch & McAuley, 1991; Passolunghi & Siegel, 2001), others did not (e.g., Temple & Sherwood, 2002; see Peng et al. for a meta-analysis).

Domain-Specific Components: Approximate Number System (ANS).

Beside the domain-general abilities, research has intensively focused on the role of basic skills tightly pertaining to the numerical domain, and hence defined as domain-specific correlates of numeracy. These include, among all, the innate ability of estimating and comparing quantities and magnitudes in an approximate manner, which are commonly referred to as the *approximate number system* (ANS; e.g., Libertus, Feigenson, & Halberda, 2011; Mazzocco, Feigenson, & Halberda, 2011). Here, we precisely consider ANS by accounting for the very basic ability of judging quantities expressed in the non-symbolic (e.g., dots) rather than in symbolic (i.e., Arabic numerals) format.

The acuity of non-symbolic ANS has been proven to be an important predictor of math learning in young children, prior to accessing formal math teaching (Hyde, Khanum, & Spelke, 2014; Libertus et al., 2011; Linsen, Verschaffel, Reynvoet, & De Smedt, 2015; Mazzocco et al., 2011; Passolunghi et al., 2014). On the other hand, many authors argued that these abilities have a minor role when symbolic and exact numerical skills are taken into account (e.g., Bartelet, Vaessen, Blomert, & Ansari, 2014; Holloway & Ansari, 2009; Sasanguie, De Smedt, Defever, & Reynvoet, 2012; Toll, Van Viersen, Kroesbergen, & Van Luit, 2015), despite a few evidences of a still significant ANS role in older children and adults (e.g., Fazio, Bailey, Thomson, & Siegler, 2014; Lourenco, Bonny, Fernandez, & Rao, 2012; Paulsen, Woldorff, & Brannon, 2010).

A relevant issue regarding ANS deals with the tasks developed to assess its acuity. Probably the most widely used task tapping into ANS is represented by approximate comparison, which requires children to compare two arrays of elements (e.g., dots), in order to rapidly judge which is the most numerous (see Halberda et al., 2008). In order to control for potential confounds due to the covariations between numerosity and irrelevant perceptual features of the stimuli (e.g., size, density, etc.), these tasks have to include perceptual constraints that inevitably pose additional cognitive demands when performed (e.g., the most numerous array is made up by dots of smaller size). Hence, inhibition skills are required to focus on numerosity without being biased by the dot size (for a detailed explanation on the set up of the ANS tasks, see Dehaene, Izard, & Piazza, 2005).

For this reason, some authors (e.g., Fuhs & McNeil, 2013; Gilmore et al., 2013; Soltész, Szűcs, & Szűcs, 2010) cautioned that ANS acuity could come out as a significant predictor of formal math ability because it is, at least in part, a measure of inhibition. Nevertheless, interindividual variability in ANS acuity is documented also in adults, for whom the ANS tasks are expected to be less demanding in terms of inhibitory control (e.g., Halberda, Ly, Wilmer, Naiman, & Germine, 2012; Lourenco, Bonny, Fernandez, & Rao, 2012).

To address these concerns, several investigations have combined two or more alternative tasks to assess ANS, beside the dot comparison task (e.g., approximate addition tasks; Barth, La Mont, Lipton, & Spelke, 2005; Iuculano, Tang, Hall, & Butterworth, 2008). Findings from these studies were also contradictory, with only low-to-moderate correlations among ANS tasks, and inconsistent associations between different ANS tasks and formal numeracy (see De Smedt, Noël, Gilmore, & Ansari, 2013; Gilmore, 2013, for reviews). Inconsistencies across studies may in part depend on the participants’ age, as some ANS aspects more than others may be indicative of math performance across grades or ages (e.g., Pinheiro-Chagas et al., 2014; Xenidou-Dervou et al., 2013). Pinheiro-Chagas et al. (2014) also suggested that a sort of hierarchy between diverse ANS components may exist, as approximate addition and estimation were found to mediate the relation between approximate dot comparison and exact calculation in middle childhood.

Affective Factors: General and Math-Specific Anxiety

Anxiety is commonly defined as an aversive emotional and motivational state in response to environmental threats, and general (or trait) anxiety refers to the degree with which individuals experience current situations as threatening (Eysenck, 1992). As regards mathematics, a specific form of anxiety has been identified and referred to as *math anxiety* (for a comprehensive review, see Eden, Heine, & Jacobs, 2013). Math anxiety consists of a feeling of apprehension and fear associated to the actual or anticipated manipulation of the numerical information (see Hembre, 1990). Math anxiety has been identified as dissociable from general anxiety from as early as 7- to 9-years of age (Young, Wu, & Menon, 2012), with specific and derailing effects on math proficiency also in children affected by MLD (e.g., Mammarella, Hill, Devine, Caviola, & Szűcs, 2015; Rubinsten & Tannock, 2010; Wu, Willcutt, Escovar, & Menon, 2014).

The relation between anxiety (both general and math-specific) and math proficiency in young children is however still debated. A dearth of literature reports evidence of decreased performance in presence of high levels of anxiety (e.g., Hembree, 1990; Owens et al., 2012). This relation is evident also in children, especially when multi-informant approaches are adopted and teachers' reports are used to assess children's anxiety levels (e.g., Kendall et al., 2007; Layne, Bernstein, & March, 2006; Lyneham, Street, Abbott, & Rapee, 2008; Salbach-Andrae, Klinkowski, Lenz, & Lehmkuhl, 2009).

With regard to math-specific anxiety, evidence is more contradictory, and the existence of any relations between math anxiety and math proficiency in young children is still a matter of debate. Actually, some findings suggest that a significant relation between math anxiety and math performance may already exist in the very first primary school grades (Ramirez et al., 2013, 2016;

Sorvo et al., 2017; Vukovic et al., 2013; Wu, Barth, Amin, Malcame, & Menon, 2012; Wu et al., 2014), whereas other studies do not support this early relation (e.g., Krinzinger, Kaufmann, & Willmes, 2009). Some authors also proposed that the relation may attain statistical and practical relevance only gradually, through the subsequent school grades (Cargnelutti, Tomasetto, & Passolunghi, 2016; Thomas & Dowker, 2000). Cargnelutti and colleagues (2016), for example, demonstrated that the concurrent (negative) relation between general anxiety and math performance was significant in second grade, whereas the contribution of math-specific anxiety was not. However, math anxiety in second grade indirectly predicted math performance one year later, thus suggesting that the affective correlates of math should be carefully monitored from the earliest school grades.

The Relation Between Cognitive and Affective Factors

The interference of high levels of anxiety on the execution of demanding cognitive tasks is well established, and different theoretical models have been proposed to account for the observed relation between anxiety and cognitive proficiency (e.g., Eysenck, Derakshan, Santos, & Calvo, 2007). For instance, a central tenet of the *attentional control theory* (Eysenck et al., 2007) is that anxiety decreases processing efficiency by deviating attention from the task at hand towards threat-related cues, which occupy the memory compartments (especially WM). This phenomenon was observed also specifically for math. According to the *inhibition mechanism theory* (Hopko, Ashcraft, Gute, Ruggiero, & Lewis, 1998), in fact, math performance impairment has to be attributed to the onset of math specific anxiety, which similarly to general anxiety absorbs the WM resources in order to suppress the competing worrisome thoughts (see Cadinu, Maass, Rosabianca, & Kiesner, 2005). Not surprisingly, the negative effects of math anxiety on cognitive proficiency were shown to increase in parallel with the WM demands of the task (Ashcraft & Kirk, 2001), and a lower WM performance was observed in children with high math anxiety (Passolunghi, Caviola, De Agostini, Perin, & Mammarella, 2016).

Although the relation between anxiety and WM is well established, far less explored is the link between anxiety and the other cognitive math abilities, such as ANS. Moreover, prior studies almost exclusively investigated the relation of ANS with math anxiety–rather than general anxiety–, and primarily took into account the symbolic ANS component. For instance, a decreased performance in symbolic magnitude processing was observed in high-math anxious adults by Núñez-Peña and Suárez-Pellicioni (2014) and by Maloney and colleagues (Maloney, Ansari, & Fugelsang, 2011; Maloney, Risko, Ansari, & Fugelsang, 2010), who additionally found that WM intervened as a mediator in the relation between symbolic skills and math anxiety. In contrast, no significant association emerged between math anxiety in the few studies that adopted non-symbolic tasks to assess magnitude processing in children (Gómez-Velázquez et al., 2015; Hart et al., 2015). Finally, in a study with young adolescents, none significant relation with math anxiety surfaced either with symbolic or non-symbolic estimation acuity (Wang et al., 2015). Evidence with this regard is hence mixed. In addition, to the best of our knowledge, no one study thus far explored the relation between anxiety and non-symbolic ANS acuity in children younger than 8.

