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Gender differences in young children's math ability attributions

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Abstract

We examined the structure underlying math ability attributions in 8- to 9-year old boys and girls. As potential determinants of math ability attributions we assessed general ability, grades, teacher evaluation of the student's math ability, and student perception of teacher ability evaluation. Although girls and boys did not differ in their general ability and grades, girls attributed math success less to high ability and math failure more to low ability. Path analyses suggested that the pathways leading to ability attributions differ between girls and boys. Girls appeared to rely mainly on perceived teacher evaluation of their ability when making math ability attributions whereas boys used both perceived teacher evaluation and the quality of their objective math performance. Only in girls was perceived teacher ability evaluation related to the ability evaluation actually held by the teacher.

Key words: mathematicalability, human sex differences, studentattitudes, teacher attitudes, ability attribution

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Of the many causal attributions that we make about ourselves, those concerning perceived level of ability are among the most influential for human functioning. This is due to both the perceived properties of own ability and the value that is frequently attached to it. Ability is typically perceived as stable and uncontrollable (see Heider, 1958; Weiner, 1986), and having high ability – especially high intellectual ability – is highly valued by most individuals in the Western culture. Therefore, self-ascriptions of low ability often have severely debilitating effects on motivation, emotion, and action: Because ability is perceived as relatively stable, attributing failure to low ability leads to the expectation that failure will continue in the future, which, in turn, may cause an individual to stop pursuing a task. Because ability is often perceived as uncontrollable, one may be convinced that one has no means to improve it. And because having high ability is often strongly valued, a perceived lack of ability frequently leads to negative emotions and decreases of self-esteem.

The just-described negative consequences of self-derogating ability attributions have been postulated for girls with respect to mathematics (math) on the basis of empirical findings concerning gender differences in attributions for success and failure. The most consistent gender difference that emerged from these studies concerned ability as a perceived causal factor of math performance. Compared to their male classmates, female students attributed success in math less to their high ability and failure more to their low ability (e.g., Eccles [Parsons], 1983; Parsons, Meece, Adler, & Kaczala, 1982, see Footnote 1; Rustemeyer & Jubel, 1996; Ryckman & Peckham, 1986, 1987; Stipek, 1984; Stipek & Gralinski, 1991; Tiedemann & Faber, 1995; Wolleat, Pedro, Becker, & Fennema, 1980). These self-derogating attributions of female students are assumed – and have partly been demonstrated (e.g. Stipek & Gralinski, 1991) – to have serious negative implications for their expectations of future success in math, their feelings accompanying success and failure, their perceptions of self-efficacy, and, consequently, their choices related to math and their long-term math achievement.

The aim of the present study was to expand our understanding of the factors underlying gender differences in math ability attributions in young children (8- to 9-year olds). For this purpose, we assessed, in addition to causal attributions for math performance, four variables that were considered to be possible (direct or indirect) causes of the previously observed differential math ability attributions in boys and girls: (a) *grades* as an index of objective math performance, (b) *general ability* as measured by a standardized test; (c) *teacher evaluations* of the students' math ability, and (d) *students' perceptions* of the teacher ability evaluations. Although, on the basis of the available evidence, it cannot be completely excluded that gender differences in math ability attributions vary with gender differences in variables *a* to *c*, the below-given overview of the existing literature suggests that such a direct correspondence is unlikely at least for the variables *a* (math performance) and *b* (general ability). Therefore, the main interest in the present study was to test the hypothesis that the *relationship* between these variables differs by gender. In the following paragraphs, we explain the reasoning underlying this hypothesis in more detail.

A first possible candidate for explaining the gender differences in ability attributions is differential *objective math performance*, with male students showing higher performance than female students. Based on the observed higher performance of their male classmates, female students may conclude that their ability is relatively low and therefore may be inclined to attribute own success less to high ability and own failure more to low ability than their male classmates. However, at least for young children, this assumption – that differential performance is a direct cause of the gender differences in ability attributions – seems implausible, for two reasons. First, a meta-analysis of relevant studies conducted by Friedman (1989) suggests that the average gender difference in math performance (in favor of boys) is "very small" (p. 206). Furthermore, Tiedemann and Faber (1994) found that in classes 1 to 4, boys and girls did not differ at all in their math performance. Second, most of the cited studies showing gender differences in ability attributions also assessed math performance, using grades as an index (Eccles [Parsons], 1983; Rustemeyer & Jubel, 1996; Stipek, 1984; Stipek & Gralinski, 1991; Tiedemann, 2000; Tiedemann & Faber, 1995) and/or scores from standardized achievement tests (Eccles [Parsons], 1983; Wolleat et al., 1980). With the exception of the study by Stipek (1984), no significant performance differences between boys and girls were found in these studies. Stipek reported that, on average, performance for boys was somewhat higher than for girls. However, as also noted by Stipek, the gender differences in attributions of success and failure observed in her study could not be explained by actual performance differences because, *within* the success and failure groups, boys and girls did not significantly differ with respect to their performance. Supporting this conclusion, Wolleat et al. (1980) found a significant association between gender and ability attributions even after controlling for performance. In sum, the existing evidence gives no support to the hypothesis that differences in math performance are a direct cause of the observed gender differences in ability attributions of math performance (at least in young children).

