Original Article

# Quality of attachment relationships and frequency of mathematics- and science-related activity offers in kindergarten as predictors of girls' and boys' mathematics-related motivation

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**Abstract:** During the kindergarten years and until shortly before school start, there are no gender differences in (precursors of) mathematical competencies or mathematics-related motivation. Shortly after school entry, however, boys are already superior to their female peers in mathematics-related competencies and motivation. We investigated in a cross-sectional study two aspects of process quality in kindergarten that can favorably influence the development of mathematics-related motivation, especially of girls: the frequency of offers of mathematics- and science-related activities and a high-quality attachment relationship with the teacher. In 135 independent dyads, the quality of attachment between kindergarten teacher and child was assessed by a one and a half-hour standardized observation (Attachment Q-Set). The teacher provided information on how often she provides mathematics- and science-related activities. The children were asked about their mathematics-related motivation and precursors of mathematical competencies were measured using a standardized test. Results show, in line with existing studies, that girls and boys did not yet differ in their precursors of mathematical competencies and mathematics-related motivation at the end of kindergarten. Girls were involved in significantly higher quality attachment relationships with their teachers than boys. While girls' mathematics-related motivation increased with the frequency of the provision of relevant activities, it did not play a role for boys' motivation. We discuss (a) how teachers can be encouraged to offer mathematics-and science-related activities more often and (b) whether a comparable quality of attachment would be shown for boys as for girls if the kindergarten teacher were male.

**Keywords:** attachment relationship, gender differences, mathematics-related motivation, precursors of mathematical competencies, process quality in early childhood education

**Beziehungsqualität und die Häufigkeit mathematik- und naturwissenschaftsbezogener Aktivitätsangebote im Kindergarten als Prädiktoren der mathematikbezogenen Motivation von Mädchen und Jungen**

**Zusammenfassung:** In der Vorschulzeit und bis kurz vor der Einschulung zeigen sich noch keine Geschlechtsunterschiede in mathematikbezogenen (Vorläufer-)Kompetenzen oder der mathematikbezogenen Motivation. Schon kurz nach der Einschulung sind Jungen dann ihren weiblichen Peers in ihrer mathematischen Kompetenz und in mathematikbezogenen motivationalen Variablen überlegen. In dieser querschnittlichen Studie untersuchen wir zwei Aspekte der Prozessqualität in der Kindertagesstätte, die die Entwicklung der mathematikbezogenen Motivation insbesondere von Mädchen günstig beeinflussen können: die Häufigkeit mathematik- und naturwissenschaftsbezogener Aktivitätsangebote und eine Bindungsbeziehung mit hoher Qualität zur pädagogischen Fachkraft. In 135 unabhängigen Dyaden wurde die Beziehungsqualität zwischen Erzieherin und Kind über eine eineinhalbstündige standardisierte Beobachtung erfasst (Attachment Q-Set). Die Erzieherin gab an, wie häufig sie mathematik- und naturwissenschaftsbezogene Aktivitäten anbietet. Die Kinder wurden zu ihrer mathematikbezogenen Motivation befragt und ihre mathematischen Vorläuferkompetenzen mit einem standardisierten Testverfahren gemessen. Die Ergebnisse zeigen in Übereinstimmung mit bereits vorliegenden Studien, dass Mädchen und Jungen sich in ihren mathematischen Vorläuferkompetenzen und ihrer mathematikbezogenen Motivation zum Ende der Kindergartenzeit noch nicht unterschieden. Mädchen waren in signifikant qualitätsvollere Bindungsbeziehungen mit ihren Erzieherinnen eingebunden als Jungen. Während mit der Häufigkeit des Angebots einschlägiger Aktivitäten die mathematikbezogene Motivation der Mädchen stieg, spielte sie für die der Jungen keine Rolle. Wir diskutieren, (a) wie Erziehungspersonen ermuntert werden können, häufiger mathematik- und naturwissenschaftsbezogene Aktivitätsangebote zu machen und (b) ob sich für Jungen eine vergleichbar qualitätsvolle Bindungsqualität wie für Mädchen zeigen würde, wenn die Erziehungsperson männlich wäre.

