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Research Article

Math Self-Assessment, but Not Negative Feelings, Predicts Mathematics Performance of Elementary School Children

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Mathematics anxiety has been associated to performance in school mathematics. The association between math anxiety and psychosocial competencies as well as their specific contribution to explain school mathematics performance are still unclear. In the present study, the impact of sociodemographic factors, psychosocial competencies, and math anxiety on mathematics and spelling performance was examined in school children with and without mathematics difficulties. The specific contributions of psychosocial competencies (i.e., general anxiety and attentional deficits with hyperactivity) and math anxiety (i.e., self-assessment in mathematics) to school mathematics performance were found to be statistically independent from each other. Moreover, psychosocial competencies—but not math anxiety—were related also to spelling performance. These results suggest that psychosocial competencies are more related to general mechanisms of emotional regulation and emotional response towards academic performance, while mathematics anxiety is related to the specific cognitive aspect of self-assessment in mathematics.

1. Introduction

Negative feelings about mathematics are usually associated with low mathematics achievement both in children and adults [1]. Mathematics anxiety (MA) is a feeling of tension, apprehension, or fear that interferes with mathematics performance, or as a state of discomfort in response to mathematics which is perceived as threatening to self-esteem [2]. As math anxious individuals avoid engagement in math tasks, they dedicate less time and effort to learn mathematics, reach lower attainment levels, enroll less in mathematics courses from high school onwards, and eventually select majors with lower mathematics requirements [3]. MA is thus of potential social and economic relevance in a globalized culture that imposes greater and greater demands on science and technology abilities of individuals in career as well as in everyday life.

MA is related to more general forms of anxiety, but can be distinguished from them. For instance, Young et al. [4] found brain activity patterns specific of MA to be unrelated to general anxiety, intelligence, working memory, or reading ability. In that study, higher levels of activation were observed in the amygdala and other regions associated with emotional processing [4], while lower levels of activation were found in areas associated to number processing and working memory [5]. MA has been linked to performance-related anxiety disorders such as test anxiety and social phobia [6–8]. Research also indicates that the genetic etiology of anxiety disorders is unspecific, being shared by different anxiety syndromes [9]. However, the correlations between behavioral measurements of MA and other forms of anxiety have been found to range in the interval between .35 for general anxiety, .38 for trait anxiety, and .52 for test anxiety [3]. Data suggesting specificity of MA were obtained by Dew et al. [10, 11]. In that study, intercorrelations between three MA measures varied from .50 to .80, while correlations between MA and other forms of anxiety were substantially lower (r's from .30 to .50).

Aversive experiences with mathematics as well as the interaction between the individual's experience and vulnerability have been related to the occurrence of MA [8, 9, 12]. Two main vulnerability factors related to MA are female gender and low math achievement. There is a trend in females to report higher levels of MA [3, 13] despite equivalent achievement [14]. This has been associated with higher propensity of females to report feelings [8] and to social stereotyping [1, 14–16]. In an fMRI study, Krendl et al. [17] showed that in a neutral control condition, female participants activated usual frontoparietal math-related networks in response to math tasks. Under conditions of gender-stereotyped threat, math-related areas were inhibited, whereas the ventral anterior cingulate cortex was activated. Moreover, female reports on MA have been reported to be mediated by spatial cognitive ability, which is knowingly dependent on fetal androgen levels more than on social stereotyping [18].

Low mathematics achievement and developmental dyscalculia are other risk factors for MA. Results from two meta-analyses indicate that the correlations between MA and IQ are positive but low ($r = .17$). The association of IQ with math achievement is slightly stronger (r's between .27 and .34) [3, 13]. Several studies focused on the reversed causality direction in the assessment of the association between MA and achievement, but the results are inconsistent. Ma and Xu [19] observed that low math achievement at Grade 7 predicted high MA six years later, while the reverse was not true: initial MA was not statistically predictive of later low achievement. Krinzinger et al. [20] showed that children being assessed from the 1st to 3rd Grade do not present an effect of "math anxiety" [1] (Krinzinger et al. [20] used a two-factor model of math anxiety on the Mathematics Anxiety Questionnaire (MAQ, Krinzinger et al. [21]. The first factor describes self-evaluation and math-related attitudes ("evaluation of mathematics") while the second factor comprises negative emotions and worries concerning mathematics ("math anxiety").) on calculation ability or vice versa. In that study, initial low calculation ability was predictive of "evaluation of mathematics." Moreover, Rubinsten and Tannock [22] compared the performance of a group of dyscalculics with that of typically achieving children in an affective arithmetic priming task. Negative affect and arithmetic stimuli induced comparable priming effects in dyscalculics. In typically achieving children arithmetic priming was not observed.