A second possible explanation of gender differences in ability attribution is differential actual ability, either *math ability* or *general ability*, as assessed by standardized tests. Such a difference (in favor of male students) has been documented in several studies (e.g., Benbow, 1988; Benbow & Stanley, 1980; Hedges & Nowell, 1995; Randhawa, 1991). However, these differences were in general small. In an analysis, that included 9-year-olds from 14 countries and 13-year-olds from 20 countries, Beller and Gafni (1996) also found reliable gender effects on math assessment tests in favor of boys; however, these effects were again small. Among 9-year-olds, which constitute the age group included in the present study, "there was essentially no performance difference between boys and girls" (Beller & Gafni, 1996, p. 373). In the earlier-mentioned studies that demonstrated gender differences in ability attributions, math and/or general ability was not assessed by standardized tests. Therefore, to obtain an index of general ability, we included four subtests of the Primary Mental Abilities (PMA; Thurstone & Thurstone, 1954) in the present study. However, in view of the results of the just-mentioned studies, it seemed unlikely that ability differences are a direct cause of gender differences in ability attributions.

A third explanation for the observed gender differences in ability attributions is differential *teacher evaluation of male and female students' ability*. That is, teachers may evaluate the (math) ability of male students, relative to female students, as higher. If so, they could convey their evaluations in a direct or indirect way to the students, thereby affecting the students' self-concept of ability and their ability attributions (for a more detailed discussion of this hypothesis, see e.g. Brophy, 1983; Eccles [Parsons], 1983; Graham, 1990; Meyer, 1982, 1992; Wigfield & Harold, 1992). Empirical evidence for differential teacher evaluations of math ability for male and female students is mixed. Studies by Fennema, Peterson, Carpenter, and Lubinski (1990) and Tiedemann (1995; 2000) suggest that teachers indeed evaluate boys' math ability as higher than that of girls. Fennema et al. asked teachers to indicate their most (and least) successful math students. The teachers attributed math success of the most successful boys more to high ability and less to high effort than that of the most successful girls. Furthermore, the teachers rated the most successful boys as more "logical" than the most successful girls. Similar results were obtained by Tiedemann. Teachers (a) rated boys' "logical thinking [ability]" concerning math as higher than that of girls, (b) judged math to be less difficult for boys than for girls, and (c) attributed boys' unexpected failure, relative to girls, less to low ability. However, these gender differences have not been replicated in two other studies (Eccles [Parsons], Adler, & Meece, 1984; Wigfield & Harold, 1992).

A fourth factor explaining the gender differences in math ability attributions is *student perception of teacher ability evaluation.* To our knowledge, this factor has been assessed only in one of the studies investigating gender differences in math ability attributions (Eccles [Parsons], 1983, see Footnote 2). The inclusion of this variable, however, is important because – if teacher ability evaluation influences pupils' ability attributions via communication – differential teacher ability evaluation is a plausible cause of gender differences in math ability attributions (and in other attitudinal and behavioral variables; cf. Parsons, Kaczala, and Meece, 1982) only if this evaluation is correctly inferred by the child – either from the teacher's direct ability communications, or from teacher behavior that communicates ability evaluations indirectly (e.g., praise and blame, helping behavior, assignment of easy or difficult tasks, emotional reactions; cf. Graham, 1990; Meyer, 1982, 1984).

In sum, the existing literature suggests that in young children (8- to 9-year olds) gender differences in (a) math performance and (b) ability either do not exist or are very small. Therefore, such differences, if they exist, are unlikely to be direct causes of the consistently found gender differences in math ability attributions. As concerns (c) differential teacher evaluations of math ability for boys and girls, the empirical findings are mixed and the causal role of these evaluations with respect to gender differences in math ability attributions has not yet been investigated. The latter is also true for (d) student perceptions of teacher ability evaluations (see Footnote 2).

However, the absence (or small magnitude) of math performance and (math) ability gender differences in young children in combination with the presence of gender differences in math ability attributions does not preclude the possibility that the *relationship* between performance or ability and math ability attributions may differ by gender. In fact, this possibility is strongly suggested by the findings of three studies linking math performance to self-concept of math ability measures: Eccles (Parsons) (1983) found what she described as an "important sex difference" (p. 109), namely that math grades were not as highly related to attitudinal variables (e.g., math expectancies, self-concept, value of math) in female students as in male students. For example, in grade 2 the association between math grades and self-concept of math ability was significantly weaker in girls (r =.29) than in boys (r = .50). Corresponding results were obtained by Eccles (Parsons) et al. (1984) for grade 2. In a study including high school students, Randhawa, Beamer, and Lundberg (1993) assessed math performance (by means of an achievement test) as well as math self-efficacy perceptions. Similar to the findings of Eccles (Parsons) and Eccles (Parsons) et al., the path coefficient linking efficacy to performance was significantly stronger for male than for female students.

