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An investigation of boys' and girls' emotional experience of math, their math performance, and the relation between these variables

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Abstract Gender differences in children's emotional experience of math, their math performance, and the relation between these variables were investigated in two studies. In Study 1, test anxiety, math anxiety, and math performance (whole-number computation) were measured in 134 children in grades 3–8 (ages 7–15 years). In Study 2, perceived math competence, math anxiety, and math performance (whole-number computation) were measured in 208 children in grades 3–6 (ages 8–13 years) using data from the study of Jansen et al. (*Learning and Individual Differences, 24*, 190–197, 2013). Gender differences occurred only in test anxiety (boys had lower test anxiety than girls). Concerning the relationship between emotional experience of math and math performance, math anxiety and math performance were negatively related, but only for girls, even when controlled for test anxiety (Study 1). However, only the relation between perceived math competence and math performance was significant in Study 2, for both boys and girls. The relation between math anxiety and math performance was not significant in this study after controlling for perceived math competence. Therefore, we might conclude that perceived math competence is a crucial variable when investigating children's emotional experience concerning math.

Keywords Gender · Math performance · Age groups · Math anxiety · Perceived math competence

Developing adequate math skills is important. Math is not only merely an important factor for success in natural sciences such as physics and chemistry but also to function adequately in daily life. Although gender differences have decreased and some studies suggest that there are almost no gender differences in levels of math achievement (Else-Quest et al. 2010; Hyde et al. 2008; Lindberg et al. 2010; Meelissen and Luyten 2008), there is still a gender gap in attitudes

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and beliefs related to math. Females tend to underestimate their achievements in math (Else-Quest et al. 2013; Lloyd et al. 2005) and many other academic areas (Gentile et al. 2009; Weiss et al. 2003), although cross-national differences are substantial (Else-Quest et al. 2010). Females' lack of self-confidence might influence their performance and be related to developing anxiety for natural sciences. Given the importance of the gender gap in attitudes and beliefs, this research is focused on how the relation between math performance, math anxiety, and perceived math competence differs between boys and girls.

According to Ashcraft (2002), math anxiety can be defined as "a feeling of tension, apprehension, or fear that interferes with math performance" (p. 13), which has negative consequences for math performance (Devine et al. 2012; Hembree 1990) and self-concept (Meece et al. 1990). Math anxiety negatively affects math performance in a direct and an indirect way. Since math anxiety is accompanied by negative thoughts and worries, it works as a dual task setting. The negative thoughts and worries are considered as resource-demanding secondary tasks and therefore reduce the available working memory capacity (Ashcraft and Krause 2007; Ashcraft and Moore 2009). Indirectly, people with high math anxiety avoid math courses and situations that require calculations (Ashcraft 2002) and as a consequence have less practice and become low achieving. Similarly, a distinction is made between state (momentary) and trait (habitual) math anxiety (Goetz et al. 2013). Trait math anxiety is assessed in the present study. Since low math scores could also lead to math anxiety (Ma and Xu 2004), a reciprocal relation between math performance and math anxiety can be assumed and is supported by meta-analysis (Hembree 1990).

So far, the majority of published studies in Western societies have demonstrated that girls reported higher levels of trait math anxiety and negative attitudes towards math than boys (Frenzel et al. 2007: sample size of more than 2000 German participants; Goetz et al. 2013: sample size of almost 700 German participants; Hembree 1990: meta analyses). However, instructional and cultural practices can differ among countries, possibly affecting the prevalence of math anxiety (Mullis et al. 2005) and the gender gap in math anxiety. The present study was conducted in the Netherlands. In comparison with other countries, math anxiety in the Netherlands is relatively low (Lee 2009), but the gender difference, with girls reporting higher levels of math anxiety, is notable (effect size of $d=-.38$, in a sample of 15-year-olds; Else-Quest et al. 2010).