Relationships between MA and mathematics achievement are complex and probably of two ways. For this reason, it is paramount to look not only at studies reporting effects of arithmetics achievement on anxiety levels but also at studies reporting effects of anxiety levels on arithmetics achievement. There is an evidence that MA may moderate the relationship between working memory and mathematics achievement in mathematics disabled undergraduates [23]. Moreover, in real-life situations, the impact of MA on mathematics achievement is mediated by cortisol levels associated with stress responses and anxiety [24]. Moreover, cognitive-behavioral interventions specifically addressing anxiety symptoms in mathematics disabled children have been shown to contribute to substantial improvement in mathematics achievement [25].

As MA probably originates from the interaction between individual vulnerability and experience in the early school years, it is necessary to investigate the specificity of the presumed vulnerability. Three main issues are addressed in this study. First, we investigated whether children with mathematics difficulties (MD) present higher levels of MA compared to typically achieving children (TA), as has been suggested by previous results [22]. Concretely, we expect children with MD to present higher levels of mathematics anxiety in the MAQ [21] when compared to matched TA children. Second, we tested whether MA can be dissociated from general anxiety proneness and psychosocial competencies in children, as suggested by previous studies with adults [3, 10, 11]. We expect that a significant effect of MA would still be present even after removing the impact of general anxiety proneness and psychosocial competencies on mathematics performance. Finally, we explored in more detail the specificity of MA in mathematics achievement comparatively to domains such as sociodemographic characteristics, psychosocial competencies, general cognitive abilities, and other nonmathematic academic subjects such as spelling ability. To examine the specificity of this relation, the impact of MA on domain-related arithmetics achievement as well as domain-unrelated spelling achievement was examined. We expect that MA should be specifically related to mathematics, but not to spelling achievement. This hypothesis will be tested by comparing the predictive strength of MA over performance in arithmetics and spelling tests. An effect of MA on arithmetics is expected to be significant while no significant effect of MA on spelling achievement should be detectable.

2. Materials and Methods

2.1. Participants. Samples were constituted by children with ages ranging from 7 to 12 years and attending from first to sixth grade. No differences between the performance-stratified groups were found regarding sex, age, and grade (Table 1). The study was approved by the local research ethics committee (COEP-UFMG). Only after giving informed consent in written form from their parents and orally from themselves, children were allowed to take part in the study.

Children were recruited from schools in Belo Horizonte and Mariana, Brazil. The proportion of children attending to private and public schools is representative of the sociodemographic characteristics of the population. In the first phase of group testing, only those children with normal intelligence (i.e., who scored above the 16th percentile in the Raven Colored Matrices Test) [26] were included in

Table 1: Descriptive data of TA and MD groups.

	TA		MD					
N	171		36		x^2	*df*	*P*	*w*
Sex (%male)	42.1		52.8		1.38	1	0.241	0.006
	Mean	SD	Mean	SD	*t*	*df*	*P*	*d*
Age (years)	9.5	1.14	9.28	1.27	1.05	205	0.293	0.190
Grade	3.39	1.15	3.08	1.05	1.45	205	0.148	0.270
Raven *z*-score	0.69	0.70	0.28	0.58	3.29	205	0.001	0.604
TDE arithmetic *z*-score	0.53	0.76	−0.90	0.47	14.66	79.7	<.001	2.690
TDE spelling *z*-score	0.67	0.56	0.05	0.58	5.99	205	<.001	1.100

TA: typically achieving; MD: mathematical difficulties; TDE: Brazilian school achievement test.

the study. These children also solved the arithmetic and spelling subtests of the Brazilian School Achievement Test (Teste do Desempenho Escolar, TDE) [27]. Those children scoring above the 25th percentile on both arithmetic and spelling subtests of the TDE were assigned to the typically achieving group (TA). The TA group consisted of 171 children. Children performing below the 25th percentile on arithmetics were assigned to the mathematical difficulties group (MD). Thirty-six children took part in the MD group (Table 1).