In the present study, we expected that, consistent with the earlier findings, boys and girls would not differ with respect to math performance (and ability). However, the strength of the association between math performance and math ability attributions was expected to differ by gender: This association was expected to be stronger for boys than for girls, probably because boys, more than girls, use high math performance as a cue for inferring high ability. A second hypothesis assumed that the strength of the association between teacher ability evaluation and perceived teacher ability evaluation would be stronger for girls than for boys. This hypothesis seemed plausible because females appear to be more sensitive to social cues (e.g. Hall, 1990).

To hypothesize an *overall* pattern of relations among the five assessed variables, ability (measured by PMA) was treated as an exogenous variable, the other four variables are endogenous. Ability was assumed to predict all the other four variables. Furthermore, grades were assumed to predict the teacher evaluation of students' ability, the students' perceived teacher evaluation and the ability attributions. The teacher evaluation of students' ability was assumed to predict the students' perceived teacher evaluation and the ability attributions. Finally, perceived teacher evaluation was assumed to predict ability attributions. The path coefficients of the model were estimated separately for boys and girls by using standard path analysis (Arbuckle, 1997). If the reasoning described above is valid, the general form of the model should be supported for both boys and girls, but there should be gender differences with respect to the path coefficients representing (a) the effects of grades on ability attributions and (b) the effects of teacher ability evaluation on perceived teacher ability evaluation.

Method

Participants

Participants were 10 teachers (7 female, 3 male) and all students from 10 classes (Grade 3) of 6 elementary schools in Castrop-Rauxel, Germany. The teachers (age range 27-54 years) had taught their classes for a minimum of 8 months with at least 3 years teaching experience. The student sample consisted of 159 girls and 152 boys, aged 8 and 9 years.

Measures

Teacher Questionnaire. For each student in their class, the teachers answered an 11-item questionnaire. The question relevant to the present study referred to the students' math ability: "How do you evaluate the child's ability concerning mathematics?"; the response alternatives were *very high* (5), *high* (4), *moderate* (3), *low* (2), and *very low* (1). Furthermore, the teachers indicated in the questionnaire the child's math grade received in the last report.

Student Questionnaires. In each class, two questionnaires were distributed by an experienced experimenter during the time scheduled for a regular math lesson. The first questionnaire assessed children’s attributions for success and failure in math. The first two questions were examples that were used to explain the nature of the task and the response mode ("Imagine that you quickly find the solution of a riddle"; "Imagine that you cannot manage to build a crane [or a ship] from bricks"). Of the following six questions, three concerned success situations and the other three failure situations in math. The success situations were: "You succeed in finding the solution of a math task", "You receive grade 1 (very good) or 2 (good) at a math test", and "You quickly find the solution to a math problem". The failure situations were: "You cannot solve a math task", "You receive grade 5 (unsatisfactory) at a math test", and "You cannot find the solution to a math problem". Following each situation, the children were asked to state the reason for their success or failure. Four causal factors were provided for success and failure, respectively (cf. Weiner, 1986): High and low ability, high and low effort, good and bad luck, and ease and difficulty of the task. For example, concerning the situation describing failure to solve a math problem, the causal factors were described as: "Is the reason that you are not intelligent enough to solve problems?", "... that you did not exert enough effort?", "... that you had bad luck and just accidentally did not solve the problem?", and "... that the problem was so difficult that hardly anybody could find the solution?". The response alternatives for each causal factor were *very much* (5), *much* (4), *somewhat* (3), *little* (2), and *not at all* (1).

In the second questionnaire given to the children, only one of the questions was relevant to the concerns of the present study. This question referred to the child's perception of teacher evaluation of his or her ability: "How does your teacher evaluate your ability in mathematics?". The response format was "My teacher believes that my ability in mathematics is *very low* (1) / *low* (2) / *moderate* (3) / *high* (4) / *very high* (5)".

General Ability Measure. To assess general ability, the children were given four subtests of the standardized German version (Kemmler, 1967) of the *Primary Mental Abilities* test (PMA; Thurstone & Thurstone, 1954). The subtests were Word test, Word groups, Figure groups, and Number. They were administered (by the same experimenter as before) to the whole class one week after the administration of the student questionnaires, again during the scheduled regular math lesson.