Test anxiety might be an alternative explanation for the relation between math performance and math anxiety. Test anxiety is a form of performance anxiety and can be defined as perceived feelings of worry and physiological overarousal for test situations. A correlation between test and math anxiety is not surprising because math anxiety questionnaires also ask for behavior during math test situations with a time limit and in which grades matter. However, since math anxiety measures are more strongly related to each other than to test anxiety measures (Dew et al. 1984), it can be assumed that test and math anxiety are two different constructs. Given the shared features of test and math anxiety and the finding that girls report higher levels of test anxiety than boys (e.g., Cassady and Johnson 2002), it is important to take test anxiety into account when investigating gender differences in the relation between math anxiety and math performance, as was done by Devine et al. (2012). Their study, conducted with secondary school children, showed that girls' math anxiety scores were higher than boys' and that the relation between math anxiety and math performance differed between boys and girls. For girls, there was a negative relation between math anxiety and math performance, which was in contrast with boys for whom this relation was weak and did not exist when test anxiety was included. Despite the importance of controlling for test anxiety, few other studies have included this variable. Furthermore, few studies have made a distinction between state and trait math anxiety with state math anxiety referring to the anxiety experienced while doing math and trait math anxiety referring to the habitual anxiety for math.

Girls' generally higher level of math anxiety compared to boys' is not always matched by a similar difference in math performance (e.g., Devine et al. 2012). Evidence for gender differences in math performance is mixed. Most striking about these gender differences is that girls tend to outperform boys in terms of math grades (Pomerantz et al. 2002) but do not perform better and sometimes perform even worse on math achievement tests (Duckworth and Seligman 2006; Kenney-Benson et al. 2006; Preckel et al. 2008). Again, cross-national differences are significant. In the Netherlands, the gender difference in math achievement is small (effect sizes ranging from −.03 to .19 in two large samples of eighth graders and 15-year-olds; Else-Quest et al. 2010). This disagreement between gender differences in performance and in math anxiety and the finding that the relation between math anxiety and math performance is stronger for girls than for boys could be explained by higher math anxiety of girls manifesting in particular in test situations. This hypothesis however does not match the results of Goetz et al. (2013) that girls report higher trait but not state math anxiety, compared to boys. Unfortunately, there are not many studies assessing math anxiety both outside a test situation (trait math anxiety) and in a test situation (state math anxiety).

Math self-concept is less limited to test situations but, in line with the gender differences in math anxiety, math self-concept tends to be lower for girls than that for boys (Kenney-Benson et al. 2006; Marsh and Yeung 1998). Self-concept is considered as a general and global assessment of self-attitudes (Huang 2013) and its precursor is self-efficacy, which refers to one's ability to complete a specific task. Perceived competence is central in these concepts (Bong and Skaalvik 2003). Whereas math anxiety is a true emotional measure, math self-concept is a motivational measure. However, math anxiety and perceived math competence are closely linked (Pietsch et al. 2003) and both are subjective personal evaluations, in contrast to the cognitive measure math performance. Therefore, we treat both math anxiety and math self-concept as indicators of the emotional experience of math.

It has been shown that perceived math self-concept and self-efficacy predict math performance (Liu 2009; Marsh et al. 2005), although the relation is probably reciprocal (Guay et al. 2003; Marsh et al. 2005; Marsh and Craven 2006; Marsh and Martin 2011). Girls' estimation of their math competence tends to be lower than boys' (Goetz et al. 2013). In the Netherlands, math self-concept is relatively high (Lee 2009), but gender differences are remarkable (effect sizes between .39 and .55 for two large samples of eighth graders and 15-year-olds; Else-Quest et al. 2010). Hence, math self-concept seems to be an important factor to take into account when studying gender differences in the relationship between the emotional experience of math and math performance. Furthermore, math self-concept and self-efficacy influence course choices (Betz and Hackett 1983; Nagy et al. 2006) and even career choices (Lent et al. 1986; Zeldin and Pajares 2000). Indeed, in spite of the relatively high math self-concept in the Netherlands, Dutch statistics do show that men are overrepresented in technical studies and occupations compared to women (CBS 2013).

We study gender differences in the relation between emotional experience of math and math performance in two studies, in samples of children with a wide age range. A wide age range (7–15 years in Study 1; 8–13 years in Study 2) is selected because age-related changes in emotional experience of math are conceivable. Since math anxiety is not an innate characteristic, it might be assumed that math anxiety emerges after math instruction and evaluation of math performance through marks at school. Possibly, math anxiety is absent before math instruction and only develops in the early school years (Gierl and Bisanz 1995; Krinzinger et al. 2009; Ramirez et al. 2013). Also, prior research demonstrated that children's self-concept in all areas increases between grades 3 and 6 (Cole et al. 2001).