In a next step, psychosocial competencies and mathematical anxiety were individually assessed using the Child Behavior Checklist (CBCL) [28] and the Math Anxiety Questionnaire (MAQ) [29], see also [30], respectively. Children answered the MAQ individually, in an appropriate room on their schools. Parents filled out the CBCL in group also in their childrens' school.

2.2. Psychological Instruments

2.2.1. Brazilian School Achievement Test (TDE) [27]. The TDE is the most widely used standardized test of school achievement with norms for the Brazilian population [28, 29]. It comprises three subtests: arithmetics, single-word spelling, and single-word reading. In the screening phase, we used the arithmetics and spelling subtests, which can be applied in groups. Norms are provided for school-aged children between the first and sixth grade. The arithmetics subtest is composed of three simple verbally presented word problems (i.e., which is the largest, 28 or 42?) and 45 written arithmetic calculations of increasing complexity (i.e., very easy: $4 - 1$; easy: $1230 + 150 + 1620$; intermediate: 823×96; hard: $3/4 + 2/8$). Specific norms for each school grade were used to characterize children's individual performance. The spelling subtest consists of dictation of 34 words of increasing syllabic complexity (i.e., *toca*; *balanço*; *cristalização*). The spelling subtest was chosen as a marker for literacy because it can be performed in groups. Reliability coefficients (Cronbach α) of TDE subtests are .87 or higher. Children are instructed to work on the problems to the best of their capacity but without time limits.

2.2.2. Raven's Colored Progressive Matrices. General intelligence was assessed with the Brazilian version of Raven's Colored Matrices [26]. Children with general intelligence below the 16th percentile were not included in the sample.

2.2.3. Math Anxiety Questionnaire (MAQ). The math anxiety questionnaire is a well-known scale developed by Thomas and Dowker [31] for the assessment of anxiety towards mathematics in primary school children. The present study used a Brazilian Portuguese version of the MAQ that was developed and standardized by Wood and colleagues [32]. The Brazilian version of the MAQ contains 24 items that can be answered by children individually or in groups within 5 to 10 minutes. The items can be combined into four-base subscales ("self-perceived performance," "attitudes in mathematics," "unhappiness related to problems in mathematics," and "anxiety related to problems in mathematics") according to the authors of the original version [31]. Moreover, Krinzinger et al. [21] have shown that the four original subscales can be combined into two main scores called "self-perceived performance and attitudes" and "mathematics anxiety." The first one, named evaluation of mathematics, includes the first two subscales, while the second one, called math anxiety, combines the last two subscales. The MAQ items have the format of one out of four types of questions: "How good are you at ...;" "How much do you like ...;" "How happy or unhappy are you if you have problems with ...;" "How worried are you if you have problems with ...." Each question is to be answered regarding six different categories related to math, namely, mathematics in general; easy calculations; difficult calculations; written calculations; mental calculations; math homework. Children are encouraged by supportive figures to give their responses according to a Likert scale with 5 points. The higher the score, the higher the math anxiety. Reliability coefficients (Cronbach α) of MAQ in the German study range between .83 and .91 for the total scale, while in the Brazilian study reliability coefficients are .88 for the total scale; .74 for the "self-perceived performance in mathematics" subscale; .75 for the "attitudes in mathematics" subscale; .85 for the subscale "unhappiness related to problems in mathematics;" finally, .81 for the subscale "anxiety related to problems in mathematics" (see [32], this issue).

2.2.4. Child Behavior Checklist 6/18 (CBCL) [30]. The CBCL is a screening instrument answered by parents that is widely

Table 2: Regression coefficients for mathematics performance (after stepwise regression).

Predictor	Regression analysis for TDE arithmetics (r^2 = .31) Unstandardized coefficient *B*	Std. error	Std. coefficient Beta	Partial *t*	sig	% change in explained variance
Intercept	−0.594	0.81		−1.14	0.26	
Age	0.03	0.01	0.41	3.26	<.001	0.00
Sex	0.06	1.05	0.03	0.53	0.59	0.00
School grade	−0.26	0.10	−0.33	−2.62	0.01	3.00
Intelligence (Raven)	0.43	0.08	0.33	5.49	<.001	15.40
Attention deficit/hyperactivity scale*	−0.02	0.01	−0.18	−2.52	0.01	2.80
MAQ self-perceived**	−0.08	0.01	−0.35	−5.87	<.001	12.40

*CBCL's subscales guided by the DSM-IV; **MAQ's factor. TDE: brazilian school achievement test; MAQ: Math Anxiety Questionnaire; CBCL: children behavior checklist.