**Schlüsselwörter:** Bindungsbeziehung, Geschlechtsunterschiede, mathematikbezogene Motivation, mathematische Vorläuferkompetenzen, Prozessqualität in der Kindertagesstätte

Many studies show that at the end of primary school and in secondary school boys outperform their female peers in mathematics (e.g., Mullis, Martin, Foy, Kelly, & Fishbein, 2020; OECD, 2019; Schipolowski, Wittig, Mahler, & Stanat, 2019; Schipolowski, Wittig, Weirich, & Böhme, 2017). Relatively few studies have examined, however, the early beginnings of this development: the period in which these gender differences first become visible and then stabilize. A more detailed analysis of such studies shows that it is only at about the end of kindergarten and at the start of primary school that gender differences emerge (Arens et al., 2016; Niklas & Schneider, 2012). For instance, investigating 922 girls and boys one and a half years before school start, one year before school start, three months before and shortly after school start, and finally, at the end of first grade, Niklas and Schneider (2012) found that only at the fourth measurement point, i.e., shortly after school entry, gender differences became apparent, namely that boys achieved higher scores in tests of mathematics-related precursor competencies than girls, with this difference then remaining stable until the end of first grade. Gender differences in early competencies are partly due to gender differences in motivation (e.g., Marsh & Craven, 2006; Marsh & Martin, 2011).

Against this background, we presumed that kindergarten has a key function in determining whether, when, and to what extent gender differences in mathematics-related motivation and competencies emerge. In this study, we investigate two aspects of process quality in early childhood education that may have a favorable influence on the development of mathematics-related motivation, especially of girls: the frequency of mathematics- and science-related activity offers in the kindergarten group and a high-quality attachment relationship of the individual child with the preschool teacher.

## Global and domain-specific process quality in kindergarten

Children profit in their socio-emotional and cognitive development from kindergarten attendance (e.g., Anders, Grosse, Roßbach, Ebert, & Weinert, 2013; Ulferts, Wolf, & Anders, 2019). In particular, knowledge and motivation in literacy, mathematics, and science acquired in early education have proven to positively impact children's later school performance in the respective domains (e.g., OECD, 2017; Sylva et al., 2013; Ulferts et al., 2019). For such positive effects to be observed it is crucial, however, that the educational quality provided within kindergarten is high. A core aspect of kindergarten quality is process quality, i.e., the emotional, social, and instructional quality of the interactions between children and preschool teachers and between children and their material and spatial environment (e.g., Anders, Roßbach, & Kuger, 2016; Kluczniok & Roßbach, 2014). Process quality can be described at two levels of abstraction. Global quality of educational processes is high when there is a warm and friendly climate of interaction and the children are cared for and supervised appropriately according to their age. Domain-specific process quality is high when children are assisted in their development in specific content or subject domains, such as their early literacy or numeracy (Kluczniok & Roßbach, 2014; Ulferts et al., 2019). Additional differentiations refer to process quality being described on the group level versus the level of the individual child (Kluczniok & Roßbach, 2014) or regarding its quality versus its quantity (e.g., Anders et al., 2013). In their meta-analysis synthesizing 17 longitudinal studies in nine European countries including 16,461 children, Ulferts et al. (2019) found positive effects of both global and domain-specific process quality on children's academic development over their school career. In our study, we investigated two indicators of process quality, as they relate to girls' and boys' mathematics-related motivation:

(a) the frequency of mathematics- and science-related activities provided by the preschool-teacher; i.e., the quantity of an aspect of domain-specific process quality on the group-level, and,

(b) the attachment-relationship with the preschool-teacher; i.e., the quality of an aspect of global process quality on the level of the individual child.

## Effects of the frequency of mathematics- and science-related activities on boys' and girls' mathematics-related motivation

Research on the numeracy environment at home or preschool shows that the frequency of engagement in mathematics related activities predicts children's competencies and motivation in mathematics later on (e.g., Anders et al., 2013; Mantzicopoulos, French & Patrick, 2019; Salminen, Pakarinen, Poikkeus & Lerkkanen, 2018; Susperreguy et al., 2020). For instance, Susperreguy and colleagues (2020) found that children who were provided with frequent operational numeracy activities (e.g., learning simple sums) profited in their performance in arithmetic and in nonsymbolic and symbolic number comparison, as observed at the end of preschool. In our study, we assumed

that educational activities presented in an inquiry-based approach and embedded into daily routines in kindergarten, which allow children to deal with numbers in a playful way, to explore science phenomena, and to reflect on their experiences together with their peers and with the teacher who scaffolds and structures children's activities, would support children's mathematics-related motivation and competencies. (Gropen, Kook, Hoisington, & Clark-Chiarelli, 2017).