In Study 1, with a design similar to that of Devine et al. (2012), math performance, math anxiety, and test anxiety are assessed, whereas Study 2 concerns measurements of math performance, math anxiety, and perceived math competence. For Study 2, data were used from Jansen et al. (2013), which were collected for different purposes. We expect math anxiety and math performance to be negatively related and the relation to be stronger for girls than for boys. Next, we expect a positive relation between perceived math competence and math performance and again, this relation may be stronger for girls than for boys (Goetz et al. 2013). Finally, we expect to replicate previous findings by observing gender differences in math anxiety (higher for girls compared to boys), perceived math competence, and math performance (both lower for girls compared to boys).

Study 1

Method

Participants A total of 135 children participated, with an age range from 7 to 15 years. One participant was removed from the sample because the participant's age was unknown. The remaining sample consisted of 134 children; 69 (34 boys and 35 girls) were children from two primary schools and 65 (39 boys and 26 girls) were children from one secondary school. The schools were located in the southern and western part of the Netherlands. Children from primary school were 16 children in third grade (mean age=9.07 years, SD=.69), 19 children in fourth grade (mean age=9.87 years, SD=.75), and 34 children in sixth grade (mean age= 11.91 years, SD=.64). Secondary school students attended pre-university education. Primary school in the Netherlands starts at the age of 4 and generally ends 8 years later, when children attend secondary school. Secondary school has three levels: preparatory vocational, senior general education, and pre-university education, in order of increasing level. In the latter two, math is compulsory. There were 23 children in seventh grade (mean age=12.65 years, SD=.55) and 42 children in eighth grade (mean age=13.72 years, SD=.50). Parents and guardians were informed in a letter and could refuse participation of their child by filling out an answer sheet. Procedures were approved by the Ethics Committee of the Psychology Department.

Gender distribution of the sample, 47 % girls and 53 % boys, generally matched the gender distribution of children in the Netherlands, 49 % girls and 51 % boys (CBS 2013). The distribution among ethnic groups in the primary schools as well as the secondary school did not match the distribution in the general population in the Netherlands, since children of non-Dutch origin were overrepresented: 64 % of the children in one primary school were of non-Dutch origin, 48 % of the children in the other primary school were of non-Dutch origin, and 29 % of the secondary school students were of non-Dutch origin. For comparison, 9 % of the Dutch population is of non-Dutch origin.

Material

Math performance Math performance was measured with the Arithmetic Number Fact Test (Tempo Test Rekenen, TTR; De Vos 2002), hereafter referred to as "Math test." The test consists of five columns and each column contains 40 problems, which makes a total of 200 problems. Each column consists of problems of one operation: addition, subtraction, multiplication, and division. The last column, the fifth, contains a mixture of the operations mentioned above. Children were allowed to work for exactly 1 min per column. The total number solved correctly constituted the total score.

Test anxiety Test anxiety was measured with the subscale self-confidence in exams of the Dutch school questionnaire (School Vragenlijst; Smits and Vorst 2013). The scale consists of 16 statements. An example of a statement is “When I take an exam, then I think I will do well,” with response options “1—That is true, 2—I do not know, and 3—That is not true.” Participants selected the response option that applied most to them. Scores are reversed for negatively framed questions. Scores ranged from 16 to 48, with higher scores indicating higher test anxiety. If the total of unanswered questions was 3 or lower, the score was corrected by multiplying the participant’s average by the total number of questions. Data from children who missed more than three questions of the test anxiety questionnaire were to be excluded from further analyses; however, this did not occur in our sample.