used in research and clinical sets. The CBCL is strongly associated with diagnoses guided by international diagnostic manuals such as DSM-IV [33]. The CBCL is divided into two independent parts. The first part consists of a range of psychosocial competencies and the second part consists of 113 items in which the parents answer about behavioral, emotional, and social adjustment of the child. Eight syndrome scales derived from exploratory and confirmatory factor analysis are extracted. In addition to the syndrome scales, there are the DSM-oriented scales, built through a clinical consensus of the items by experienced psychiatrists and psychologists, among them the scales "anxiety problems" and "attention deficit/hyperactivity problems." CBCL data were compared with international norms obtained in a multicultural study (group 3 in [34]), for which there is data on the comparability of the Brazilian population [35].

3. Results

3.1. Single Comparisons. *t*-tests were used to compare TA and MD groups regarding general anxiety and math anxiety. Degrees of freedom were corrected for in homogeneities of variance when the associated Levene's test was significant.

The typically achieving group presented substantially higher levels of performance in arithmetics and spelling than MD children. MD children presented spelling abilities in the normal range (all children >25th percentile). Moreover, no difference between TA versus MD children was observed in CBCL subscales (all *P* values higher than .124). Finally, the self-perceived performance subscale of the MAQ revealed group differences between TA and MD children. Group comparison showed substantially more positive self-evaluation in the TA group when compared to MD children ($t(205) = -3.64$; $P \leq .001$; $d = -.067$). Other factors of the MAQ were nonsignificant, all *P* values higher than .136.

To assess more precisely the specific contribution of psychosocial competencies and mathematics anxiety on arithmetics and spelling abilities, a range of regression models was calculated.

3.2. Regression Analysis. In a second analysis, the specific impact of the different scales of general anxiety as well as of math anxiety on school performance was evaluated in a range of hierarchical multiple-regression models. Separate models were calculated for mathematics and spelling performance. Modelling the impact of general anxiety and mathematics anxiety on measures of spelling performance served to test the specificity of the effect of math anxiety on mathematics performance. While measures of general anxiety should contribute to explain the variance in both mathematics and spelling performance, MAQ scales should be specifically related to mathematics performance and not to spelling performance. For this reason, the last range of models serves to investigate the specificity of the association between math anxiety and school performance on mathematics. Data from TA and MD groups were combined in this analysis. In the first step, general factors predicting individual differences in school performance were included in the regression models. These were sociodemographic factors (gender, school grade, and age) as well as general intelligence. In a second step, those among the six scales of the CBCL which explained specific variance were added to the model (stepwise method). The same procedure was adopted in the third step, when the four MAQ scales were added to the model. The stepwise method was used in the second and third steps to avoid redundant predictors entering the model and producing overfitting.

Table 2 shows the results from the final stepwise regression model calculated for mathematics performance. Although the amount of explained variance in arithmetics achievement was low, regression models revealed that age, school grade, general intelligence as well as attentional deficits and hyperactivity, and self-perceived performance in mathematics contributed independently to explain mathematics performance in TA and MD children.

Table 3 shows the results from the final stepwise regression model calculated for spelling performance. Although the amount of explained variance in spelling performance was low, regression models revealed that general intelligence as well as attentional deficits and hyperactivity contributed independently to explain spelling performance in TA and MD children.

3.3. Path-Analysis Models. As a complement to the results obtained in the regression analyses, path-analyses including

Table 3: Regression coefficients for spelling performance (after stepwise regression).

Predictor	Regression analysis for TDE spelling (r^2 = .14)					
	Unstandardized coefficient		Std. coefficient	Partial t	sig.	% change in explained variance
	B	Std. error	Beta			
Intercept	0.94	0.63		0.49	0.14	
Age	0.001	0.01	0.02	0.11	0.92	0.00
Sex	0.09	0.08	0.07	0.11	0.27	0.50
School grade	0.03	0.08	0.05	0.33	0.74	0.00
Intelligence (Raven)	0.21	0.06	0.24	0.45	0.001	7.50
Attention deficit/hyperactivity scale*	−0.02	0.00	−0.21	3.15	<.001	4.30

* CBCL's subscales guided by the DSM-IV. TDE: Brazilian School Achievement Test; CBCL: children behavior checklist.

Table 4: Fit statistics for path models regarding arithmetics and spelling performance.