In Germany, 96 % of the kindergarten teachers are female (Statistisches Bundesamt, 2020, p. 57). At the same time, research on gender stereotypes shows that mathematics is strongly associated with the male gender. While the explicit gender stereotype that mathematics ability is higher in males than females is not fully understood until the age of about eight to nine (e. g., Hannover, Wolter, Drewes, & Kleiber, 2014; Muzzatti & Agnoli, 2007; Steffens et al., 2010), the first indications that girls and boys are aware of that stereotype appear during the kindergarten years (e. g., Cvencek, Meltzoff, & Greenwald, 2011; Rio & Strasser, 2013). For instance, Rio and Strasser (2013) found that already 5-year old girls and boys thought that girls would find mathematics harder, perform worse at it, and like it less than language, while they considered boys as equally confident and competent in both mathematics and language. Investigating primary school children using an Implicit Association Test, Cvencek et al. (2011) found that boys associated mathematics with their own gender significantly more than girls and that boys more likely selected a character of their own gender as "liking to do math more" than girls did. Also using an Implicit Association Test, Steffens, Jelenec, and Noack (2010) found that girls in fourth grade responded more quickly to a combination of the terms "math" and "boys" than to a combination of the terms "math" and "girls".

Other research suggesting that the gender stereotype of mathematics emerges already in the preschool years was conducted within the stereotype threat paradigm (Ambady, Shih, Kim & Pittinsky, 2001; Tomasetto, Alparone & Cadinu, 2011). In this research, it is hypothesized that a negative performance-related stereotype that exists in regards to a group to which one belongs can affect people in a performance situation if the stereotype is activated in that situation. For instance, Tomasetto et al. (2011) found that girls from kindergarten to second grade whose mothers endorsed the gender stereotype regarding mathematical abilities were impaired in their mathematical performance when they had to draw a picture of a "girlish girl" (rather than a fairy tale landscape) right before having to work on the mathematics tasks, i. e., when their gender identity had been experimentally primed.

The gender stereotype of mathematics implies that girls benefit from counter-stereotypical role models who engage and excel in the relevant domain and share their own gender (Olsson & Martiny, 2018). Applied to our study, female preschool teachers engaging in frequent mathematics- and science-related activities invalidate the assumption that mathematics is not for girls as ingroup-role models (Marx & Ko, 2012). Furthermore, more frequent offers of such activities by a female teacher reflect a normalcy and naturalness, i. e., that girls are expected by their teachers to enjoy these activities as much as boys do. By the same token, girls can infer from fewer offers that they are not expected by their teacher to be interested in these types of activities. For these reasons, we expected that female kindergarten teachers who frequently offer mathematics- and science-related activities are particularly effective in supporting mathematics-related motivation in girls: they are perceived as competent in that domain, they share girls' identity of being female, and they suggest to girls that these activities are interesting and important for girls, too. Our research hypothesis therefore reads that while girls' mathematics-related motivation is strengthened with increasing frequency of mathematics- and science-related activity offers provided by the teacher, the frequency of such offers is irrelevant for the motivation of boys.

## Effects of the quality of attachment relationships in kindergarten on boys' and girls' mathematics-related motivation

The extent to which children can benefit from the educational activities provided by the teacher should depend on the quality of their relationship with the teacher, an aspect of global process quality. Researchers have typically measured global process quality on the level of the group of children (see Ulferts et al., 2019, for a review). Here, trained observers describe the teacher's behavior towards the children, for instance with respect to emotional climate, sensitivity, or need support. In contrast, as we were interested in potentially different effects for girls and boys, we measured process quality for each individual child by observing his or her attachment relationship with the teacher. High attachment relationship quality is instrumental in children's academic development (e. g., Pianta & Stuhlman, 2004). In a high-quality attachment relationship, the child's learning is promoted by the teacher providing emotional support and at the same time supporting the child's exploratory behavior (e. g., Ahnert, Pinquart & Lamb, 2006; Verschueren & Koomen, 2012). In such a relationship, children should be willing to take advantage of

the educational activities provided by the teacher because they feel emotionally safe and experience optimal guidance adapted to their individual needs. We therefore predicted that children benefit more from the teacher's mathematics- and science-related activity offers to the extent that the quality of their attachment relationship with the teacher is high. In order to test this assumption, we considered it necessary to observe the interactive behavior of the child and the teacher, instead of just having the teacher describe the quality of the relationship. This is because the influence of the quality of the relationship on the child's use of the learning opportunities offered by the teacher should unfold at the level of actual interactive behaviors (cf. Solomon & George, 2008).