Math anxiety Math anxiety was measured with a Dutch translation of the Math Anxiety Scale for Children (MASC; Chiu and Henry 1990). The original MASC consists of 22 items, each describing a situation that relates to math (e.g., “Being given a math quiz that you were not told about”). Participants indicated their degree of anxiety in the described situation on a 4-point-scale ranging from “not nervous” to “very nervous.” In the translation (the MASC-NL; introduced in Jansen et al. 2013), one situation was removed because it was uncommon for Dutch schools (“Using the tables in the back of a math book”). To compensate, two situations were added (“You need to solve the math problem which is hidden in a story”; “You do not understand a math problem”). In total, the MASC-NL consisted of 23 items. Scores, therefore, ranged from 23 to 92, with a higher score indicating a higher level of math anxiety. For missing data, the same procedure was followed as for the test anxiety questionnaire. None of the children left more than three questions unanswered.

Procedure The two questionnaires, concerning test anxiety and math anxiety, and the math test were group administered in the participants’ classrooms. Questionnaires were always administered immediately one after another, with administration of the math test before or after the questionnaires. The order of the two questionnaires differed between participants. Therefore, there were four orders in which questionnaires and math test were administered. At the beginning of each test, examples using sample questions were used. After participants had completed the questionnaires and math test, they received an exit questionnaire to inquire whether they had completed the questionnaires seriously. Children received sweets as a reward for participation.

Results

Age- and gender-related differences in emotional experience of math and math performance Test anxiety, math anxiety, and math test scores were compared between the different orders of assessment by performing a multivariate ANOVA. The effect of order was not significant, indicating that order of assessment did not affect scores on any of the instruments. Thus, scores of different orders were collapsed. Descriptive statistics for boys’ and girls’ scores on test anxiety, math anxiety, and math test scores are displayed by grade in Table 1. Because an ANOVA showed no significant differences in math test scores between grades 3 and 4, F (1, 33)=.284, p=.60, and average age in these grades differed less than one year from each other, we considered these groups as one combined grade. A chi-square test

Table 1 Means and standard deviations (SD) for age, math test scores, test anxiety scores, and math anxiety scores for boys and girls by grade

	Grade				
	3–4	6	7	8	Total
N	35	34	23	42	134
Boys (%)	46	47	57	62	53
Age	9.5 (.82)	11.9 (.64)	12.7 (.55)	13.7 (.50)	12.0 (1.74)
Math test scores					
Boys	79.6 (21.15)	130.1 (21.38)	137.5 (16.30)	146.5 (21.03)	126.1 (32.77)
Girls	79.0 (23.97)	113.5 (19.25)	133.6 (21.24)	140.3 (17.11)	113.1 (31.94)
Test anxiety scores					
Boys	36.1 (3.90)	35.9 (4.16)	35.0 (4.10)	35.0 (3.78)	35.4 (3.90)
Girls	36.1 (4.31)	37.9 (2.97)	38.2 (3.29)	39.3 (2.78)	37.7 (3.57)
Math anxiety scores					
Boys	44.7 (12.69)	39.3 (12.82)	40.2 (11.60)	38.2 (9.12)	40.3 (11.34)
Girls	43.1 (12.11)	39.7 (9.76)	36.6 (6.85)	38.6 (8.40)	40.0 (9.89)

was performed to determine whether boys and girls were equally distributed across (combined) grades. The chi-square test was not significant, meaning that age and gender were independent.

Math test, math anxiety, and test anxiety scores were compared by grade and by gender. Although scores were not normally distributed, scores did not violate the assumption of equal variances, so a multivariate ANOVA was performed.[1] Multivariate ANOVA with dependent variables math test, math anxiety, and test anxiety scores and independent variables gender and grade showed a significant effect of gender, Pilai's trace=.134, F (3, 124)=6.388, p<.001, η^2=.134, and grade, Pilai's trace=.628, F (9, 378)=11.111, p<.001, η^2=.209. There was no significant effect of the interaction between gender and grade, Pilai's trace=.076, F (9, 378)= 1.086, p=.372, η^2=.025.

More specifically, there was a significant effect of gender on test anxiety, F (1, 126)=12.770, p<.001, η^2=.092. Boys had lower test anxiety scores than girls (see Table 1). Note that the gender effects for math test and math anxiety scores were not significant, meaning that boys and girls had similar levels of math performance and math anxiety.