Arithmetic performance	CMIN	df	P	RMR	GFI	AGFI	CFI	RMSEA
Null model	95	10	0	1.915	0.899	0.638	0.816	0.203
Raven-MAQ (sp)	88	9	0	1.462	0.916	0.664	0.829	0.207
Raven-Arith	53	8	0	1.421	0.942	0.737	0.904	0.164
CBCL (anx)-Arith	52	7	0	1.415	0.943	0.709	0.903	0.176
CBCL (ADH)-Arith	45	6	0	1.401	0.953	0.719	0.915	0.178
MAQ (sp)-Arith	10	5	0.08	1.391	0.989	0.919	0.990	0.067
CBCL (anx)-MAQ (sp)	7.5	4	0.110	1.148	0.991	0.92	0.992	0.066
CBCL (ADH)-MAQ (sp)	7.5	4	0.110	1.148	0.991	0.92	0.992	0.066
Spelling performance	CMIN	df	P	RMR	GFI	AGFI	CFI	RMSEA
Null model	48	10	0	1.874	0.944	0.800	0.907	0.136
Raven-MAQ (sp)	41	9	0	1.408	0.954	0.817	0.921	0.132
Raven-Spell	25	8	0.001	1.399	0.970	0.864	0.958	0.102
CBCL (anx)-Spell	25	7	0.001	1.400	0.970	0.845	0.956	0.112
CBCL (ADH)-Spell	13	6	0.049	1.387	0.985	0.912	0.984	0.073
MAQ (SP)-Spell	10	5	0.086	1.386	0.989	0.919	0.989	0.067
CBCL (anx)-MAQ (sp)	7.5	4	0.110	1.144	0.991	0.920	0.991	0.066
CBCL (ADH)-MAQ (sp)	7.5	4	0.110	1.144	0.991	0.920	0.991	0.066

CMIN: minimum value; RMR: root mean square residual; GFI: goodness of fit index; AGFI: adjusted goodness of fit index; CFI: comparative fit index; RMSEA: root mean square error of approximation. MAQ (sp): self-perceived performance factor of MAQ; arith: arithmetic subtests of TDE; Spell: spelling subtests of TDE CBCL (anx): anxiety subscale of CBCL; CBCL (ADH): attention deficit hyperactivity subscale of CBCL.

demographic and cognitive factors as well as general anxiety and math anxiety were calculated separately for spelling and mathematics performance. These models included only the subscales among those subscales of the CBCL and MAQ, which exerted a specific contribution to explaining variance in mathematics or spelling performance in the regression models. As regarding regression models, path models evaluating the impact of MAQ on spelling performance served as a control measure for unspecific associations between the MAQ and school performance. To estimate the strength of the effects of general anxiety and math anxiety on mathematics and spelling performance, a range of path models was calculated and compared. As indexes of model quality regarding the fit of single models, the Chi-square and the approximate fit indexes *RMR*, *GFI*, *AGFI*, *CFI*, and *RMSEA* [36] were used. In this context, a nonsignificant Chi-square reveals that the discrepancy between data and model specifications are negligible. The *RMR* evaluates the proportion of residuals in comparison to the covariances accounted for by the models. Values smaller than .1 are considered adequate. *GFI*, *AGFI*, and *CFI* evaluate, respectively, the degree of misspecification present on the model. Generally, values over .95 and .90 are accepted as good. A value above .95 is considered good for the *CFI* as well. Finally, the Root mean square error of approximation, or *RMSEA*, considers the model complexity when evaluating model fit. The *RMSEA* is considered acceptable, when it is lower than .05. The Chi-square difference between models was employed to compare models with an increasing amount of free parameters. Models were calculated in the software AMOS v.19 using the maximum likelihood estimation function.

Fit statistics of path models are shown in Table 4. The null models described in Table 4 only included covariances between sociodemographic variables, general cognitive abilities, and psychosocial competencies, but no directed path from a variable to another. Further path models are designated by the paths added to them, which were not present in the previous models in the row.