# Hypotheses

Against this research background, our research hypotheses were as follows.

- To the extent that the teacher offers mathematics- and science-related activities, girls benefit in their mathematics-related motivation, while the frequency of such offers is irrelevant for the motivation of boys.
- To the extent that attachment relationship quality with the teacher is high, both boys and girls benefit from the teacher's mathematics- and science-related activity offers in their mathematics-related motivation.

# Methods

## Sample

One hundred and thirty-five dyads of a female kindergarten teacher ($N$ = 135) and either a boy ($n$ = 65) or a girl ($n$ = 70) from their group of children were included. To obtain independent child-teacher dyads, only one dyad was drawn at random from randomly selected kindergarten groups in Berlin, Germany. From the majority of kindergarten only one group was selected, but also eleven kindergarten with two group, three with three groups, and one kindergarten with four groups were included. Informed written consent was obtained from all parents and teachers and participation was voluntary with the possibility to opt-out at any time. If parents refused to participate, another child was chosen from the kindergarten group. Children and their teachers were investigated in individual sessions during the last two months of kindergarten before the children entered school and when they were $M$ = 71.4 months old ($SD$ = 3.3, range = 65–78 months). The time period during which the children had already been cared for by the respective teacher varied between 2 and 65 months, $M$ = 2.4 years, $SD$ = 19 months. The kindergarten groups were heterogeneous with respect to age with a difference between oldest and youngest child ranging from 3 to 65 months, $M$ = 25.9 months, $SD$ = 16.6 months. The mean level of socioeconomic background of the children's families as operationalized by the HISEI (Highest International Socio-Economic Index of Occupational Status; Ganzeboom, de Graaf, & Treiman, 1992) was $M$ = 57.73, $SD$ = 14.75, and slightly higher than expected in representative samples.

## Instruments

### Mathematics-related motivation

As dependent variable, we measured mathematics-related motivation via ten items. For our age group, items are suitable that reflect children's motivational-affective reactions (liking, enjoyment) towards mathematics related tasks (cf. Arens et al., 2016). Sample items read "How much do you like counting without someone helping you?" or "How much do you like to calculate, for example in games or riddles or when adding up money?". The entire scale (developed by Bachmann & Burock, 2008) is displayed in the Appendix. Children were examined in individual sessions by a trained test leader (student assistants of a local university who were majoring in psychology, in educational sciences, or in a teacher training program). Questions and response scales were read out loud, and the test leaders inserted children's responses in questionnaire protocols. Children had to respond on scales displaying three "smiley" faces: one with a big smile, (3 = I like it very much), one with a slight smile (2 = I like it), and one with a neutral expression (1 = I do not like it much) – as pretesting had shown that children did not use any negative response options (sad smileys). The scale reached an internal consistency of Cronbach's α = .83, with an overall mean of $M$ = 2.23, $SD$ = 0.50.

### Attachment relationship quality between kindergarten teacher and child

To capture interaction quality, we used the Attachment Q-Set (AQS; Waters & Deane, 1985), an observation procedure suitable for measuring attachment relationships of children and adapted for non-parental caregivers. The child-teacher-dyad was observed by one out of 11 trained observers (student assistants of a local university who were majoring in psychology, in educational sciences, or in a teacher training program) over a time-period of one and a half hours during a regular day at kindergarten where no further specific instruction for play or learning interactions

was given. The interactions were documented on-site in a written protocol and coded immediately afterwards on 90 items referring to different aspects of emotional security and exploration support. The 11 independent observers were thoroughly trained before conducting the observations, and interrater reliability was good, *ICC* = .95. (cf. Glüer, 2013, p. 219).

The value for attachment relationship quality was derived from a correlation with experts' ratings of a hypothetical ideally attached child. Hence, the individual correlation coefficients reflect the overlap between our observer's ratings of the child's behaviors in the interaction with the teacher on the one hand and experts' ratings of the behaviors of a hypothetical child in a high-quality attachment relationship on the other. The values had an average of *M* = 0.30, *SD* = 0.15, *range* −0.11 to 0.64. A cut-off value of *r* = .33 is considered to divide children into having an insecure or secure attachment to the kindergarten teacher (cf. Ahnert et al., 2006), however, we used the value as continuous variable in our models.