The Current Study

The core purpose of the present research was to achieve a more thorough view on the interplay between the cognitive and the affective factors that contribute to math proficiency in young schoolchildren. Our first goal was therefore to determine the unique and independent contribution of each of these diverse factors to early math performance. Second, we aimed to inspect whether the cognitive abilities (and, in case, which of them) might intervene as mediators in the relation between anxiety and math performance. Hence, we sought to verify whether anxiety–both general and math-specific– might disrupt math proficiency not only by interfering with the domain-general factors, such as WM, but also by disrupting the acuity of the domain-specific ANS components. To the best of our knowledge, this was the first study to explore the interplay between both general and math anxiety not only with WM, but also with the non-symbolic

ANS abilities in the definition of math proficiency. As the research conducted thus far to address these issues in the earliest school grades is particularly sparse, we chose to target children attending Grade 2.

In detail, concerning the cognitive factors, we assessed diverse WM and ANS components. In this way, we attempted to understand whether possible discrepancies across previous studies might be due to the evaluation of different components within these constructs. For this reason, in relation to memory, we investigated both its verbal and visuo-spatial components. In reference to the former, we separately assessed the recall of both numbers (digits) and words. We opted to focus exclusively on WM, basically for the reason that–contrary to STM–it involves high-control processes, which are both strongly relevant to math learning, and also selectively impaired by anxiety (e.g., Ashcraft & Kirk, 2001; Eysenck, Payne, & Derakshan, 2005). Regarding ANS, we included three different tasks tapping into different facets of non-symbolic magnitudes processing (i.e., approximate comparison, addition, and numerosity estimation). Finally, we assessed intelligence in order to ensure that our findings might hold even when controlling for the influence of individual differences in the general intellectual level.

We hypothesized that anxiety (especially general anxiety, at least in children of this age) might significantly contribute to math performance above and beyond the cognitive factors. We expected that it might be also indirectly related to math, through the negative effect on both the domain-general and the domain-specific cognitive abilities that support math performance.

Method

Participants

One hundred and sixty one Grade 2 children were recruited for the study. Children attended eight different classes across five primary schools in Northeastern Italy. From the initial sample, three children were excluded because of diagnosed neurological diseases, and two for atypical age for their grade. The resulting sample included 156 children (72 females; mean age 7 years 7 months). An *a priori* sample size calculation using the G*Power software indicated that a sample size of 137 participants would be required to detect a medium size effect in bivariate correlation analyses with power = .95 and α = .05 (two-tailed). The achieved power with 156 participants was .97.

Procedure

Formal consent was obtained from the school headmaster, math teachers and students' parents. The study took place in the second term of Grade 2. Anxiety and math skills were investigated by collectively administering the related tests to the whole class, whereas the cognitive precursors were individually assessed in a quiet room outside the classroom. Teachers' ratings of children's general anxiety were also collected, as adults' observation of children's anxiety in relevant contexts (e.g., at school) were proven to provide a more robust and reliable assessment than the self-reports from children themselves, at least until the age of 8-9 years (e.g., Newcomer, Barenbaum, & Bryant, 1994; see De Los Reyes et al., 2015, for a meta-analysis). To the contrary, math anxiety is a more specific and context-dependent construct, that appears to be reliably and validly assessed through age-appropriate self-report measures even in young children (e.g., Ganley & Kowalsky, 2016; Ramirez et al., 2013, 2016; Wu et al., 2012, 2014).

Measures

Cognitive factors.

Intelligence.

Intelligence was assessed by administering the Vocabulary and Block design subtests from the WISC-III scale (Wechsler, 1991, Italian edition, 2006), respectively for the assessment of verbal and performance intelligence. These are the two subtests that most strongly correlate with the global IQ (i.e., IQ measured with the whole scale), and proven to be adequate for a global intelligence assessment (Sattler, 1992).

Vocabulary. This subtest entailed children to give exhaustive definitions of up to 30 selected words. Responses received 0 to 2 points in relation to their exhaustiveness, giving a maximum of 60 points. Task reliability expressed by Cronbach's alpha was .74.

Block design. This subtest required the reproduction of up to 12 bi-dimensional configurations by means of solid cubes in a predefined range of time. Scoring varied according to the correct reproduction time, with a maximum of 69 points. Task reliability expressed by Cronbach's alpha was .80.

For both subtests, raw scores were converted into age-referenced scores ranging 1 to 19. By averaging these two age-referenced scores, we then computed a composite Intelligence score, which we used as a control variable.

Working memory (WM): Verbal.

The following two tasks were administered to assess verbal WM.

Backward word recall (see Passolunghi & Siegel, 2004). The task required children listening the experimenter while reading word lists of increasing length, and then reproducing them in the inverted order (from the last to the first word). The test included up to 14 trials, two for each of the seven difficulty levels (two- to eight- word spans). Each correct reproduction received 1 point, with a maximum score of 14 points. Task reliability expressed by Cronbach's alpha was .86.

Backward digit recall (from WISC-III, Wechsler, 1991, Italian edition, 2006). In this task, children were asked to listen to digit lists of increasing length to then reproduce them in the inverted order of presentation. The test consisted of 14 trials, two for each of the seven levels of increasing difficulty (two- to eight- digit spans). Each correct reproduction received 1 point, resulting in a maximum score of 14 points. Task reliability expressed by Cronbach's alpha was .85.

Working memory (WM): Visuo-spatial.

The *Path dual task* (adapted from Lanfranchi, Cornoldi, & Vianello, 2004) required children to perform two concomitant tasks: Selective recall of the first step (square) of pathways of increasing length traced on a grid by the experimenter, and the simultaneous performance of a secondary task (i.e., tap the hand on the desk when a target square was touched). One point was assigned only if the selective recall and the secondary task were both correctly performed, giving a maximum score of 8 points. Task reliability expressed by Cronbach's alpha was .81.

Approximate Number System (ANS).

Three tasks were administered to achieve a multifaceted assessment of ANS. In developing these tasks, we followed the recommendations reported in previous studies (e.g., Barth et al., 2005; Piazza, Izard, Pinel, Le Bihan, & Dehaene, 2004). In order to prevent children's responses from relying to irrelevant quantity parameters of the stimuli, we controlled for dot and array size, total area, and dot density.

Approximate magnitude comparison (adapted from Piazza et al., 2010). Children were asked to detect the most numerous of the two array of dots simultaneously presented on the pc screen. For each trial, one of the arrays contained the reference number of dots (16), while the other contained the target number of dots (10 to 22, 11 and 21 excluded). The task included four trials for each of the 10 possible target numerosities, giving total number of 40 trials. To each correct response, 1 point was assign, resulting in a maximum score of 40. Task reliability expressed by Cronbach's alpha was .62.

Approximate addition (adapted from Iuculano, Tang, Hall, & Butterworth, 2008). Two arrays of blue dots were shown in succession on the left side of the screen and hidden one at a time behind a black occluder. Dots had to be approximately mentally summed and then compared to a third array of red dots appearing on the right. Children had to rapidly judge whether the final amount of blue dots was more or less numerous than the array of red dots. The total number of dots per trial was between eight and 25, with proportions between the total number of blue vs. red dots being 4:5, 4:6, 4:7 and their reciprocals 5:4, 6:4, 7:4. The test consisted of 24 trials, four for each of the six possible proportions. Each correct response was assigned 1 point, with a maximum score of 24 points. Task reliability expressed by Cronbach's alpha was .65.

Estimation (see Baroody & Gatzke, 1991). Children were required to provide the approximate estimation of the number of dots appearing on the pc screen. Children were said that the maximum numerosity was 30. Each estimation received 0 to 3 points according to the degree of approximation to the actual numerosity (3 points for a response within 10% of the actual numerosity, 2 points within 20%, 1 point within 10%, 0 points otherwise). The final maximum score was 87 points. Task reliability expressed by Cronbach's alpha was .82.

Anxiety.

General anxiety.