Table 4 reveals that very satisfactory model fit was reached both in the case of mathematics (model MAQ (self-perceived)-Arith, Figure 1(a)) and spelling abilities (model CBCL (ADH)-Spell, Figure 1(b)). Model MAQ (self-perceived)-Arith depicts the effects of general intelligence on mathematics self-perceived performance and mathematics achievement. A large amount of residuals as indicated by the *RMR* cannot be accounted by the variables inserted in the model; however, the nonsignificant Chi-square and the other indices of approximate fit yielded acceptable values for both models MAQ (self-perceived)-Arith and CBCL (ADH)-Spell. Although in both cases the values obtained in the *RMSEA* are slightly above the acceptable levels (Table 3), it may be associated to the low number of degrees of freedom in the model and does not invalidate the results [36]. Importantly, the nonsignificant Chi-square cannot be attributed to a lack of power to detect discrepancies between data and model structure, since the sample size $n = 207$ employed in the present study is sufficient to guarantee enough statistical power.

In the model MAQ (self-perceived)-Arith, attentional deficits and hyperactivity as well as mathematics self-perceived performance also have specific effects on arithmetics performance. Finally, mathematics self-perceived performance is statistically independent from general anxiety and attentional deficits and hyperactivity. Most importantly, however, is that MAQ scores were important in predicting the arithmetic scores, and not at all important for spelling scores.

Model CBCL (ADHD)-Spell depicts the effects of general intelligence on mathematics self-perceived performance and spelling performance. Moreover, attentional deficits and hyperactivity (but not mathematics self-perceived performance) showed specific effects on spelling performance. MAQ self-perceived performance scores were not relevant for predicting the spelling scores. This is indicative that this MAQ subscale is not evaluating self-perceived performance in an unspecific way but rather seems to be specifically related to the domain of mathematics.

4. Discussion

In the present study the association of math anxiety and more general forms of anxiety as well as their specific contribution to arithmetics achievement were examined. Group comparisons revealed that the children between 7 and 12 years old with and without mathematics difficulties show comparable levels of psychosocial competencies and general anxiety, as assessed by the CBCL. As expected, children with mathematics difficulties also present much lower levels of self-perceived performance for mathematics than typically achieving children. Moreover, in typically achieving children, age, school grade, general intelligence, attentional deficits, and hyperactivity as well as self-perceived performance in mathematics contributed independently to explain mathematics achievement. A different pattern of results was observed for spelling performance. Here, general intelligence, attentional deficits and hyperactivity, and general anxiety contributed independently to explain spelling performance. These results indicate that both hyperactivity/inattention as well as mathematics specific forms of self-assessment predict mathematics performance. Moreover, these results show that self-perceived performance for mathematics as measured by the MAQ is specific for mathematics abilities since it does not predict spelling performance. In summary, the results suggest that mathematics performance is associated with different forms of anxiety. Some more general anxiety, which impair performance not only in mathematics but also in other academic abilities such as spelling, and others more specific, which are directly related to self-perceived performance in mathematics. In the following, these results will be discussed in more detail.

MD children show lower levels of self-perceived performance in mathematics when compared to TA. Following the rationale examined by Krinzinger et al. [21], this scale is more associated to self-assessment of and attitudes towards mathematics. Interestingly, the subscales of the MAQ reflecting unhappiness and anxiety for mathematics presented no significant differences between groups. Some recent studies suggest the presence of such differences [37, 38]. Those authors found associations of MA and math performance in early graders with combined measures of MA. Nevertheless, in these studies it is impossible to dissociate between the specific impact of cognitive and affective components of MA on the reported associations such as in the present study, where four separated dimensions of MA can be distinguished. For this reason, the positive results by Ramirez et al. [37] and Wu et al. [38] should be interpreted cautiously, since it is impossible to determine whether the positive differences obtained should be attributed to cognitive, affective, or both components of MA.

None of the CBCL subscales revealed any significant difference between MD and TA children. Moreover, comparatively to TA individuals, children with MD in our study do not exhibit performance differences in aspects of psychosocial functioning such as attention deficit/hyperactivity and general anxiety and math anxiety levels. One possibility is that our participants are still of a relatively young age for these effects to take over. Literature indicates that it takes some time to build up the psychosocial negative consequences of persistent math failure [39]. For instance, Auerbach and colleagues [39] assessed dyscalculic children from 10/11 years of age to the age of 16/17 years. At the age of 16/17 years, dyscalculics exhibited higher mean levels of maladjustment in several CBCL and Youth Self-Report scales, most notably those pertaining to both internalizing and externalizing disorders, while no significant statistical differences between persistent and non persistent dyscalculics were present in the initial assessment at 10/11 years old. These results suggest that at the assessed ages children with mathematics difficulties are not necessarily less adjusted in behavior, cognition, or affect than the average TA children. These findings are in line with fMRI evidence on specific patterns of neural activation related to math anxiety but not to other more general processes [4].