For grade, there was only a significant effect on math test scores, F (1, 126)=67.302, p<.001, η^2=.022; scores from all grades except grades 7 and 8 differed significantly from each other, with math scores increasing with age. Because of this age-related increase of math abilities, math test scores were transformed to Z-scores by grade, resulting in an average Z-score of 0 for math test scores in each grade.

Gender differences in the relation between emotional experience of math and math performance To investigate the relation between math anxiety and math performance and to

[1] Kolmogorov-Smirnov tests showed that math anxiety, test anxiety, and math test scores were not normally distributed, D (134)=.131, p<.001, D (134)=.080, p=.034, D (134)=.086, p=.017 in the total sample. Kolmogorov-Smirnov test was also significant for boys' math anxiety, D (71)=.109, p=.037, boys' test anxiety, D (71)=.107, p=.044, boys' math test score, D (71)=.107, p=.043, and girls' math anxiety, D (63)=.189, p<.001. Since Levene's test was not significant, homogeneity of variances of all scores across grades, combined grades, and gender can be assumed.

test whether this relation differed between boys and girls after controlling for test anxiety, a regression analysis was conducted. Math test *Z*-scores were the dependent variable. Independent variables were math anxiety, test anxiety, gender, age and two-way interactions gender×math anxiety, gender×test anxiety, age×math anxiety, and age×test anxiety. In both the backward and the forward procedures, all effects were excluded except the interaction effect gender×math anxiety. The fit of the regression model including the interaction between gender and math anxiety was R^2=.081, F (1, 132)=12.78, p<.001. The standardized beta coefficient of the interaction effect was B=−.297, p<.001. To further investigate this interaction, the correlation between math anxiety and math test scores was calculated separately for boys and girls. For boys, there was no significant relation between math anxiety and math performance, r=−.150, p=.210, but for girls, this relation was significant, r_s=−.37, p=.003. Also, the relation remained significant for girls after controlling for test anxiety, r_s=−.36, p=.004.

Conclusion

Boys had lower test anxiety than girls, but boys and girls obtained comparable scores on the math test and did not differ with respect to math anxiety. Nevertheless, the crucial difference between boys and girls was the correlation between math test scores and math anxiety, which was significant and negative for girls but not for boys, also after controlling for test anxiety. In other words, higher math anxiety was related to lower math performance for girls but not for boys. There were no indications of developmental changes in the relation between math anxiety and math test scores.

Study 2

Study 2 concerns data that were reported by Jansen et al. (2013), who described changes in math performance, math anxiety, and perceived math competence after training with a math practice program by comparing responses to a pretest and a posttest. Here, we only analyzed responses to the pretest, focusing on gender-related differences in the scores on measurements of emotional experience of math (math anxiety, perceived math competence) and math performance and the relation between these concepts. Jansen et al. did not study these differences. Below, a summary of the method is reported to ease understanding of the results. Details can be found in Jansen et al.

Method

Participants A total of 208 (110 boys and 98 girls) children of three primary schools participated, ranging in age from 8 to 13 years. There were 52 children in third grade (mean age=9.16 years, SD=.41), 48 children in fourth grade (mean age=10.36, SD=.62), 59 children in fifth grade (mean age=11.39 years, SD=.58), and 49 children in sixth grade (mean age=12.33 years, SD=.45). The schools were located in the south-west and western part of the Netherlands. Gender distribution of the sample (47 % girls and 53 % boys) generally matched the gender distribution of children in the Netherlands (49 % girls and 51 % boys; CBS 2013). Exact numbers on ethnicity of the children were unknown. Two schools (74 % of the sample) were located in neighborhoods where the majority of the inhabitants were of non-Dutch origin. At the third school, the majority of the children were of Dutch origin. Parents and guardians were informed in a letter and could refuse participation of their child. Research was approved by the Ethics Committee of the Psychology Department.

Material

Math performance Math performance was measured with the Tempo Test Automatiseren (TTA; De Vos 2010; successor of TTR in Study 1). TTA is used in primary schools (grades 3–6) to monitor children's math performance. The test has four sheets and each sheet contains 50 problems with one operation: addition, subtraction, multiplication, and division. Children were allowed to work exactly 2 min per sheet. The total number solved correctly constituted the total score.