### Frequency of mathematics- and science-related activities in kindergarten

Kindergarten teachers were asked via a self-administered questionnaire to indicate how often they provide 6 different activity offers addressed to their entire kindergarten group in the course of a regular week that are broadly related to the field of mathematics and science on a scale from 1 (never) to 5 (very often). The entire scale is listed in Table 1. We calculated a sum score to indicate a formative indicator (cf. Diamantopoulos, Riefler, & Roth, 2008) of the general extent of provided activities in mathematics- and science-related fields, *M* = 20.07, *SD* = 3.10. The scale showed an internal consistency of Cronbach's α = .66. Since we wanted to specify a broad range of different activities relevant to mathematics and science, we considered this reliability appropriate.

### Precursors of mathematical competencies in kindergarten

As control variable, children's precursors of mathematical competencies were measured using an early numeracy test („Osnabrücker Test zur Zahlbegriffsentwicklung", van Luit, van de Rijt, Hasemann, 2001). This test consists of eight subdimensions ranging from comparisons, classifications, rank ordering, using number words, one-to-one mapping, synchronous and truncated counting, and applying knowledge about numbers. Children were investigated in individual sessions by a trained test leader (student assistants of a local university who were majoring in psychology, in educational sciences, or in a teacher training program). Competence tasks were presented by the test leader following a standardized testing protocol. For our study purpose, we calculated a sum score for each child as an overall measure of precursor competencies in mathematics, *M* = 28.28, *SD* = 27.12, *range* 15–40.

## Statistical analyses

We used the statistical software program *Stata* to produce descriptive results. Data preparation was finalized using *SPSS*. Regression models were estimated with *Mplus version 8* (Muthén & Muthén, 1998–2017). A full information maximum likelihood (FIML) estimator was used to handle missing data (Allison, 2009; Enders & Bandalos, 2001). There was only a small amount of missing data in this study, ranging from 11 missing cases in teacher's questionnaires to two missing cases in children's individual test sessions and attachment observations. We checked the measurement invariance for our dependent variable, mathematics-related motivation, across gender. Furthermore, we controlled for age span of the kindergarten group (z-standardized) in our analyses.

To test our hypotheses, we conducted a multiple group comparison between girls and boys in a structural equation model. First, we calculated a fully constrained model to regress mathematics-related motivation on children's gender, frequency of mathematics- and science-related activities, attachment relationship quality, and the interaction term between frequency of activities and attachment relationship quality, controlling for precursors of mathematical competencies (Model 1). To test hypothesis 1, in a second model (Model 2) we constrained all regression paths and covariances between predictors, except for the regression coefficient for frequency of mathematics- and science related activities provided by the teacher. In a third model (Model 3) we used a stepwise approach to freely estimate further regression coefficients between girls and boys to check for the best model fit. The Mplus syntax and model outputs are available at: https://osf.io/nkm4e/

**Table 1.** Items measuring mathematics- and science related activities provided by the kindergarten teacher during a regular week

| # | Wording of item |
|---|---|
| 1 | Measuring, calculating, or estimating numbers, proportions, and times (e.g., counting things, estimating quantities) |
| 2 | Using audio-visual media (e.g., television, computer, internet, movies) |
| 3 | Observing and exploring nature (e.g., woods, plants, animals) |
| 4 | Experimenting with natural materials (e.g., sand, soil, water, clay) |
| 5 | Applying and understanding technics (e.g., explaining technical connections, Lego-Technics, handiwork, repairing) |
| 6 | Role-playing on the topics "technics" and "nature" (e.g., repair shop, cars, ships) |

# Results

## Preliminary analyses

Table 2 shows the bivariate correlations between the variables as well as means and standard deviations for girls and boys for all variables included in the regression models. Mathematics-related motivation and precursors of mathematical competencies were positively correlated with $r = .33$, $p < .001$. We tested the measurement invariance for our dependent measure of mathematics-related motivation across the genders by comparing the measurement models in a confirmatory factor analysis approach. For mathematics-related motivation, the acceptable model fit, $\chi^2 = 108.990$, $df = 86$, $p = .048$; CFI = .911, RMSEA = .063 (90 %CI .007–.097), SRMR = .096, and a negligible CFI-difference to the prior metric model, $\chi^2 = 99.285$, $df = 77$, $p = .045$; CFI = .914, RMSEA = .066 (90 %CI .011–.101), SRMR = .092, confirmed partial scalar invariance. The only restriction from total scalar invariance was the free estimate for the factor loadings of three items: items 4, 8, and 10. There was no significant gender difference in children's mathematics-related motivation: Girls ($M = 2.25$, $SD = 0.46$) and boys ($M = 2.23$, $SD = 0.54$) were similarly motivated at the end of kindergarten, with a latent mean difference of −0.10, $SE = 0.22$, $p = .656$. There was no significant gender difference in children's precursors of mathematical competencies either, $t_{(131)} = -0.58$, $p = .282$: Girls ($M = 28.54$, $SD = 5.08$) and boys ($M = 28.02$, $SD = 5.27$) performed equally well at the end of kindergarten in mathematical tasks. However, there was a substantial and large gender difference in attachment quality: Boys were on average in a lower quality attachment relationship to their kindergarten teacher ($M = .24$, $SD = .14$) than girls ($M = .36$, $SD = .14$), $t_{(133)} = -5.08$, $p < .001$, $d = 0.86$.