Depression and Anxiety in Youth Scale (*DAYS*, Newcomer et al., 1994; Italian ed., 1995), developed for youths from 6 years of age onward. The scale includes a self- and a teacher-reported measure. Concerning the self-rating measure (hereafter *Anxiety-Self*), we partially amended the original scale by removing or re-formulating some statements (for instance, the statement "I want to kill myself" was removed). The administered scale included eight items with a four-point-response scale ranging from 0 (*never*) to 3 (*always*). The maximum score was 24 points. Scale reliability expressed by Cronbach's alpha was .60.

The teachers' scale (hereafter *Anxiety-Observed*) was retained in the original version. The questionnaire includes seven statements with a dichotomous response modality (*true* or *false*). Responses indicating the presence of an anxiety symptom were scored 1 point. The maximum score was 7 points. Scale reliability expressed by Cronbach's alpha was .65.

Math anxiety.

The *Scale for Early Math Anxiety* (*SEMA*, translated and adapted from Wu & Menon, 2012) includes 20 items requiring children to image either to have to solve a given math problem or to be experiencing common situations occurring during math lessons; they had therefore to indicate the level of nervousness they would have felt if these conditions were truly happening. This version provided four instead of the original five response options: *Not nervous at all*, *a little nervous*, *somewhat nervous*, and *very nervous*. Each response was scored 0 (*not nervous at all*) to 3 (*very nervous*), giving a maximum score of 60 points. Scale reliability expressed by Cronbach's alpha was .87.

Math tasks.

Written computation, specifically developed by taking as reference the math textbooks (see Cargnelutti et al., 2016). It comprises 16 arithmetic computations (additions and subtractions) to be solved in 10 min. For each correct solution. 1 point was assigned, giving a maximum of 16 points. Task reliability expressed by Cronbach's alpha was .84.

Word problems (from Giovanardi Rossi & Malaguti, 1994) required children to solve six word problem questions involving additions and subtractions. Up to 1.5 points were assigned for each correct answer (1 point for the correct set out of the expression, plus 0.5 for the correct execution of the computation). The maximum score was 9 points. Task reliability expressed by Cronbach's alpha was .69.

MAT-2, module *Number* (from Amoretti, Bazzini, Pesci, & Reggiani, 2007) includes 11 tasks assessing a wide spectrum of abilities (e.g., ranking numbers from the smallest to the greatest or decomposing numbers) to be performed in 20 min. Each correctly solved exercise was scored 1 point, with a maximum score of 11 points. Task reliability expressed by Cronbach's alpha was .74.

The scores achieved in the three tasks were standardized and then averaged in order to compute a global Math composite score.

Results

Preliminary Results

The statistical analyses were performed by the *PAW Statistics 21* statistical package. Descriptive statistics and bivariate correlations between the variables used in the subsequent analyses are reported in Table 1. All the included measures attained adequate reliability. Math score was significantly associated with all variables, except for Approximate magnitude comparison, Self-Anxiety, and SEMA.

[Insert Table 1 here]

Cognitive and Affective Correlates of Math

In order to assess the unique contribution of each variable to math attainment, we ran a blockwise regression analysis with the math composite score as criterion variable (see Table 2). To assess whether anxiety significantly contributed to unique Math variance beyond the cognitive correlates, we entered the cognitive variables in the first block of the regression model, and the three anxiety variables in the second block. Because mild-to-moderate interrelations were expected and observed among the cognitive measures, a stepwise selection procedure was adopted within each block of the regression model in order to prevent multicollinearity effects, with $p \leq .05$ and $p \geq .10$ values as inclusion and exclusion criteria, respectively.

[Insert Table 2 here]

As detailed in Table 2, among the cognitive predictors inserted in Block 1, Intelligence, Backward digit recall, Approximate addition, and Estimation were entered in the model, whereas Backward word recall, Path dual task, and Approximate magnitude comparison were not. With the cognitive abilities only concurring to the determination of math score, the model accounted for 21% of the total variance. When adding the anxiety measures included in Block 2, also Anxiety-Observed emerged as significant predictor and was retained in the model. The predictivity of the model further increased by 3%, and the full model accounted for 24% of variance in Math. None of the previously retained cognitive abilities was removed from the model in subsequent steps of the analyses. However, as apparent from Table 2, the contribution of Backward digit recall, Approximate addition, and Estimation slightly reduced when Anxiety-Observed was entered in the model, thus suggesting that part of the variability in the math score was shared among cognitive and affective factors.

Mediation Analyses

In order to test the hypothesis that deficiencies in both domain-general and domain-specific cognitive abilities may mediate the relation between anxiety and math performance, we ran a multiple mediation model using the analytical approach and the PROCESS macro for SPSS by Hayes (2015). This approach allows to simultaneously estimate total, direct, and indirect effects of the main predictor on the dependent variable through each proposed mediator. The point estimate and the confidence intervals (CI) for the indirect effects were estimated through a bias-corrected bootstrapping procedure with 10,000 resamples. Based on the blockwise regression results, only Backward digit recall, Approximate addition, and Estimation were retained as candidate mediators. Anxiety-Observed was modeled as the main predictor, and general Intelligence was retained as a covariate. Results of the mediation analysis are reported in Figure 1.

[Insert Figure 1]

The total effect of Anxiety-Observed (B_{TOTAL} = -.17, *SE* = .04, *p* = .002, 95%CI: -.26;-.08), on Math was significant, but was markedly reduced when the three candidate mediators were inserted in the model (B_{DIRECT} = -.11, *SE* = .04, *p* = .014, 95%CI: -.20;-.02). The paths linking Anxiety-Observed to Backward digit recall and Approximate addition–but not Estimation–were significant. Both the mediated paths linking Anxiety-Observed to Math through either Backward digit recall (B_{INDIRECT} = -.023, *SE* = .015, 95%CI: -.062;-.001) or Approximate addition (B_{INDIRECT} = -.026, *SE* = .013, 95%CI: -.061;-.006) were significant, whereas the path through Estimation was not (B_{INDIRECT} = -.008, *SE* = .009, 95%CI: -.034;.004).

A plausible explanation for the present results is that anxiety may interfere with Approximate addition (and not Estimation) because the former task requires higher executive control than the latter, and therefore recruits WM resources. To evaluate this hypothesis, we ran a sequential mediation analysis; here, a two-step indirect path linking Anxiety-Observed to Math through Backward digit recall and, in sequence, Approximate addition, was added to the mediation model. However, results confirmed that both the simple indirect paths from Anxiety-Observed to Math through Backward digit span ($B_{INDIRECT}$ = -.023, *SE* = .015, 95%CI: -.061;-.001) and Approximate addition ($B_{INDIRECT}$ = -.027, *SE* = .015, 95%CI: -.065;-.007) remained significant, whereas the sequential indirect path (i.e., Anxiety-Observed – Backward digit span – Approximate addition – Math) was not ($B_{INDIRECT}$ = -.002, *SE* = .003, 95%CI: -.003;.011).

Discussion

The relation between anxiety and mathematics proficiency in very young students is still an underinvestigated issue, and the interplay between anxiety and the diverse cognitive abilities at the basis of math is even less explored. Whereas some studies focused on the link between anxiety and WM (e.g., Ramirez et al., 2013, 2016; Vukovic et al., 2013), or between anxiety and domain-specific correlates of math abilities (e.g., Gómez-Velázquez et al., 2015), to the best of our knowledge no single study to date simultaneously took into account both domain-general and domain-specific cognitive components, in order to observe whether and how they can be differentially associated with both general and math-specific anxiety. Our study was designed to fill these gaps, by trying to achieve a more exhaustive picture of cognitive and affective contributors of math achievement in young schoolchildren.

Independent Effects of Cognitive and Affective Components on Math Performance

Consistent with previous findings with older students (e.g., Owens et al., 2012), the results from the present study highlighted that already in young schoolchildren a significant negative relation could be traced between general anxiety and math performance. This outcome is important because it evidences how negative affective states may interfere with cognitive proficiency since the earliest primary school grades (e.g., Cargnelutti et al., 2016; MacKinnon McQuarrie et al., 2014). Notably, the contribution of general anxiety remained significant even when controlling for both domain-general (i.e., WM and intelligence) and domain-specific (i.e., ANS) cognitive correlates of math. This finding also highlights that, all the other things being equal, general anxiety alone is sufficient to depress early math performance. Moreover, the size of the anxiety effect was almost comparable– and in some cases greater– to the contribution of the single cognitive factors we examined.