Results

Mean scores

Table 1 presents, separately for boys and girls, the means and standard deviations of the four PMA subtests, the PMA total score computed on the basis of these subtests, and the math grade received in the last report. These data were analyzed using a one-way multivari-

Table 1:
Means (M) and standard deviations (SD) of ability measures and grades for girls and boys

	Boys (*n* = 152)		Girls (*n* = 159)	
	M	*SD*	*M*	*SD*
PMA-Word test	101.91	8.91	101.70	9.98
PMA-Word groups	101.18	11.06	101.18	10.85
PMA-Figure groups	102.36	11.04	104.33	9.20
PMA-Number	100.01	9.55	99.48	8.87
PMA Total Score	101.51	7.83	101.79	7.42
Grade	3.16	0.97	3.28	0.90

Note: PMA = Primary Mental Abilities test.

ate analysis of variance with gender as the independent variable and the scores of the four subtests, plus grade score, as dependent variables. This analysis showed no significant gender effect, $F(5, 305) = 1.59$. This finding was replicated for separate univariate analyses of variance for each dependent variable, including the PMA total score. Only the PMA subtest Figure groups showed a marginally significant gender effect, $F(1, 309) = 2.96$, $MSE = 102.85$, $p < .10$, reflecting a somewhat higher test performance for girls as compared to boys (all other Fs < 1.39). Hence, boys did not significantly differ from girls in their performance on an objective test of general ability nor – replicating earlier results for this age group – in their objective math performance (as measured by their last report grade).

Table 2 presents, separately for boys and girls, the means and standard deviations of the teacher evaluation of the children's ability, the children's perception of teacher evaluation, and their attributions of success and failure in math. Each of these variables was subjected to a one-way analysis of variance with gender as the independent variable. Concerning the *teacher ability evaluation*, the difference between girls and boys was marginally significant, $F(1, 309) = 2.84$, $MSE = 0.93$, $p < .10$: Teachers tended to evaluate the boys' math ability as higher. Consistent with this tendency, boys rated the *teacher evaluation of their own ability* higher than girls, $F(1, 309) = 6.23$, $MSE = 0.48$, $p < .02$. Concerning *attributions of success and failure*, only those pertaining to ability differed significantly between boys and girls. Replicating the results of previous studies, boys attributed success more to their high ability and failure less to their low ability than girls, $F(1, 309) = 4.51$, $MSE = 8.64$, $p < .05$, and $F(1, 309) = 3.79$, $MSE = 8.07$, $p = .05$. This tendency was also reflected in a significant gender effect on the ability attribution difference measure "As-Af" reported in Table 2 (ability attribution of success [As] minus ability attribution of failure [Af]), $F(1, 309) = 6.34$, $MSE = 21.85$, $p <.02$.

Table 2:
Means (M) and standard deviations (SD) of teacher ratings and children ratings and significance (p) of difference between girls and boys

	Boys		Girls		
	M	*SD*	*M*	*SD*	*p*
Teacher evaluation	3.32	1.00	3.14	0.92	< .10
Perceived teacher evaluation	3.63	0.74	3.43	0.65	< .02
Attributions of success					
Ability (As)	7.22	3.22	6.52	2.64	< .05
Effort	6.59	3.70	6.88	3.20	-
Task	5.26	3.37	5.27	3.27	-
Luck	3.69	3.25	4.13	3.25	-
Attributions of failure					
Ability (Af)	3.04	2.84	3.67	2.84	= .05
Effort	4.59	3.04	5.04	3.01	-
Task	4.11	2.83	4.13	2.98	-
Luck	5.74	3.33	5.40	2.83	-
As-Af	4.18	5.04	2.85	4.30	< .02

Note. As = ability attribution of success; Af = ability attribution of failure; As-Af = As minus Af.

Correlations

To investigate the relationships among the assessed variables of main interest, Pearson product-moment correlations among these variables were computed separately for boys and girls. As can be seen from Table 3, most of the correlation coefficients were comparatively high (and all were significant at *p*s < .01); furthermore, their direction did not differ between boys and girls. As can be seen, first, there was a strong association between PMA total scores and math grades (the negative sign of the correlation coefficients is due to the fact that in Germany, lower grades indicate higher performance). Second, there was also a strong positive correlation between teacher evaluation of the children's ability and PMA scores as well as grades. Third, children's perception of the teacher evaluation of their ability was moderately associated with their PMA scores, grades, and teacher evaluation: Children tended to rate teacher evaluation of their ability as higher, (a) the higher their PMA score, (b) the better their grade, and (c) the more positive the teacher evaluated their ability. Finally, the ability attribution difference measure (As-Af) was significantly associated with all other variables. That is, children had a stronger tendency to attribute success to their high ability, as compared with their attribution of failure to low ability, the higher their PMA scores, the better their grades, the more highly the teacher evaluated their ability, and the higher the children rated the teacher's evaluation of their ability.

Although the direction of the correlation coefficients was the same for boys and girls, three of the coefficients were – similar to the earlier-mentioned results of Eccles (Parsons) (1983) and Eccles (Parsons) et al. (1984) – substantially higher for boys than for girls (cf. Table 3): For boys, perceived teacher evaluation was more strongly associated with PMA scores ($p < .05$) and grades ($p < .01$) than for girls, and the ability attribution difference measure was more strongly associated with grades ($p < .05$).