Perceived math competence Perceived math competence was measured with the scale "Perceived Math Competence" (Jansen et al. 2013). This extra scale was added to the original version of the Dutch Perceived Competence Scale for Children (Veerman et al. 1997), which is a translation of the Perceived Competence Scale for Children (Harter 1982). Scores on this Perceived Math Competence scale were analyzed here, but scales "Cognitive Competence", "Social Competence", and "General Self-worth" were also administered. The scale "Perceived Math Competence" consisted of six items. On each item, a participant chose between two statements. For example, a participant chose between the statement "Some children are good at math" and the statement "Other children have a bit more trouble with math." Next, a participant indicated whether the statement was "completely true" or was "somewhat true" for him/her. In this example, the choice for the statement "Other children have a bit more trouble with math" corresponded to a score of 1 if the participant indicated that the statement was completely true, and to 2 if the participant indicated that the statement was somewhat true. Choosing the statement "Some children are good at math" corresponded to 3 points if the participant indicated that the statement was somewhat true, and to 4 points if the participant indicated that the statement was completely true. Hence, total scores ranged from 6 to 24, with higher scores indicating higher perceived math competence.

Math anxiety The MASC-NL was administered to assess math anxiety (see"Study 1").

Procedure Administration was group wise and took place in participants' classrooms. Questionnaires were administered in fixed order: Perceived Competence Scale for Children, MASC-NL, and math test. Administration lasted about 1 h.

Results

Age- and gender-related differences in emotional experience of math and math performance Descriptive statistics for boys' and girls' scores on math anxiety, math performance, perceived math competence by grade are displayed in Table 2. A chi-square test was performed to determine whether the ratio of boys and girls was equal across grades. The chi-square test was not significant, meaning that grade and gender were independent from each other.

Table 2 Means and standard deviations (SD) for age, math test scores, perceived math competence scores, and math anxiety scores for boys and girls by grade

	Grade				
	3	4	5	6	Total
N	52	48	59	49	208
Boys (%)	58	42	54	57	53
Age	9.16 (0.41)	10.36 (0.62)	11.39 (0.58)	12.33 (0.45)	10.82 (1.28)
Math test scores					
Boys	106.2 (24.96)	142.7 (24.99)	149.0 (36.10)	158.3 (24.41)	138.6 (34.86)
Girls	111.18 (31.00)	131.2 (38.91)	141.3 (39.77)	157.8 (24.58)	135.2 (37.87)
Perceived math competence scores					
Boys	17.6 (3.97)	18.9 (3.88)	18.3 (4.74)	16.6 (3.72)	17.8 (4.162)
Girls	17.3 (4.57)	15.8 (4.37)	16.9 (6.42)	17.1 (4.56)	16.7 (5.05)
Math anxiety scores					
Boys	44.1 (14.41)	32.7 (10.23)	39.4 (11.96)	38.2 (11.14)	39.2 (12.63)
Girls	41.0 (14.12)	42.0 (12.77)	40.2 (13.55)	39.4 (9.75)	40.7 (12.58)

Math test, math anxiety, and perceived math competence scores were compared by grade and by gender. Although assumptions of normality and equal variances were violated for some variables, we performed a multivariate ANOVA because of robustness of ANOVA.[2] Multivariate ANOVA was performed with dependent variables math anxiety, perceived math competence, math test scores, and independent variables grade and gender. The MANOVA showed no significant effect of gender on any of the variables, Pilai's trace=.016, F (3, 198)= 1.049, p=.372, η^2=.016. The interaction between gender and grade was also not significant, Pilai's trace=.046, F (9, 600)=1.027, p=.417, η^2=.015. However, there was a significant effect of grade, Pilai's trace=.35, F (9, 600)=8.806, p<.001, η^2=.117, but it was only significant for math test scores, F (2, 200)=21.841, p<.001, η^2=.247: Scores from all grades differed significantly from each other, with math scores increasing with age. Because of this age-related increase of math abilities, math test scores were transformed to Z-scores by grade, resulting in an average Z-score of 0 for math test scores in each grade.