It has however to be pointed out that the observed relation between anxiety and the other constructs of interest was limited to the measure of general anxiety, and more precisely to the teachers' proxy report of children's anxiety. This pattern of results is consistent with previous studies, in which the agreement between children's self-reports and the proxy reports of general anxiety from either parents' (e.g., Miller, Martinez, Shumka, & Baker, 2014; Weeks, Coplan, & Kingsbuty, 2009) or teachers' (e.g., Baldwin & Dadds, 2007; Miller et al., 2014) is commonly quite low (see the recent meta-analysis by De Los Reyes et al., 2015). Teachers' capacity to detect the anxiety symptoms, when present, was repeatedly demonstrated (e.g., Kendall et al., 2007; Lyneham et al., 2008; Newcomer et al., 1994; Salbach-Andrae et al., 2009), and the discrepancy with children's self-ratings was hypothesized to depend on the children's difficulty to appraise a multifaceted and complex construct such as general anxiety.

Contrary to general anxiety, math-specific anxiety appeared to be unrelated with math performance. In this case, past evidence suggests that the lack of relation with performance is not likely to depend on the children's difficulty in answering the scale: Math anxiety is a specific construct that can be contextualized and reliably self-reported even by young children (see Ramirez et al., 2013, 2016; Wu et al., 2012, 2014; but see Ganley & Kowalsky, 2016). The absence of a significant relation between math anxiety and math performance is consistent with previous studies conducted by using the same measures with 7-year-old children in the same cultural context (Cargnelutti et al., 2016), but inconsistent with those reported by Wu and colleagues (2012) in a different school system. We may argue that the different pattern of results may depend, at least in part, on the fact that formal mathematical instruction is not prompted in Italy before entering primary school (at the age of 6); on the contrary, children in other school systems usually receive formal math instruction (and in some cases also formal evaluation) at a lower age (e.g., from 4 to 5 years of age in the UK). It is therefore plausible that math anxiety, although clearly detectable since the earliest school grades, could become significantly related to math performance only after a reasonably long experience with math instruction. Unfortunately, cross-cultural studies investigating children's math anxiety in different countries are not available to date, and more thorough research is needed to better clarify the onset of the detrimental association between anxiety and math performance in young schoolchildren. Future research adopting alternative approaches to the assessment of math-specific and general anxiety, such as physiological measures (see MacKinnon McQuarrie et al., 2014), could help unraveling the issue.

As regards the cognitive factors contributing to math proficiency, our findings confirmed the involvement of both domain-general and domain-specific cognitive processes. However, in line with prior literature, the diverse components of both WM and ANS contributed to a different extent to formal math outcomes. In detail, even though the visuo-spatial component of WM was associated with math outcomes with an effect size comparable to that of the verbal memory components, it did not emerge as a significant predictor of math performance when other cognitive factors were controlled for. In line with previous evidence (e.g., De Smedt et al., 2009; Holmes & Adams, 2006; McKenzie et al., 2003), it might be speculated that visuo-spatial WM could exert a chief role in the earliest stages of numeracy development. Conversely, when children begin to master robust verbal competence and spontaneous rehearsal strategies at around the age of 7, the visuo-spatial memory components may become relatively less important. However, the cross-sectional design of the present research does not allow a direct test of this conjecture. Therefore, future research should more deeply address the issue, also considering the fact that evidences exist in support of the involvement of visuo-spatial WM also in older children, both typically achieving (e.g. (e.g., Passolunghi & Mammarella, 2012).

With respect to the verbal WM component, a significant involvement emerged for the measure based on digit (but not word) recall, even though the two indices were moderately correlated. This pattern of results is in line with previous studies, in which a stronger association between WM and math emerged when numerical material was used to assess memory efficiency (e.g., Landerl et al., 2004; Passolunghi & Cornoldi, 2008; Siegel et al., 2012). However, other studies found similar associations between math and either numerical or non-numerical tasks testing verbal WM (e.g., Koonz & Bench, 1996; Temple & Sherwood, 2002). Actually, there is lack of consensus with respect to the relation between diverse WM components and math skills. It is plausible for the different aspects of WM to have a differential impact on math in dependence of the specific math skill that is taken into account (for recent meta-analyses, see Friso-van den Bos et al., 2013; Peng et al., 2016). It appears therefore advisable for future studies to more deeply investigate the relation between different components of WM and math, with a further particular attention to the children's age.

As regards ANS, results revealed that only the tasks assessing approximate addition and estimation abilities were related to math proficiency, whereas no association emerged between the widely used dot comparison task and formal math. Further, the lack of strong intercorrelations among the diverse ANS measures may actually reflect the multifaceted nature of the innate ability to manipulate numerosities in an approximate manner.

In a developmental perspective, our results may indicate that some ANS measures (such as the dot comparison task) may lose importance when taking into account formal math learned in primary school children, whereas others (such as approximate addition and estimation) may still be relevant. For instance, even though dot comparison is probably the most widely used task to assess ANS, consistent findings on its predictive role in math were actually found in very young children (e.g., Libertus et al., 2011; Mazzocco et al., 2011; Passolunghi et al., 2014; Xenidou-Dervou et al., 2013), whereas more conflicting evidence emerged from studies with older children (e.g., Holloway & Ansari, 2009; Sasanguie et al., 2012). It could therefore happen that, through development and education, some abilities more than others may results to be relevant. This position is corroborated, for example, by Pinheiro-Chagas et al. (2014), who found that the impact of approximate comparison on math performance in primary school children was mediated by the acuity in approximate comparison and estimation. Unfortunately, very few studies to date combined diverse measures to assess ANS and its relation to formal math, and almost no work attempted an exploration of developmental changes in the associations between approximate and exact numerical abilities. Future research is therefore needed to address this gap.

Relation Between Cognitive and Affective Components in Determining Math Performance

Beyond proving further evidence for the direct negative relation between general anxiety and math performance, the present study also attempted to understand whether anxiety might also indirectly disrupt math proficiency by negatively affecting the domain-general and the domain-specific cognitive correlates of math. In fact, while the negative influence of anxiety on the execution of tasks involving WM is well established (at least in older children and adults, see Eysenck et al., 2007), its impact on more automatic and basic quantitative skills, such as those related to non-symbolic ANS, is still underinvestigated. Our findings proved that–among the correlates that significantly predicted math proficiency–WM for digits and the approximate addition skills were both significant mediators of the relation between general anxiety and math, whereas estimation was not.

The finding concerning WM is in line with robust empirical evidence proving that high anxiety levels could deplete the WM resources at the basis of math (see Beilock, 2008, for a discussion). As a consequence, when children are faced with math tasks in presence of external factors–as anxiety–that reduce the WM resources, they are prompted to use less demanding but also less efficient strategies, hence leading to a poorer performance (Barrouillet & Lépine, 2005; Ramirez et al., 2016).

The finding related to the mediating role of the ANS measure of approximate addition is indeed more innovative, given that the few studies targeting the relation between ANS and anxiety had different aims, and mainly focused on math anxiety rather than on general anxiety (e.g., Gómez-Velázquez et al., 2015; Hart et al., 2015; Wang et al., 2015). Importantly, and different from our findings, the majority of prior studies did not observe any significant involvement of ANS components, at least when expressed by non-symbolic skills.

Different explanations could account for our observed relation between general anxiety and approximate addition skills. One possibility calls for the involvement of the inhibition processes with which anxiety is known to interfere, as for instance contended by the inhibition mechanism theory (Hopko et al., 1998). As outlined by some scholars, inhibition may be involved in the execution of tasks tapping ANS, and by partialling out the contribution of inhibition, the predictive power of ANS on math was found to reduce or even disappear (e.g., Fuhs & McNeil, 2013; Gilmore et al., 2013; Soltész et al., 2010). In line with this reasoning, one may hypothesize that approximate addition mediates the relation between anxiety and math proficiency in the measure that anxiety depresses the inhibition skills that are necessary to perform the task. Unfortunately, no measure of inhibition was included in the present work, and future studies are needed to disentangle the possible role of inhibitory skills. However, in a more general vein, we took into account the possibility that approximate addition–but not estimation–exerted a mediating role between anxiety and math proficiency because the former task requires executive resources to be performed, whereas the latter does not. Results from a sequential mediation analysis, in which verbal WM (namely memory for digits) was inserted as a first-order mediator between anxiety and the approximate addition measure, did not support this contention, and confirmed that the two measures independently acted as mediators of the relation between general anxiety and math proficiency.