Path analyses

The structure of the relations summarized in Table 2 was further investigated by means of path analysis, separately for boys and girls. A fully hierarchical model, corresponding to the hypothesized causal order of the variables described in the Introduction, was estimated

Table 3:
Pearson product-moment correlation coefficients

	PMA		GR		TE		PTE	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
GR[a]	-.64	-.63						
TE	.66	.59	-.79	-.73				
PTE	.46	.24	-.52	-.22	.46	.31		
As-Af	.46	.31	-.54	-.32	.45	.38	.61	.51

Note. PMA = Primary Mental Abilities total score; GR = grade; TE = teacher evaluation; PTE = perceived teacher evaluation; As-Af = ability attribution of success minus ability attribution of failure. Correlations differing by sex (p < .05) are underlined.

[a] The lower the grade, the higher is the performance.

using the program AMOS (Arbuckle, 1997). In boys, the analysis showed several insignificant paths, namely the paths linking general ability (PMA) to ability attributions (As-Af), teacher ability evaluation (TE) to perceived teacher ability evaluation (PTE), and TE to As-Af. Thus, in a second step, these paths were eliminated. The resulting final model is shown in Figure 1a. This model shows a good fit to the data ($\chi^2[3, N = 152] = 1.75$, n.s., $NFI = .99$).

In girls, the paths linking the following variables were insignificant: PMA to PTE, PMA to As-Af, grades (GR) to PTE, GR to As-Af, TE to As-Af. These paths were eliminated; the resulting final model is shown in Figure 1b. This model provides, according to the "ratio" and the normed fit index (NFI), an acceptable fit to the data ($\chi^2[5, N = 159] = 14.66$, $p < .02$, ratio: 2.93, $NFI = .95$).

As can be seen from the figures, the results were only partly consistent with the hypotheses described in the Introduction; in particular, the prediction that the same model would be found for both boys and girls, was not supported. In more detail, the following results were obtained.

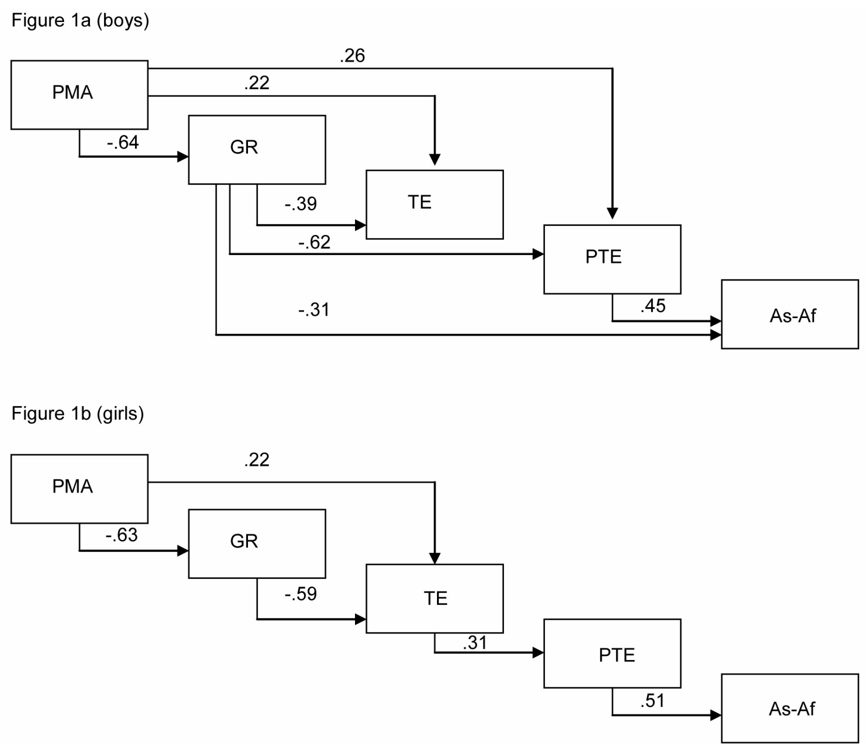

Figure 1 :
Final path models showing standardized path coefficients for boys (Figure 1a) and girls (Figure 1b). PMA = Primary Mental Abilities scores; GR = math grade; TE = teacher evaluation; PTE = perceived teacher evaluation; As-Af = difference measure: ability attribution for success minus ability attribution for failure

As expected, general ability (PMA) was reliably predictive of math grades (GR) and teacher ability evaluation (TE) in boys and girls (the negative sign of the path coefficients linking GR to the other variables is due to the fact that, as mentioned above, in Germany lower grades indicate higher performance). Also consistent with expectations, grades had a significant effect on teacher ability evaluation in both boys and girls. Finally, again consistent with expectations, perceived teacher ability evaluation had a significant effect on ability attributions (As-Af) in both boys and girls.

However, deviating from predictions, teacher ability evaluation had a significant effect on perceived teacher ability evaluation (PTE) only in girls (for boys, the corresponding path coefficient was not significant and was eliminated in the final model). By contrast, in boys perceived teacher ability evaluation was predicted by general ability and by grades. In addition, the expected path linking grades to ability attribution emerged only in boys (for girls, the corresponding path coefficient was -.05). In sum, the structure underlying ability attributions differed in boys and girls.