Gender differences in the relation between emotional experience of math and math performance To investigate the relations between perceived math competence and math anxiety on the one hand and math performance on the other hand and to test whether this relation differed between boys and girls, a regression analysis was conducted. The dependent variable was math test Z-scores. The independent variables were: math anxiety scores, perceived math competence scores, gender, age, and the two-way interactions gender×math anxiety, gender×perceived math competence, age×math anxiety, and age×perceived math

[2] Kolmogorov-Smirnov tests showed that math test scores were normally distributed in the total sample and that math anxiety and perceived math competence were not normally distributed in the total sample, D (208)=.112, p<.001, D (208)=.085, p=.001. Also, Kolmogorov-Smirnov tests showed that boys' math anxiety scores were not normally distributed, D (110)=.135, p<.001, and that girls' math anxiety scores and perceived math competence scores were not normally distributed, D (98)=.116, p=.003, D (98)=.106, p=.008. For all grades, math test scores were normally distributed, but Kolmogorov tests were significant for math anxiety and perceived math performance scores. For gender, Levene's test was significant for perceived math competence, F (1, 206)= 8.60, p=.004. For grade, Levene's test was significant for perceived math competence, F (3, 204)=4.10, p=.007, and math test score, F (3, 204)=3.52, p=.016.

competence. The backward procedure selected a model that contained the main effect of math anxiety, the interaction effect age × math anxiety, and the interaction effect age × perceived math competence. The fit of this model was $R^2=.26$, $F(3, 204)=24.41$, $p<.001$. However, a forward procedure resulted in the inclusion of the main effect of perceived math competence only. The fit of this model was $R^2=.26$, $F(1, 206)=72.61$, $p<.001$. The most parsimonious model is reported here. The standardized beta of the main effect of perceived math competence was $B=0.511$, $p<.001$, indicating that a higher level of perceived math competence was associated with higher math performance. For illustrative purposes, note that the correlation between math performance and math anxiety was, comparable to Study 1, significant and negative for girls, $r=-.233$, $p=.021$, and not significant for boys, $r=-.071$, $p=.461$. However, when including both math anxiety and perceived math competence in the regression analysis, the relation between math anxiety and math performance was not significant, neither for boys nor for girls.

Conclusion

Boys and girls did not differ with respect to math anxiety, perceived math competence and math test scores. The main interest here however was whether the relation between these variables differed between boys and girls. However, for both boys and girls, higher math performance was associated with higher perceived math competence, and no relation was observed between math anxiety and math performance. Age-related differences were also not observed.

Discussion

Both reported studies focused on gender differences concerning the relation between emotional experience of math and math performance in children between 7 and 15 years old. In both samples, we measured math anxiety and math performance. In the first sample, we controlled for test anxiety. In the second sample, perceived math competence was included. Results indicated that boys had lower test anxiety than girls, which is in line with previous research (Cassady and Johnson 2002; Chapell et al. 2005; Devine et al. 2012). In both samples, we did not find gender differences in the level of reported math anxiety, which is in contrast with most previous research (Frenzel et al. 2007; Hembree 1990; Goetz et al. 2013) and also in contrast with results in a large Dutch sample of 15-year-olds (Else-Quest et al. 2010). There might be several reasons for this result. First, expectations of the Dutch society for boys to perform well on natural sciences and math-related subjects might motivate boys to be less willing than girls to openly admit that they have test and math anxiety. Validation of the Dutch translation of the original questionnaire is desirable, if possible with physiological data. Second, the composition of both samples does not represent a typically Dutch child. Children of non-Dutch origin were overrepresented, which was due to the particular schools that were interested in participating in the studies. Schools often have either an under- or an overrepresentation of ethnic majorities, which is related to concentration of ethnicities in the neighborhood of the school. Possibly, schools with an overrepresentation of ethnic majorities are more open-minded towards educational research and more interested in considering additional educational material, given the challenges they are faced with. Since the gender gap in attitudes towards mathematics differs substantially across different countries (Else-Quest et al. 2010), this might be one of the explanations for not finding any gender differences in math anxiety. A third reason may be the high educational level of the secondary school children in the first sample, because studies have observed that in highly educated circles, men and women take over each other's roles (Thornton et al. 1983). Fourth, the present studies were conducted in relatively young samples (compare e.g., Else-Quest et al. 2010; Hembree 1990). Although no differences were found in math anxiety between the age groups we tested, it is expected that math anxiety increases in grades 9 and 10 (Hembree 1990) and the gender gap may increase as well. Finally, it should be noted that absence of gender differences in math anxiety has been observed before (e.g., Birgin et al. 2010; Haynes et al. 2004) and that gender differences may also depend on the type of math anxiety assessed (Goetz et al. 2013).