Conclusion

In sum, the outcomes of the present study extend previous literature in two directions. First, the negative relation between anxiety and math performance was confirmed also for very young students. Second, this relation was observed to operate through the disruption of some of both domain-general and domain-specific cognitive correlates of math abilities. Notably, also one task pertaining to ANS (i.e., Approximate addition) emerged as a crucial mediator of this relation, independently from the parallel depletion of verbal WM resources.

In relation to anxiety, significant outcomes were confined to general anxiety, whereas math anxiety resulted roughly unrelated to both math performance and cognitive abilities. Future investigations are consequently necessary to inspect when math anxiety could begin to assume a significant role not only as a math predictor, but also as a factor able to deflate the cognitive abilities underlying math skills.

Results of the present study are however noteworthy from the educational viewpoint. By highlighting the involvement of affective components in even very young students, these findings suggest that a coordinated evaluation of both affective and cognitive factors could be fundamental as an indicator of academic proficiency (in agreement with Trezise & Reeve, 2014). Hence, to avoid negative repercussions of poor math proficiency in different aspects of children's life, greater care has to be taken to precociously detect and treat not only deficiencies in cognitive math abilities–as traditional approaches do–but also fragilities occurring at the affective sphere.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed., Text Revision). Washington, DC: Author.

Amoretti, G., Bazzini, L., Pesci, A., & Reggiani, M. (2007). *MAT-2. Test di matematica*. Firenze: GIUNTI O.S.

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General*, *130*, 224–237. doi:10.1037//0096-3445.130.2.224

Andersson, U., & Lyxell, B. (2007). Working memory deficit in children with mathematical difficulties: A general or specific deficit? *Journal of experimental child psychology*, *96*, 197–228. doi:10.1016/j.jecp.2006.10.001

Baddeley, A. D. (1986). *Working Memory*. Oxford, UK: Oxford University Press.

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. A. Bower (Ed.), *Recent advances in learning and motivation* (vol. 8, pp. 47–89). New York, NY: Academic Press.

Baldwin, J. S., & Dadds, M. R. (2007). Reliability and validity of parent and child versions of the Multidimensional Anxiety Scale for Children in community samples. *Journal of the American Academy of Child and Adolescent Psychiatry*, *46*, 252–260. doi:10.1097/01.chi.0000246065.93200.a1

Barbaresi, W. J., Katusic, S. K., Colligan, R. C., Weaver, A. L., & Jacobsen, S. J. (2005). Math learning disorder: Incidence in a population-based birth cohort, 1976–82, Rochester, Minn. *Ambulatory Pediatrics*, *5*, 281–289. doi:10.1367/A04-209R.1

Baroody, A. J., & Gatzke, M. R. (1991). The estimation of set size by potentially gifted kindergarten-age children. *Journal for Research in Mathematics Education*, *22*, 59–68. doi:10.2307/749554

Barrouillet, P., & Lépine, P. (2005). Working memory and children's use of retrieval to solve addition problems. *Journal of Experimental Child Psychology*, *91*, 183–204. doi:10.1016/j.jecp.2005.03.002

Bartelet, D., Vaessen, A., Blomert, L., & Ansari, D. (2014). What basic number processing measures in kindergarten explain unique variability in first-grade arithmetic proficiency? *Journal of Experimental Child Psychology*, *117*, 12–28. doi:10.1016/j.jecp.2013.08.010

Barth, H., La Mont, K., Lipton, J. S, & Spelke, E. S. (2005). Abstract number and arithmetic in preschool children. *Proceedings of the National Academy of Sciences*, *102*, 14116–14121. doi:10.1073/pnas.0505512102

Beilock, S. L. (2008). Math performance in stressful situations. *Current Directions in Psychological Science*, *17*, 339–343. doi:10.1111/j.1467-8721.2008.00602.x

Berteletti, I., Prado, J., & Booth, J. R. (2014). Children with mathematical learning disability fail in recruiting verbal and numerical brain regions when solving simple multiplication problems. *Cortex*, *57*, 143–155. doi:10.1016/j.cortex.2014.04.001

Bull, R., Espy, K. A., & Wiebe, S. A. (2008). Short-term memory, working memory, and executive functioning in preschoolers: Longitudinal predictors of mathematical achievement at age 7 years. *Developmental Neuropsychology*, *33,* 205–228. doi:10.1080/87565640 801982312.

Cadinu, M., Maass, A., Rosabianca, A., & Kiesner, J. (2005). Why do women underperform under stereotype threat? Evidence for the role of negative thinking. *Psychological Science*, *16*, 572–578. doi:10.1111/j.0956-7976.2005.01577.x

Carey, E., Devine, A., Hill F., & Szűcs, D. (2017) Differentiating anxiety forms and their role in academic performance from primary to secondary school. *PLoS ONE 12*, 1–20. doi:10.1371/journal.pone.0174418.

Cargnelutti, E., Tomasetto, C., & Passolunghi, M. C. (2017). How is anxiety related to math performance in young students? A longitudinal study of Grade 2 to Grade 3 children. *Cognition and Emotion*, *31*, 755–764. doi:10.1080/02699931.2016.1147421

Carretti, B., Cornoldi, C., De Beni, R., & Palladino, P. (2004). What happens to information to be suppressed in working-memory tasks? Short and long term effects. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, *57*, 1059–1084. doi:10.1080/02724980343000684

Cirino, P. T. (2011). The interrelationships of mathematical precursors in kindergarten. *Journal of Experimental Child Psychology*, *108*, 713–733. doi:10.1016/j.jecp.2010.11.004

Cornoldi, C., & Vecchi, T. (2003). *Visuo-spatial working memory and individual differences*. Hove, UK: Psychology Press.

De Los Reyes, A., Augenstein, T. M., Wang, M., Thomas, S. A., Drabick, D. A. G., Burgers, D. E., & Rabinowitz, J. (2015). The validity of the multi-informant approach to assessing child and adolescent mental health. *Psychological Bulletin*, *141*, 858–900. doi:10.1037/a0038498

De Smedt, B., Janssen, R., Bouwens, K., Verschaffel, L., Boets, B., & Ghesquière, P. (2009). Working memory and individual differences in mathematics achievement: A longitudinal study from first grade to second grade. *Journal of Experimental Child Psychology*, *103*, 186–201. doi:10.1016/j.jecp.2009.01.004

De Smedt, B., Noël, M.-P., Gilmore, C., & Ansari, D. (2013). How do symbolic and non-symbolic numerical magnitude processing skills relate to individual differences in children's mathematical skills? A review of evidence from brain and behavior. *Trends in Neuroscience and Education*, *2*, 48–55. doi:10.1016/j.tine.2013.06.001

Dehaene, S., Izard,V., & Piazza, M. (2005) Control over non-numerical parameters in numerosity experiments. Unpublished manuscript (available on www.unicog.org).

Dehaene, S., Piazza, M., Pinel, P., & Cohen L. (2003). Three parietal circuits for number processing. *Cognitive Neuropsychology*, *20*, 487–506. doi:10.1080/02643290244000239

Eden, C., Heine, A., & Jacobs, A. M. (2013). Mathematics anxiety and its development in the course of formal schooling–A review. *Psychology*, *4*, 27–35. doi:10.4236/psych.2013.46A2005

Eysenck, M. W. (1992). *Anxiety: The cognitive perspective*. Hove, UK: Erlbaum.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7,* 336–353. doi:10.1037/1528-3542.7.2.336

Eysenck, M. W., Payne, S., & Derakshan, N. (2005). Trait anxiety, visuospatial processing, and working memory, *Cognition and Emotion*, *19*, 1214–1228. doi:10.1080/02699930500260245

Fazio, L. K., Bailey, D. H., Thompson, C. A., Siegler, R. S. (2014). Relations of different types of numerical magnitude representations to each other and to mathematics achievement. *Journal of Experimental Child Psychology*, *123*, 53–72 doi:10.1016/j.jecp.2014.01.013

Friso-van den Bos, I., van der Ven, S. H., Kroesbergen, E. H., & van Luit, J. E. (2013). Working memory and mathematics in primary school children: A meta-analysis. *Educational Research Review, 10,* 29–44. doi:10.1016/j.edurev.2013.05.003

Fuchs, L. S., Geary, D. C., Compton, D. L., Fuchs, D., Hamlett, C. L., Seethaler, P. M., Bryant, J. D, & Schatschneider, C. (2010). Do different types of school mathematics development depend on different constellations of numerical versus general cognitive abilities? *Developmental Psychology*, *46*, 1731–1746. doi:10.1037/a0020662