Moreover, a significant association between self-perceived performance and math attainment must be analyzed in the context of the development of self-perceptions in school children. Children may have some difficulty making

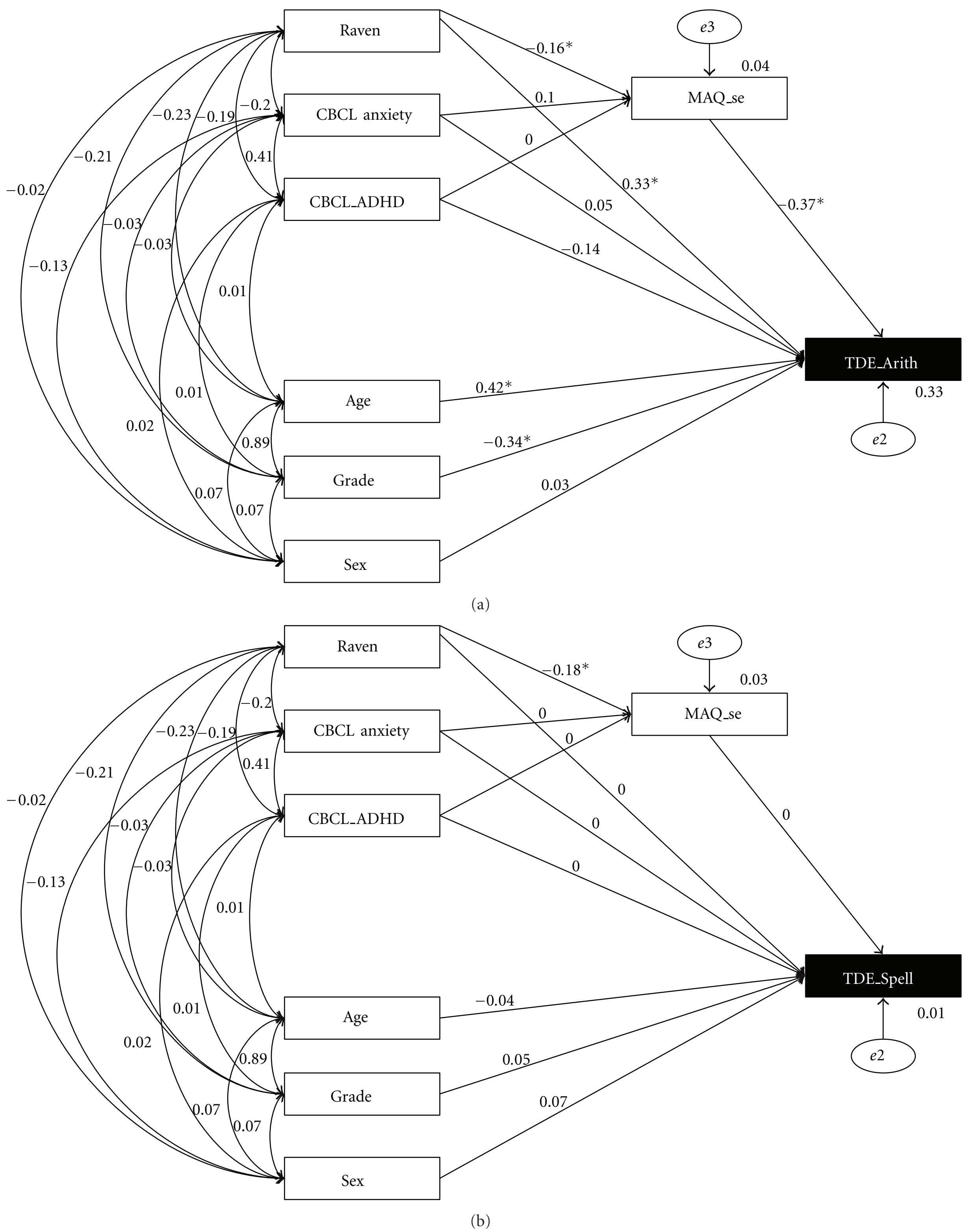

Figure 1: Path-analyses models describing the effects of sociodemographic factors, psychosocial competencies as well as self-perceived performance in mathematics on arithmetics, and spelling performance. Paths marked with * are statistically significant.

realistic assessment of their performance early in the elementary school [40]. For example, in a study by Nicholls [41], correlations between self-assessments and reading attainment raised from virtually nonexistent in the first grade to around 0.70 in the sixth grade (see also [42]). Other evidence indicates that it is not until 11–13 years old that performance begins to systematically benefit from error-related feedback [43]. Our results are, however, more in line with other research showing that from 7 or 8 years onward, children are able to make self-assessments of performance which are more similar to those of their teachers [44, 45]. These results have an important implications for the motivation to learn mathematics. Self-assessment is an important motivational factor [46], which may be an antecedent to more affective aspects of MA observable in high school and college [19, 47], presumably as the math curriculum is more demanding and self-assessments more unfavorable to many students.