Results did not indicate higher scores for boys on perceived math competence. Previous research showed mixed results on gender differences in perceived math competence. In contrast to the results of Cole et al. (2001), we did not find increases in perceived math competence as children entered higher grades. A possible explanation for this result might be that children become more aware of their capabilities as they enter higher grades.

Results from both of our studies also did not reveal differences between boys' and girls' math test scores. It is acknowledged that the present studies only included measurements for the basic operations, with whole numbers, and therefore results may not be generalizable to other domains of mathematics. However, the absence of gender differences in math performance matches earlier findings in the Dutch population (e.g., Else-Quest et al. 2010).

The relation between math performance and math anxiety differed between boys and girls, but only in the first study. For girls, but not for boys, math anxiety and math performance were negatively related. However, the second study, which included the measurement of perceived math competence, showed no gender differences in the relation between math performance and math anxiety. Perceived math competence and math performance were positively and significantly related for both boys and girls. Therefore, we might conclude that perceived math competence is more important in predicting math performance of Dutch children than math anxiety. However, although both studies included measurements of math anxiety and math performance, it remains unknown if gender differences in the relation between math performance and math anxiety can be fully ascribed to the level of perceived math competence. A study including measurements of math anxiety, math performance, test anxiety, and perceived math competence is necessary for that conclusion.

In summary, boys experienced less test anxiety than girls. Though boys and girls might not differ on their reported math anxiety, we must be aware of the fact that the same scores might have different effects for boys and girls. For example, the same heightened level of math anxiety might have different effects for boys and girls, and it is crucial to understand why the relation is different. Gender differences in stress responses have been observed in adult studies, for example in the study of Wang et al. (2007), where stress level was manipulated by instructing participants to do either mental arithmetic or to count backward. The observed differences seem consistent with a theory that women tend to react to stress with a so-called tend-and-befriend response, whereas men seem to be more inclined to react with a fight-and-flight (competitive) response. Wang et al. do note, however, that inconsistencies do exist between their results and this theory. Perhaps, the effect of math anxiety might disappear if we take into account children's perceived math competence. Hence, it is not only important to control for test anxiety, but it might be even more important to control for perceived math competence. Future research is needed to determine the relation of perceived math competence to math anxiety and math performance for students in other countries.

For the time being, recommendations for Dutch schools might be to stimulate self-confidence especially in math-related subjects. It should be noted that the current relations are correlational, not causal. It is therefore possible that self-confidence will only rise after an increase of performance. However, the motivational increase due to high self-confidence may contribute to an improvement in math performance. Ways to stimulate self-confidence are: helping children to better cope with feedback and adapt math exercises to their individual capacities (make sure exercises are not too difficult or too easy) so that children experience success instead of numerous failures. This can be accomplished in online exercise programs, which use principles from computer-adaptive testing (e.g., Klinkenberg et al. 2011). An additional approach may be to teach children an incremental theory of math skills, which implies that their math skills are malleable. Yeager and Dweck (2012) summarize the results of interventions that aimed at communicating this malleability, which show that both math performance and commitment improved. Moreover, Rattan et al. (2012) show that instructors may communicate the opposite to students, i.e., the conviction that math abilities are fixed, which is detrimental for students' expectations on their achievement and, consequently, their effort and commitment. Although these studies were aimed at older children and university students, the approach of teaching incremental theories of academic performance to students and instructors seems promising for improving self-confidence of primary school children.

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Current themes of research:

Development of math abilities. Motivational and affective factors influencing math performance.

Most relevant publications in the field of Psychology of Education (max: 5):

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Current themes of research:

Development of math abilities. Motivational and affective factors influencing math performance. Decision making.

Most relevant publications in the field of Psychology of Education (max: 5):

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