Fuchs, L. S., Geary, D. C., Fuchs, D., Compton, D. L., & Hamlett, C. L. (2016). Pathways to third-grade calculation versus word-reading competence: Are they more alike or different? *Child development*, *87*, 558–567. doi:10.1111/cdev.12474

Fuhs, M., & McNeil, N. (2013). ANS acuity and mathematics ability in preschoolers from low-income homes: Contributions of inhibitory control. *Developmental Science*, *16*, 136–148. doi:10.1111/desc.12013

Ganley, C. M., & McGraw, A. L. (2016). The development and validation of a revised version of the Math Anxiety Scale for Young Children. *Frontiers in Psychology*, *7*, 1181. doi:10.3389/fpsyg.2016.01181

Gathercole, S. E., & Alloway, T. P. (2006). Practitioner review: Short-term and working memory impairments in neurodevelopmental disorders: Diagnosis and remedial support. *Journal of Child Psychology and Psychiatry*, *47*, 4–15. doi:10.1111/j.1469-7610.2005.01446.x

Geary, D. C. (2011). Cognitive predictors of achievement growth in mathematics: A 5-year longitudinal study. *Developmental Psychology*, *47*, 1539–1552. doi:10.1037/a0025510

Geary, D. C., Hoard, M. K., Byrd-Craven, J., & Desoto, M. (2004). Strategy choices in simple and complex addition: Contributions of working memory and counting knowledge for children with mathematical disability. *Journal of Experimental Child Psychology*, *88*, 121–151. doi:10.1016/j.jecp.2004.03.002

Gilmore, C. (2013). Approximate arithmetic in childhood. In A. Dowker & R. Cohen Kadosh (Eds), *The Oxford Handbook of Mathematical Cognition* (pp. 310–330). Oxford, UK: OUP. doi:10.1093/oxfordhb/9780199642342.013.006

Gilmore, C. K., Attridge, N., Clayton, S., Cragg, L., Johnson, S., Marlow, N., Simms, V., & Inglis, M. (2013). Individual differences in inhibitory control, not non-verbal number acuity, correlate with mathematics achievement. *PloS ONE*, *8*, e67374. doi:10.1371/journal.pone.0067374

Giovanardi Rossi, P., & Malaguti, T. (1994). *Valutazione delle abilità matematiche. Analisi dei livelli di apprendimento e dei disturbi specifici. Guida per l'insegnante*. Trento: Centro Studi Erickson.

Gómez-Velázquez, F. R., Berumena, G., & González-Garrido, A. A. (2015). Comparisons of numerical magnitudes in children with different levels of mathematical achievement. An ERP study. *Brain Research*, *1627*, 189–200. doi:10.1016/j.brainres.2015.09.009

Grolnick, W. S., & Ryan, R. M. (1990). Self-perceptions, motivation, and adjustment in children with learning disabilities: A multiple group comparison study. *Journal of Learning Disabilities*, *23*, 177–184.

Halberda, J., Ly, R., Wilmer, J. B., Naiman, D. Q., & Germine, L. (2012). Number sense across the lifespan as revealed by a massive Internet-based sample. *Proceedings of the National Academy of Sciences*, *109*, 11116–11120. doi:10.1073/pnas.1200196109

Halberda, J., Mazzocco, M. M. M., & Feigenson, L. (2008). Individual differences in non-verbal number acuity correlate with math achievement. *Nature*, *455*, 665–668. doi:10.1038/nature07246

Hart, S. A., Logan, J. A. R., Thompson, L., Kovas, Y., McLoughlin, G., & Petrill, S. A. (2016). A latent profile analysis of math achievement, numerosity, and math anxiety in twins. *Journal of Educational Psychology*, *108*, 181–193. doi:10.1037/edu0000045

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension and aging: A review and a new view. In G. H. Bower (Ed.), *The psychology of learning and motivation* (pp. 193–225). New York, NY: Academic Press.

Hayes, A. F. (2015). The PROCESS macro for SPSS and SAS.

Hembree R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*, 33–46. doi:10.2307/749455

Hitch, G. J., & McAuley, E. (1991). Working memory in children with specific arithmetical learning difficulties. *British Journal of Psychology*, *82*, 375–386.

Holmes, J., & Adams, J. W. (2006). Working memory and children's mathematical skills: Implications for mathematical development and mathematics curricula. *Educational Psychology*, *26,* 339–366. doi:10.1080/01443410500341056

Holloway, I. D., & Ansari, D. (2009). Mapping numerical magnitudes onto symbols: The numerical distance effect and individual differences in children's mathematics achievement. *Journal of Experimental Child Psychology*, *103*, 17–29. doi:10.1016/j.jecp.2008.04.001

Hopko, D. R., Ashcraft, M. H., Gute, J., Ruggiero, K. J., & Lewis, C. (1998). Mathematics anxiety and working memory: Support for the existence of a deficient inhibition mechanism. *Journal of Anxiety Disorders, 12*, 343–355. doi:10.1016/S0887-6185(98)00019-X

Hyde, D. C., Khanum, S., & Spelke, E. S. (2014). Brief non-symbolic, approximate number practice enhances subsequent exact symbolic arithmetic in children. *Cognition*, *131*, 92–107. doi:10.1016/j.cognition.2013.12.007

Iuculano, T., Tang, J., Hall, C. W. B., & Butterworth, B. (2008). Core information processing deficits in developmental dyscalculia and low numeracy. *Developmental Science, 11*, 669–680. doi:10.1111/j.1467- 7687.2008.00716.x

Jarvis, H. L., & Gathercole, S. E. (2003). Verbal and nonverbal working memory and achievements on national curriculum tests at 7 and 14 years of age. *Educational and Child Psychology*, *20*, 123–140.

Kendall, P. C., Puliafico, A. C., Barmish, A. J., Choudhury, M. S., Henin, A., & Treadwell, K. S. (2007). Assessing anxiety with the child behavior checklist and the teacher report form. Journal of anxiety disorders, 21, 1004-1015. doi: 10.1016/j.janxdis.2006.10.012

Koontz, K. L., & Berch, D. B. (1996). Identifying simple numerical stimuli: Processing inefficiencies exhibited by arithmetic learning disabled children. *Mathematical Cognition*, *2*, 1–23. doi:10.1080/135467996387525

Krajewski, K., & Schneider, W. (2009). Exploring the impact of phonological awareness, visual-spatial working memory, and preschool quantity-number competencies on mathematics achievement in elementary school: Findings from a 3-year longitudinal study. *Journal of Experimental Child Psychology*, *103*, 516–531. doi:10.1016/j.jecp.2009.03.009

Krinzinger, H., Kaufmann, L., & Willmes, K. (2009). Math anxiety and math ability in early primary school years. *Journal of Psychoeducational Assessment, 27*, 206–225. doi:10.1177/0734282908330583

Landerl, K., Bevan A., & Butterworth, B. (2004). Developmental dyscalculia and basic numerical capacities: A study of 8-9-year-old students. *Cognition*, *93*, 99–125. doi:10.1016/j.cognition.2003.11.004

Lanfranchi, S., Cornoldi, C., & Vianello, R. (2004). Verbal and visuo-spatial working memory deficits in children with Down syndrome. *American Journal on Mental Retardation*, *109*, 456–466. doi:10.1352/0895-8017(2004)109

Layne, A. E., Bernstein, G. A., & March, J. S. (2006). Teacher awareness of anxiety symptoms in children. *Child Psychiatry and Human Development*, *36*, 383–392. doi:10.1007/s10578-006-0009-6.