## Multiple group comparison

In Table 3 the findings of the multiple group comparison in a structural equation model for mathematics-related motivation as predicted by attachment quality, frequency of activities, and gender, controlled for children's precursors of mathematical competencies, are reported. The model fit of the constrained Model 1 was insufficient with $\chi^2 = 40.562$, $df = 17$, $p = .001$; CFI = .065, RMSEA = .143 (90 %CI .087–.201), SRMR = .120, meaning that the theoretical model with fixed regression paths between girls and boys to predict mathematics-related motivation did not fit the empirical data well. Model 2 with all paths constrained except the regression coefficient for frequency of mathematics- and science-related activities again showed an insufficient model fit with $\chi^2 = 24.884$, $df = 14$, $p = .036$; CFI = .568, RMSEA = .107 (90 %CI .028–.175), SRMR = .111, therefore we freely estimated further regression coefficients between girls and boys. Our final Model 3 was conducted with additionally freely estimated regression coefficients for mathematical competencies and attachment

**Table 2.** Bivariate correlations of dependent and independent variables as well as means and standard deviations separate for girls and boys

| | (1) | (2) | (3) | Girls | Boys |
|---|---|---|---|---|---|
| | | | | *M (SD)* | *M (SD)* |
| (1) Mathematics- and science-related activities | | | | 20.59 (8.50) | 19.53 (10.18) |
| (2) Attachment quality | **.32** | | | 0.36 (0.14) | 0.24 (0.14) |
| (3) Mathematics-related motivation | .01 | −.02 | | 2.25 (0.46) | 2.23 (0.54) |
| (4) Precursors of mathematical competencies | .03 | −.02 | **.49** | 28.54 (5.08) | 28.02 (5.27) |

*Notes*: Significant correlation coefficients in boldface.

Table 3. Children's mathematics-related motivation as predicted by child's precursors of mathematical competencies, teachers' mathematics- and science-related activity offers, attachment quality, and interaction effect in multiple group comparison approach

| Model 3: | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|
| | *b* | *SE* | β | *p* | *b* | *SE* | β | *p* |
| Precursors of mathematical competencies | 0.05 | 0.01 | 0.50 | .001 | 0.01 | 0.01 | 0.13 | .238 |
| Mathematics- and science-related activities | 0.03 | 0.03 | 0.19 | .301 | 0.08 | 0.04 | 0.56 | .039 |
| Attachment quality | 3.73 | 1.92 | 0.97 | .052 | 4.31 | 1.97 | 1.34 | .029 |
| Activities*attachment | −0.19 | 0.09 | −1.01 | .044 | −1.19 | 0.09 | −1.28 | .044 |

*Notes*: Boys: $R^2 = .279$; Girls: $R^2 = .086$; displayed is Model 3, controlled for age span in kindergarten group (z-standardized); Model fit: $\chi^2 = 11.964$, $df = 11$, $p = .366$; CFI = .962, RMSEA = .036 (90 %CI .000–.136), SRMR = .089; interaction term constrained between groups representing the fixed interaction between attachment quality and mathematics- and science-related activity offerings by teachers for both genders.

relationship quality and had a good model fit, $\chi^2 = 11.964$, $df = 11$, $p = .366$; CFI = .962, RMSEA = .036 (90 %CI .000–.136), SRMR = .089.

In our first research hypothesis, we had expected that girls but not boys profit in their motivation from their teacher offering mathematics- and science-related activities. Consistent with this expectation, the frequency of activities was positively related to girls' mathematics-related motivation ($b = 0.08$, $SE = 0.04$, $\beta = 0.56$, $p = .039$), whereas it did not matter for boys ($b = 0.03$, $SE = 0.03$, $\beta = 0.19$, $p = .301$).