Discussion

In the discussion we will first give a brief summary of the results and highlight the most interesting findings. We will then try to clarify the nature of gender differences in math ability attributions and finally discuss, how teachers may influence gender differences in math ability attributions.

The present study replicated a number of previous findings described in the Introduction: (1) as compared to boys, girls attributed math success less to high ability and math failure more to low ability; (2) girls and boys (8 to 9 years old) did not differ with respect to math performance and general ability; (3) the math grades of girls were related less strongly to attitudinal variables (perceived teacher evaluation, ability attribution) than those of boys.

The most interesting result of the present study concerns the apparent differences in the system underlying ability attributions in girls and boys. These differences suggest that the two groups used partly different cues to make attributions of math ability. Of the potential cues for math ability attributions that were assessed in the present study, girls seemed to rely only on perceived teacher evaluation of their ability, that is on what they thought the teacher was thinking about their math ability. This effect was furthermore at least partially correct, as indicated by the significant path from the ability evaluation actually held by the teacher to the perceived teacher ability evaluation. In contrast, the quality of girls' actual math performance, as reflected in their grades, had no direct effect on their ability attributions. This may indicate that girls were more sensitive to cues that signaled teacher ability evaluation.

Boys, in contrast, seemed to rely on both perceived teacher evaluation of their math ability and the quality of their objective math performance when making math ability attributions. Interestingly, furthermore, in boys the ability evaluation actually held by the teacher had no direct effect on the perceived teacher ability evaluation. This could mean that boys were insensitive to cues signaling teacher evaluation of their math ability. Rather, boys seemed to infer the teacher's evaluation from their own math performance. The differential structure underlying the ability attributions of boys and girls may also partly account for the fact that girls, on average, made more self-derogating math ability attributions than boys. First, as noted, the genders differed significantly in perceived teacher evaluation of their math ability: Girls estimated the teacher's opinion of their math ability to be lower than boys (cf. Table 2). Perceived teacher evaluation, however, had a strong significant effect on ability attributions in both genders (cf. Figures 1a and 1b). Second, girls, in contrast to boys, disregarded their objective performance (grades) when making ability attributions. Taken together, this may explain the observed lower ability estimates in girls.

To further clarify the nature of the gender differences concerning the link between performance and ability attributions, a two-way analysis of variance was performed on ability attributions (As-Af) using performance (high vs. low grades) and gender as two-level factors. This analysis yielded a significant Performance X Gender interaction, $F(1, 307) = 4.96$, $MSE = 85.09$, $p < .03$. Given low performance, girls and boys did not differ significantly in their ability attributions (2.12 and 2.46, $t[234] = 0.61$). However, when performance was high, girls attributed success less to their high ability and failure more to their low ability than did boys (5.75 vs. 8.56, $t(73) = 3.35$, $p < .002$). Thus, the gender difference in the factors underlying math ability attributions seemed to more specifically reflect the fact that girls disregarded high math performance as a cue for inferring high ability. A possible interpretation for this finding is that boys attach a higher importance to math than girls do (Eccles (Parsons) et al., 1984). Therefore grades in math can have a higher impact on self-related beliefs (like attributions) in boys than in girls.

In conclusion, the gender difference in math ability attributions observed in the present and in previous studies among 8- to 9-year olds cannot be explained by ability or math performance differences. Rather, the present study suggests that the paths leading to these attributions differ between boys and girls. To summarize, in *boys*, both perceived teacher evaluation and math performance had direct effects on ability attributions: Boys, as compared to girls, thought that the teacher evaluated their math ability as relatively high and, correspondingly, attributed success more to ability and failure less to lack of ability than girls did. Furthermore, boys, more than girls, used high math performance to infer high ability. In *girls*, on the other hand, only perceived teacher evaluation had a direct effect on math ability attributions: Girls, as compared to boys, thought that the teacher evaluated their math ability as relatively low and, correspondingly, attributed success less to ability and failure more to lack of ability than boys did. The quality of performance had no direct effect on girls' math ability attributions.

The results of this study raise questions about teachers' influence on gender differences in achievement-related beliefs concerning mathematics. Despite the absence of gender differences in general ability and math performance, teachers in the present study tended to evaluate the girls' math ability as lower than that of boys. Consistent with this tendency, girls rated the teacher's evaluation of their own math ability as lower than boys. We do not know why teachers in this study tended to believe that girls have lower math ability than boys. However, regardless of the origin of this belief, it seems reasonable to assume that this belief may have consequences for teacher-student interactions (cf. Brophy & Good, 1974). Direct communications of how one estimates another person's ability seem to be rare (see Blumberg, 1972), and may be suppressed when the target person's ability is perceived to be low because one does not want to hurt the target person's self-esteem. However, in spite of the intention not to cause harm, teachers may subtly and unknowingly convey their ability estimates to the students (cf. Meyer, 1982, 1992). These communications may contribute to the self-derogating math ability attributions of girls.