Libertus, M. E., Feigenson, L., & Halberda, J. (2011). Preschool acuity of the approximate number system correlates with school math ability. *Developmental Science 14*, 1292–1300. doi:10.1111/j.1467-7687.2011.01080.x

Linsen, S., Verschaffel, L., Reynvoet, B., & De Smedt, B. (2015). The association between numerical magnitude processing and mental versus algorithmic multi-digit subtraction in children. *Learning and Instruction*, *35*, 42–50 doi:10.1016/j.learninstruc.2014.09.003

Lourenco, S. F., Bonny, J. W., Fernandez, E. P., & Rao, S. (2012). Nonsymbolic number and cumulative area representations contribute shared and unique variance to symbolic math competence. *Proceedings of the National Academy of Sciences United States of America*, *109*, 18737–18742. doi:10.1073/pnas.1207212109

Lyneham, H. J., Street, A. K., Abbott, M. J. & Rapee, R. M. (2008). Psychometric properties of the School Anxiety Scale-Teacher Report (SAS-TR). *Journal of Anxiety Disorders*, *22*, 292–300. doi:10.1016/j.janxdis.2007.02.001

Lyons, I. M., & Beilock, S. L. (2012). Mathematics anxiety: Separating the math from the anxiety. *Cerebral Cortex*, *22*, 2102–2110. doi:10.1093/cercor/bhr289

MacKinnon McQuarrie, M. A., Siegel, L. S., Perry, N. E., & Weinberg, J. (2014). Reactivity to stress and the cognitive components of math disability in grade 1 children. *Journal of Learning Disabilities*, *47*, 349–365. doi:10.1177/0022219412463436

Maloney, E. A., Ansari, D., & Fugelsang, J. A. (2011). The effect of mathematics anxiety on the processing of numerical magnitude. *The Quarterly Journal of Experimental Psychology*, *64*, 10–16. doi:10.1080/17470218.2010.533278

Maloney, E. A., Risko, E. F., Ansari, D., & Fugelsang, J. (2010). Mathematics anxiety affects counting but not subitizing during visual enumeration. *Cognition*, *114*, 293–297. doi:10.1016/j.cognition.2009.09.013

Mammarella, I. C., Hill, F., Devine, A., Caviola, S., & Szűcs, D. (2015). Math anxiety and developmental dyscalculia: A study on working memory processes. *Journal of clinical and experimental neuropsychology*, *37*, 878–887. doi:10.1080/13803395.2015.1066759

Mazzocco, M. M. M., Feigenson, L., & Halberda, J. (2011). Preschoolers' precision of the approximate number system predicts later school mathematics performance. *PloS ONE*, *6*, e23749. doi:10.1371/journal.pone.0023749

McCloskey, M. (2007). Quantitative literacy and developmental dyscalculias. In D.B. Berch and M.M.M. Mazzocco (Eds.) *Why is math so hard for some children? The nature and origins of* *children's mathematical learning difficulties and disabilities*. Baltimore, MD: Brookes Publishers.

McKenzie, B., Bull, R., & Gray, C. (2003). The effects of visual-spatial and phonological disruption on children's arithmetical skills. *Educational and Child Psychology, 20*, 93–108.

Meyer, M. L., Salimpoor, V. N., Wu, S. S., Geary, D.C., & Menon, V. (2010). Differential contribution of specific working memory components to mathematics achievement in 2nd and 3rd graders. *Learning and Individual Differences*, *20*, 101–109. doi:10.1016/j.lindif.2009.08.004.

Miller, L. D., Martinez, I. J., Shumka, E., & Baker, H. (2014). Multiple informant agreement of child, parent, and teacher ratings of child anxiety within community samples. *The Canadian Journal of Psychiatry*, *59*, 34–39.

Newcomer, P. L., Barenbaum, E. M., & Bryant, B. R. (1994). *Depression and anxiety in youth scale*. Austin, TX: PRO-ED.

Nosworthy, N., Bugden, S., Archibald, L., Evans, B., & Ansari, D. (2013). A two-minute paper-and-pencil test of symbolic and nonsymbolic numerical magnitude processing explains variability in primary school children's arithmetic competence. *PloS one*, *8*, e67918. doi: 10.1371/journal.pone.0067918

Núñez-Peña, M. I., & Suárez-Pellicioni, M. (2014). Less precise representation of numerical magnitude in high math-anxious individuals: An ERP study of the size and distance effects. *Biological Psychology*, *103*, 176–183. doi:10.1016/j.biopsycho.2014.09.004

Owens, M., Stevenson, J., Hadwin, J. A., & Norgate, R. (2012). Anxiety and depression in academic performance: An exploration of the mediating factors of worry and working memory. *School Psychology International*, *33*, 443–449. doi:10.1177/0143034311427433

Passolunghi, M. C., Caviola, S., De Agostini, R., Perin, C., & Mammarella, I. C. (2016). Mathematics anxiety, working memory, and mathematics performance in secondary-school children. *Frontiers in Psychology*, *7*, 42. doi:10.3389/fpsyg.2016.00042

Passolunghi, M. C., Cargnelutti, E., & Pastore, M. (2014). The contribution of general cognitive abilities and Approximate Number System (ANS) in early mathematics. *British Journal of Educational Psychology*, *84*, 631–649. doi:10.1111/bjep.12054

Passolunghi, M. C., & Cornoldi, C. (2008). Working memory failures in children with arithmetical difficulties. *Child Neuropsychology*, *1*, 1–14. doi:10.1080/09297040701566662

Passolunghi, M. C., & Lanfranchi, S. (2012). Domain-specific and domain-general precursors of mathematical achievement: A longitudinal study from kindergarten to first grade. *British Journal of Educational Psychology*, *82*, 42–63. doi:10.1111/j.2044-8279.2011.02039.x.

Passolunghi, M. C., Lanfranchi, S., Altoè, G., & Sollazzo, N. (2015). Early numerical abilities and cognitive skills in kindergarten children. *Journal of Experimental Child Psychology*, *135*, 25–42. doi:10.1016/j.jecp.2015.02.001

Passolunghi, M. C., & Mammarella, I. C. (2012). Selective spatial working memory impairment in a group of children with mathematics learning disabilities and poor problem-solving skills. *Journal of Learning Disabilities*, *45*, 341–350. doi:10.1177/0022219411400746

Passolunghi, M. C., & Siegel, L. S. (2001). Short-term memory, working memory, and inhibitory control in children with specific arithmetic learning disabilities. *Journal of Experimental Child Psychology*, *80*, 44–57. doi:10.1006/jecp.2000.2626

Passolunghi, M. C., & Siegel, L. S. (2004). Working memory and access to numerical information in children with disability in mathematics. *Journal of Experimental Child Psychology*, *88,* 348–367. doi:10.1016/j.jecp.2004.04.002

Paulsen, D. J., Woldorff, M. G., & Brannon, E. M. (2010). Individual differences in non-verbal number discrimination correlate with Event-related Potentials and measures of probabilistic reasoning. *Neuropsychologia*, *48*, 3687–3695. doi:10.1016/j.neuropsychologia.2010.08.014

Peng, P., Namkung, J., Barnes, M., & Sun, C. (2016). A meta-analysis of mathematics and working memory: Moderating effects of working memory domain, type of mathematics skill, and sample characteristics. *Journal of Educational Psychology, 108*, 455–473. doi:10.1037/edu0000079

Piazza, M., Facoetti, A., Trussardi, A. N., Berteletti, I., Conte, S., Lucangeli, D., Dehaene, S., & Zorzi, M. (2010). Developmental trajectory of number acuity reveals a severe impairment in developmental dyscalculia. *Cognition, 116*, 33–41. doi:10.1016/j.cognition.2010.03.012.

Piazza, M., Izard, V., Pinel, P., Le Bihan, D., & Dehaene, S. (2004). Tuning curves for approximate numerosity in the human intraparietal sulcus. *Neuron*, *44*, 547–555.

Pinheiro-Chagas, P., Wood, G., Knops, A., Krinzinger, H., Lonnemann, J., Starling-Alves, I., Willmes, K., & Haase, V. G. (2014). In how many ways is the Approximate Number System associated with exact calculation? *PLoS ONE*, *e111155*. doi:10.1371/journal.pone.0111155

Ramirez, G., Chang, H., Maloney, E. A., Levine, S. C., & Beilock, S. L. (2016). On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies. *Journal of Experimental Child Psychology*, *141*, 83–100 doi:10.1016/j.jecp.2015.07.014

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory and math achievement in early elementary school. *Journal of Cognition and Development, 14*, 187–202. doi:10.1080/15248372.2012.664593

Reuhkala, M. (2001). Mathematical Skills in Ninth-graders: Relationship with visuo-spatial abilities and working memory. *Educational Psychology*, *21*, 387–399. doi:10.1080/01443410120090786

Roberts Jr., R. J., & Pennington, B. F. (1996). An interactive framework for examining prefrontal cognitive processes. *Developmental Neuropsychology*, *12*, 105–126. doi:10.1080/87565649609540642

Rubinsten, O., & Tannock, R. (2010). Mathematics anxiety in children with developmental dyscalculia. Behavioral and Brain Functions, 6, 46. doi:10.1186/1744-9081-6-46

Salbach-Andrae, H., Klinkowski, N., Lenz, K., & Lehmkuhl, U. (2009). Agreement between youth-reported and parent-reported psychopathology in a referred sample. *European Child & Adolescent Psychiatry*, *18*, 136–143. doi:10.1007/s00787-008-0710-z

Sasanguie, D., De Smedt, B., Defever, E., & Reynvoet, B. (2012). Association between basic numerical abilities and mathematics achievement. *British Journal of Developmental Psychology*, *30*, 344–357. doi:10.1111/j.2044-835X.2011.02048.x

Sattler, J. M. (1992). *Assessment of children's intelligence*. San Diego, CA: Academic Press.