The present results regarding the ability of young children to assess their own performance in mathematics are in line with those presented by Krinzinger and coworkers [20]. These authors showed that low calculation ability in the first grade was predictive of "evaluation of mathematics" in the third grade, a composite measure of two MAQ scales: self-perceived performance and attitude. Ma and Xu [19] also found that prior low math achievement in adolescents is predictive of higher levels of MA assessed by questions tapping on more affective components. This discrepancy suggests that it may take some time until the affective consequences of low performance on MA accrue.

Regression analyses conducted in the present study complemented the pattern of results by looking at the predictive value of sociodemographic and general cognitive factors, psychosocial competencies, and mathematics anxiety on arithmetics and spelling achievement. After removing the effects of age, general intelligence, and school grade from data, one still is able to detect specific effects of attentional deficits and hyperactivity as well as of mathematics self-perceived performance on arithmetics performance. This suggests that the impact of hyperactivity and mathematics self-perceived performance on arithmetics performance cannot be reduced to general aspects of cognition, age, gender, or sociodemographic differences in TA children (see also [37, 38]).

The impact of hyperactivity symptoms and mathematics self-perceived performance on arithmetics achievement has very different meanings. Attentional deficits and hyperactivity are associated with lower achievement not only in arithmetics but also in spelling. In the literature, many reports support these results [48, 49]. Interestingly, affective problems and general anxiety also have been associated with lower spelling performance in the present study. These results can be interpreted as a less-specific effect of psychosocial competencies on school performance, since spelling abilities are necessary in almost all topics taught in school. However, we cannot offer a more definitive answer to this question based on our data alone. Moreover, mathematics self-perceived performance impacts on arithmetics performance in a very specific way. The regression analysis of spelling performance revealed no effect of mathematics self-perceived performance on spelling performance. The comparison of this result with the significant effect of mathematics self-perceived performance on arithmetics reveals that there is an effect of mathematics anxiety on arithmetics performance that cannot be reduced to the impact of more general level of anxiety or psychosocial competencies.

Path-analysis models also have corroborated the results of regression analyses that there is an effect of mathematics self-perceived performance on arithmetics achievement. Another important aspect of path-analyses is that the construct of mathematics self-perceived performance was found to be statistically independent from psychosocial competencies in 7–12 years old children. Among the different facets of mathematics anxiety, only the particular aspect of mathematics self-perceived performance was associated to arithmetics performance in a specific way. The perception of cognitive resources, knowledge, and competencies to solve arithmetics problems explained individual differences in arithmetics performance, which cannot be accounted by any specific aspect of general psychosocial competencies. Absence of effects of general anxiety on math performance suggests that the MA is a subject-specific phenomenon, in line with previous research in adolescents and college students [3, 13].

The MA construct as assessed by the MAQ is a complex one, composed of several cognitive and affective components. Lack of association between math achievement and performance on the scale assessing the more affective or dysphoric component of MA deserves explanation. Children with lower achievement in math may be using a coping strategy of "insulating" or detaching themselves from their difficulties in order to resolve internal conflict. Testing of this hypothesis would require further studies focusing on the coping processes employed by MD children. Nevertheless, it is positive news that low mathematics performance may not immediately elicit negative feelings towards mathematics. This may favor early training and support procedures, which may prevent that low mathematics performance triggers a circle of anxiety and avoidance towards mathematics.

5. Conclusions

MA can be reliably assessed in elementary school children and its correlates are specific as no evidence for an early association between general anxiety, literacy, and math performance is present in 7–12 years old children. Moreover, MA comprises both cognitive and affective components. Low mathematics performance may be detected by children already in the early school grades. However, it may take a considerable time for that to increase so much anxiety towards mathematics that more general psychosocial competencies also would be compromised.

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