At first sight, the results of Parsons et al. (1982) seem to contradict this possibility. These authors found only few differences in teacher-student interactions concerning boys and girls; "other than these few differences, boys and girls were treated similarly" (p. 333). However, this finding may be due to the fact that the observational system used by the authors did not include teacher behaviors that have been documented to be low-ability cues, or assessed teacher behaviors in an insufficiently differentiated way (e.g., by not distinguishing between praise for success at *very easy* and *very difficult* tasks). Teacher behaviors that can communicate low-ability messages include praise for success at a very easy task and lack of criticism for failure at difficult tasks, the assignment of very easy tasks, the expression of pity for failure, and unsolicited help (e.g., Barker & Graham, 1987; Graham, 1984; Graham & Barker, 1990; Meyer et al., 1979; Meyer, Bedau, & Engler, 1988; Rustemeyer, 1984; for summaries, see Graham, 1990; Meyer 1982, 1984). Based on their belief of lower math ability in girls, teachers may direct these behaviors more frequently at girls than boys. These indirect communications of low ability would therefore be important factors that contribute to girls' self-derogating ability attributions.

References

1. Arbuckle, J. L. (1997). Amos Users' Guide Version 3.6. Chicago, Ill.: SmallWaters.
2. Barker, G., & Graham, S. (1987). Developmental study of praise and blame as attributional cues. Journal of Educational Psychology, 79, 62-66.
3. Beller, M., & Gafni, N. (1996). The 1991 International Assessment of Educational Progress in Mathematics and Sciences: The gender differences perspective. Journal of Educational Psychology, 88, 365-377.
4. Benbow, C. P. (1988). Sex differences in mathematical reasoning ability in intellectually talented preadolescents: Their nature, effects, and possible causes. Behavioral and Brain Sciences, 11, 169-183.
5. Benbow, C. P., & Stanley, J. C. (1980). Sex differences in mathematical ability: Fact or artifact? Science, 210, 1262-1264.
6. Blumberg, H. H. (1972). Communication of interpersonal evaluations. Journal of Personality and Social Psychology, 23, 157-162.
7. Brophy, J. E. (1983). Research on the self-fulfilling prophecy and teacher expectations. Journal of Educational Psychology, 75, 631-661.
8. Brophy, J. E., & Good, T. (1974). Teacher-student relationships: Causes and consequences. New York: Holt, Rinehart & Winston.
9. Eccles (Parsons), J. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), Achievement and achievement motives (pp. 75-146). San Francisco: W. H. Freeman.
10. Eccles (Parsons), J., Adler, T., & Meece, J. L. (1984). Sex differences in achievement: A test of alternate theories. Journal of Personality and Social Psychology, 46, 26-43.
11. Fennema, E., Peterson, P. L., Carpenter, T. P., & Lubinski, C. A. (1990). Teachers' attributions and beliefs about girls, boys, and mathematics. Educational Studies in Mathematics, 21, 55-69,
12. Friedman, L. (1989). Mathematics and the gender gap: A meta-analysis of recent studies on sex differences in mathematical tasks. Review of Educational Research, 59, 185-213.

13. Graham, S. (1984). Communicating sympathy and anger to black and white children: The cognitive (attributional) consequences of affective cues. Journal of Personality and Social Psychology, 47, 40-54.
14. Graham, S. (1990). Communicating low ability in the classroom: Bad things good teachers sometimes do. In S. Graham & V. S. Folkes (Eds.), Attribution theory: Applications to achievement, mental health, and interpersonal conflict (pp. 17-36). Hillsdale, NJ: Erlbaum.
15. Graham, S., & Barker, G. P. (1990). The down side of help: An attributional-developmental analysis of helping behavior as a low-ability cue. Journal of Educational Psychology, 82, 7-14.
16. Hall, J.A. (1990). Nonverbal sex differences: Accuracy of communication and expressive style. Baltimore, MD: Johns Hopkins University Press.
17. Hedges, L. V., & Nowell, A. (1995). Sex differences in mental test scores, variability, and numbers of high-scoring individuals. Science, 269, 41-45
18. Heider, F. (1958). The psychology of interpersonal relations. New York: Wiley.
19. Kemmler, L. (1967). Erfolg und Versagen in der Grundschule [Success and failure in elementary school]. Göttingen, Germany: Hogrefe.
20. Meyer, W.-U. (1982). Indirect communications about perceived ability estimates. Journal of Educational Psychology, 74, 888-897.
21. Meyer, W.-U. (1984). Das Konzept von der eigenen Begabung [Self-concept of ability]. Bern, Switzerland: Huber.
22. Meyer, W.-U. (1992). Paradoxical effects of praise and criticism on perceived ability. In W. Stroebe & M. Hewstone (Eds.), European review of social psychology (Vol. 3, pp. 259-283). Chichester, England: John Wiley & Sons.
23. Meyer, W.-U., Bachmann, M., Biermann, U., Hempelmann, M., Plöger, F., & Spiller, H. (1979). The informational value of evaluative behavior: Influences of praise and blame on perceptions of ability. Journal of Educational Psychology, 71, 259-268.
24. Meyer, W.-U., Bedau, U., & Engler, U. (1988). Indirekte Mitteilungen über Fähigkeitseinschätzungen in hypothetischen Lehrer-Schüler-Interaktionen [Indirect communications about perceived ability estimates in hypothetical teacher-student-interactions]. Zeitschrift für Pädagogische Psychologie, 2, 235-242.
25. Parsons, J., Kaczala, C. M., & Meece, J. L. (1982). Socialisation of achievement attitudes and beliefs: Classroom influences. Child Development, 53, 322-339.
26. Parsons, J., Meece, J. L., Adler, T. F., & Kaczala, C. M. (1982), Sex differences in attributions and learned helplessness. Sex Roles, 8, 421-432.
27. Randhawa, B. S. (1991). Gender differences in academic achievement: A closer look at mathematics. Alberta Journal of Educational Research, 37, 241-257.
28. Randhawa, B. S., Beamer, J. E., & Lundberg, I. (1993). Role of mathematics self-efficacy in the structural model of mathematical achievement. Journal of Educational Psychology, 85, 41-48.
29. Rustemeyer, R. (1984). Selbsteinschätzung eigener Fähigkeit - vermittelt durch die Emotionen anderer Personen [Self-evaluation of ability - mediated by other persons' emotions]. Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 16, 149-161.
30. Rustemeyer, R., & Jubel, A. (1996). Geschlechtsspezifische Unterschiede im Unterrichtsfach Mathematik hinsichtlich der Fähigkeitseinschätzung, Leistungserwartung, Attribution sowie im Lernaufwand und im Interesse [Gender differences in mathematics with respect to evaluation of own ability, performance expectancy, attribution, perceived own effort, and interest]. Zeitschrift für Pädagogische Psychologie, 10, 13-25.