Siegel, L., Pinkerton, N., Ford, L., & Anderson, A. (2012). The cognitive components of a mathematical disability: The influence of definitional variables. *Proceedings of the 36th Annual IARLD Conference*. Padua, Italy.

Soltész, F., Szűcs, D., & Szűcs, L. (2010). Relationships between magnitude representation, counting and memory in 4- to 7-year-old children: A developmental study. *Behavioral and Brain Functions, 6*, 1–14. doi:10.1186/1744-9081-6-13

Sorvo, R., Koponen, T., Viholainen, H., Aro, T., Räikkönen, Peura, P., Dowker, A., & Aro, M. (2017). Math anxiety and its relationship with basic arithmetic skills among primary school children. *British Journal of Educational Psychology*. doi:10.1111/bjep.12151

Temple, C.M., & Sherwood, S. (2002). Representation and retrieval of arithmetical facts: Developmental difficulties. *Quarterly Journal of Experimental Psychology*, *55*A, 733–752. doi:10.1080/02724980143000550

Thomas, G., & Dowker, A. (2000). Mathematics anxiety and related factors in young children. Paper presented at British Psychological Society Developmental Section Conference, Bristol (UK).

Toll, S.W. M., Van Viersen, S., Kroesbergen, E. H., & Van Luit, J. E. H. (2015). The development of (non-)symbolic comparison skills throughout kindergarten and their relations with basic mathematical skills. *Learning and Individual Differences*, *38*, 10–17. doi:10.1016/j.lindif.2014.12.006

Trezise, K., & Reeve, R. A. (2014). Working memory, worry, and algebraic ability. *Journal of Experimental Child Psychology*, *121*, 120–136. doi:10.1016/j.jecp.2013.12.001

Vukovic, R. K., Kieffer, M. J., Bailey, S. P., & Harari, R. R. (2013). Mathematics anxiety in young children: Concurrent and longitudinal associations with mathematical performance. *Contemporary Educational Psychology*, *38*, 1–10. doi:10.1016=j.cedpysch.2012.09.001

Wang, Z., Lukowski, S. L., Hart, S. A., Lyons, I. M., Thompson, L. A., Kovas, Y., Mazzocco, M. M. M., Plomin, R., & Petrill, S. A. (2015). Is math anxiety always bad for math learning? The role of math motivation. *Psychological Science*, *26*, 1863–1876. doi:10.1177/0956797615602471

Wechsler, D. (1991). *WISC-III. Wechsler Intelligent Scale for Children- Third Edition*. Italian Edition (2006). Firenze: Giunti O. S.

Weeks, M., Coplan, R. J., Kingsbury, A.The correlates and consequences of early appearing social anxiety in young children. (2009). *Journal of Anxiety Disorders*, *23*, 965–972. doi:10.1016/j.janxdis.2009.06.006

Wu, S. S., Barth, M., Amin, H., Malcame, V., & Menon, V. (2012). Math anxiety in second and third graders and its relation to mathematics achievement. *Frontiers in Psychology, 3*, 1–11. doi:10.3389/fpsyg.2012.00162

Wu, S., & Menon,V. (2012). *Scale for Early Mathematics Anxiety (SEMA) in Young Children*. Available at: http://mathbrain.stanford.edu/?q=publications.

Wu, S. S., Willcutt, E. G., Escovar, E., & Menon, V. (2014). Mathematics achievement and anxiety and their relation to internalizing and externalizing behaviors. *Journal of Learning Disabilities*, *47*, 503–514. doi:10.1177/0022219412473154

Xenidou-Dervou, I., De Smedt, B., van der Schoot, M., & van Lieshout, E. C. D. M. (2013). Individual differences in kindergarten math achievement: The integrative roles of approximation skills and working memory. *Learning and Individual Differences, 28*, 119–129. doi:10.1016/j.lindif.2013.09.012

Young, C. B., Wu, S. S., & Menon, V. (2012). The neurodevelopmental basis of math anxiety. *Psychological Science*, *23*, 492–501. doi:10.1177/0956797611429134

Table 1

Descriptive Statistics and Inter-Correlations Between All Variables

		Descriptive statistics						Zero-order correlations									
		Mean	*SD*	Min	Max	Skewness	Kurtosis	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1.	Intelligence	10.82	2.63	3.00	18.50	0.01	0.30	.19*	.26**	.13	.23**	.06	.04	.09	-.05	-.12	.33***
2.	Verbal WM (Backward word span)	1.89	1.32	0.00	5.00	0.20	-0.94	-	.39**	.13	.16*	.02	.10	-.06	-.16*	-.01	.21**
3.	Verbal WM (Backward digit span)	3.85	1.25	0.00	7.00	0.02	-0.23	-	-	.20**	.16*	.03	.02	-.02	-.26**	.07	.29**
4.	Visuo-Spatial WM (Path dual task)	6.27	1.71	0.00	8.00	-1.29	1.73	-	-	-	.10	.19*	.03	.07	-.01	.01	.21**
5.	Estimation	58.19	12.96	6.00	82.00	-1.27	2.59	-	-	-	-	.27***	.06	.12	-.10	-.05	.27**
6.	Approximate Comparison	26.94	3.64	16.00	36.00	-0.30	0.34	-	-	-	-	-	.26**	.03	-.11	-.03	.12
7.	Approximate Addition	17.60	2.67	7.00	23.00	-1.07	1.73	-	-	-	-	-	-	-.07	-.23**	-.13	.25**
8.	Anxiety-Self	7.03	3.79	0.00	20.00	0.53	-0.05	-	-	-	-	-	-	-	.15	.37***	<.01
9.	Anxiety-Observed	1.47	1.52	0.00	7.00	1.03	0.61	-	-	-	-	-	-	-	-	.09	-.29***
10.	Math Anxiety	14.44	11.00	0.00	57.00	0.89	0.86	-	-	-	-	-	-	-	-	-	-.10
11.	Composite Math Score	7.71	2.75	0.00	12.00	-0.77	0.28	-	-	-	-	-	-	-	-	-	-

Note. Min = minimum; Max = maximum; *SD* = standard deviation.
$^{\dagger}p < .10$, $*p \leq .05$, $**p \leq .01$, $***p \leq .001$.

Table 2

Blockwise Regression Model Predicting Math Performance From Cognitive and Affective Factors.

	B	*SE (B)*	*β*	*p*	R^2	ΔR^2
Block I – Cognitive Factors						
Step 1					.11***	-
Intelligence	0.11	0.03	.33	.000		
Step 2					.17***	.06**
Intelligence	0.11	0.03	.32	.000		
Approximate addition	0.08	0.03	.24	.001		
Step 3					.21***	.04**
Intelligence	0.09	0.03	.24	.002		
Approximate addition	0.08	0.02	.23	.002		
Backward digit span	0.15	0.05	.22	.005		
Step 4					.24***	.03*
Intelligence	0.08	0.03	.25	.002		
Approximate addition	0.08	0.02	.24	.002		
Backward digit span	0.14	0.05	.20	.010		
Estimation	0.01	0.01	.16	.028		
Step II – Affective Factors						
Step 5					.27***	.03*
Intelligence	0.09	0.03	.25	.001		
Approximate addition	0.06	0.02	.18	.011		
Backward digit span	0.10	0.05	.14	.063		
Estimation	0.01	0.01	.16	.035		
Anxiety-Observed	-0.11	0.05	-.18	.01		

Note. *SE* = standard error. Within each block, a stepwise procedure was adopted for variable selection. Inclusion criterion: $p \leq .05$; removal criterion: $p \geq .10$.
*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$.

Figure caption

Figure 1. Multiple Mediation Model.

Figure 1. Unstandardized coefficient of the mediation model between general anxiety (Anxiety-Obs) and math achievement (Math) through backward digit memory, approximate addition, and estimation (standard errors presented in parentheses). In squared parentheses, the total effect (with standard error) of Anxiety-Observed on Math. Dashed lines indicate non-significant paths. $^{\dagger}p < .10$, $^{*}p \leq .05$, $^{**}p \leq .01$, $^{***}p \leq .001$.