We had further expected that to the extent that attachment relationship quality is high, children, irrespective of their gender, profit from the teacher's activity offers (hypothesis 2). Consistent with this expectation, the two-way interaction of activity frequency and attachment quality was significant ($b = -1.19$, $SE = 0.09$, $\beta = -1.01$, $p = .044$). Post-hoc probing of the simple slopes revealed, however, a pattern which deviated from our research hypothesis and simple slopes were not significant. The interaction term between frequency of activity offers and attachment quality is depicted in Figure 1.

Mathematics-related motivation in both higher- and lower-quality relationships was independent of the extent to which the teacher offered relevant activities (frequency of activities: –1SD $b = 0.56$, $SE = 0.41$, $p = .171$; + 1SD $b = -0.29$, $SE = 0.32$, $p = .360$). Furthermore, the frequency of mathematics- and science-related activity offers did not matter for children's mathematics-related motivation, neither in higher-quality attachment relationships ($b = -0.01$, $SE = 0.01$, $p = .340$) nor in lower-quality attachment relationships ($b = 0.03$, $SE = 0.02$, $p = .219$).

In addition to the effects pertaining to our research hypotheses we found that boys with higher competencies were more motivated in mathematics ($b = 0.05$, $SE = 0.01$, $\beta = 0.50$, $p < .001$), while precursor competencies did not matter for girls' motivation ($b = 0.01$, $SE = 0.01$, $\beta = 0.13$, $p = .238$). Furthermore, we found that with better attachment quality girls' motivation increased ($b = 4.31$, $SE = 1.97$, $\beta = 1.34$, $p = .029$), while it was unrelated to boys' motivation ($b = 3.73$, $SE = 1.92$, $\beta = 0.97$, $p = .052$).

## Discussion

Since kindergarten appears to be a critical period for the emergence of gender differences in mathematics-related motivation and competencies, we investigated two aspects of process quality in more detail that we expected to promote mathematics-related motivation, especially in girls: namely, the frequency of offers of mathematics- and science-related activities and a high-quality relationship with the kindergarten teacher. In line with previous research (Arens et al., 2016; Niklas & Schneider, 2012), we found no substantial gender differences in children's mathematics-related motivation and precursor competencies at the end of kindergarten. These findings are consistent with the assumption that the well-documented gender differences in mathematics motivation and competencies (e.g., Mullis et al., 2020; OECD, 2019; Schipolowski et al., 2019; Schipolowski et al., 2017) only begin to emerge after the end of kindergarten and around the time of school entry.

A high frequency of mathematics- and science-related activities offered by the kindergarten teacher during a regular week was beneficial for girls' mathematics-related motivation, while it did not matter for boys' motivation. Consistent with our expectation, female kindergarten teachers providing many mathematics-and science-related activities strengthened girls' – but not boys' – mathematics-related motivation. This finding is consistent with the assumption that female kindergarten teachers can function as successful and counter-stereotypical models (cf. Olsson & Martiny, 2018), protecting girls from the negative effect of the ability-based gender stereotype of mathematics (cf. Steffens et al., 2010). Through their own role model behavior, teachers can create a stronger expectation among girls that mathematics is "for girls," that is, that girls and women do well in mathematics, enjoy mathematics, and think of mathematics as important. Our findings also imply that teachers can reinforce negative gender stereotypes which was, for example, described by Wolter, Braun and Hannover (2015): Kindergarten teachers who endorsed traditional gender role attitudes negatively impacted reading-related motivation and precursor competencies in boys, i.e., the group of children affected by a negative achievement-related stereotype in reading. Kindergarten teachers should therefore be attentive to provide a variety of activities and offer them equally to all

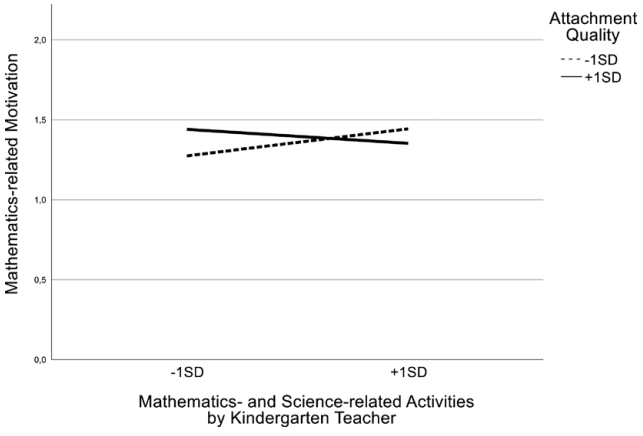


**Figure 1.** Effect of the interaction of mathematics- and science related activity offers provided by the kindergarten teacher and attachment quality on children's mathematics-related motivation.

children in their group to avoid a reinforcement of gender-stereotyped patterns in children's motivation.