31. Ryckman, D. B., & Peckham, P. D. (1986). Gender differences on attribution patterns in academic areas for learning disabled students. Learning Disabilities Research, 1, 83-89.
32. Ryckman, D. B., & Peckham, P. D. (1987). Gender differences in attributions for success and failure. Journal of Early Adolescence, 7, 47-63.
33. Stipek, D. J. (1984). Sex differences in children's attributions for success and failure on math and spelling tests. Sex Roles, 11, 969-981.
34. Stipek, D. J., & Gralinski, H. (1991). Gender differences in children's achievement-related beliefs and emotional responses to success and failure in mathematics. Journal of Educational Psychology, 83, 361-371.
35. Thurstone, L. L. & Thurstone, T. G. (1954). SRA Primary mental abilities technical supplement. Chicago: Science Research Associates.
36. Tiedemann, J. (1995). Geschlechtstypische Erwartungen von Lehrkräften im Mathematikunterricht in der Grundschule [Gender-specific teacher expectancies in elementary school mathematics]. Zeitschrift für Pädagogische Psychologie, 9, 153-161.
37. Tiedemann, J. (2000). Parents' gender stereotypes and teachers' beliefs as predictor of children's concept of their mathematical ability in elementary school. Journal of Educational Psychology, 92, 1-8.
38. Tiedemann, J., & Faber, G. (1994). Mädchen und Grundschulmathematik: Ergebnisse einer vierjährigen Längsschnittuntersuchung zu ausgewählten geschlechtsbezogenen Unterschieden in der Leistungsentwicklung [Girls and mathematics in elementary school: Results of a four-year longitudinal study on gender differences in performance development]. Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 26, 101-111.
39. Tiedemann, J., & Faber, G. (1995). Mädchen im Mathematikunterricht: Selbstkonzept und Kausalattributionen im Grundschulalter [Instructing girls in mathematics: Self-concept and causal attributions in elementary school]. Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 27, 61-71.
40. Weiner, B. (1986). An attributional theory of motivation and emotion. New York: Springer Verlag.
41. Weiner, B., Graham, S., Stern, P., & Lawson, M. (1982). Using affective cues to infer causal thoughts. Developmental Psychology, 18, 278-286.
42. Wigfield, A., & Harold, R. D. (1992). Teacher beliefs and children's achievement self-perceptions: A developmental perspective. In D. H. Schunk & J. L. Meece (Eds.), Student perceptions in the classroom (pp. 95-121). Hillsdale, NJ: Erlbaum.
43. Wolleat, P. L., Pedro, J. D., Becker, A., & Fennema, E. (1980). Sex differences in high school students' causal attributions of performance in mathematics. Journal for Research in Mathematics Education, 11, 356-366.

Footnotes

1) Parsons et al. (1982) found gender-related differences in math ability attributions for success and failure only when assessing attributions by a rank-order technique. Eccles (Parsons), Adler, and Meece (1984) found a gender effect on math ability attributions only for failure and only for low-expectancy students.

2) Eccles (Parsons) (1983) assessed students' perceptions of their teachers' *and* parents' math ability evaluations. The two assessments were then combined into one measure (perception of socializers' perception of math ability). However, the separate effects of perceived *teacher* evaluation on other variables were not reported by Eccles (Parsons).