For boys, it was found that the more advanced their precursor competencies were, the more motivated they were with regard to mathematics. This is in line with the empirically well-documented skill development effect, according to which high achievement has a favorable effect on self-evaluative and motivational-affective variables (e.g., Retelsdorf, Köller & Möller, 2014). At the same time, as expected, for boys we did not find the positive effect of a high frequency of mathematics- and science-related activity offers provided by the teacher that was evident in girls. A possible explanation is that, due to their lower involvement in attachment relationships with the teacher, boys were more strongly influenced in their motivation by their competencies and a corresponding self-perception of their competencies than by aspects of the interaction with the teacher.

Many preschool teachers lack relevant experiences that would help their own content knowledge and their own understanding of how children learn about mathematics and science (Barenthien, Oppermann, Anders, & Steffensky, 2020). As a result, they may be reluctant to make mathematics- and science related activity offers to their kindergarten groups. Glüer and Lohaus (2016) found that female kindergarten teachers provided more female stereotyped learning opportunities than male kindergarten teachers. This finding suggests that female kindergarten teachers may feel even less self-efficient or experience less pleasure than male teachers in providing mathematics- and science-related activities. Since most kindergarten teachers are female, special attention should be paid in their training to ensure that they have mathematics- and science-specific content knowledge and a strong self-efficacy in teaching mathematics and science content. Barenthien et al. (2020) found that learning opportunities provided in initial teacher education and in-service professional development regarding science-specific professional knowledge had a favorable impact on teachers' science-specific pedagogical content knowledge and self-efficacy beliefs.

We had hypothesized that it would be children in a high-quality attachment relationship who benefit the most in their mathematics-related motivation from the teacher's activity offers. Hence, we had expected that the frequency of relevant activities, as a quantitative dimension of domain-specific process quality, would interact with the attachment quality of the child-teacher relationship, as a qualitative dimension of global process quality: In a high-quality attachment relationship, child and teacher may spend more time together working on a task or teachers may be more successful in motivating the child to stay engaged in the activity even when facing difficulties. Deviating from this expectation, however, the simple slopes of interaction between relationship quality and frequency of relevant activity offerings were non-significant. A possible explanation can be offered by looking at the non-significant pattern of simple slopes: Among children whose teacher rarely offered relevant activities and who were also involved in a low-quality attachment relationship with that teacher, mathematics-related motivation was particularly weak, i.e., it was weaker than in children in high-quality attachment relationships and it was weaker than in children in low-quality relationships with frequent relevant activities. Possibly, children who could neither benefit from a frequent offer of relevant activities nor from a high-quality relationship with the teacher were at a disadvantage in their mathematics-related motivation. While children in a low-quality attachment relationship may not perceive their teacher as a role model, they nevertheless profited in their mathematics-related motivation from the teacher's mathematics- and science-related activity offers by engaging in them.

While previous research found high attachment quality to be beneficial for developmental outcomes irrespective of the child's gender (Ahnert, Pinquart & Lamb, 2006; Verschueren & Koomen, 2012), in our study only girls profited in their mathematics-related motivation from a good relationship with their teacher. Perhaps the fact that the female teacher providing mathematics- and science-related activities was a particularly effective role model for girls implies that she may just not serve as a positive role model for boys in this domain. All of our ex-post-explanations need to be confirmed in future studies examining not only larger samples but also content domains that have a different gender connotation.

Our observations of the quality of the child-teacher relationships revealed that girls were more closely attached to their kindergarten teachers than boys, a finding from our sample that has already been reported by Glüer (2013). This result is consistent with evidence from various other studies according to which boys are involved in less quality interactions or secure attachment relationships with their preschool teacher than girls (e.g., Ahnert et al., 2006; Koepke & Harkins, 2008; Spilt, Koomen, & Jak, 2012; Tsigilis, Gregoriadis, Grammatikopoulos, & Zachopoulou, 2018; Winer & Phillips, 2012; Wolter, Glüer, & Hannover, 2014). A possible interpretation is that girls and boys differ in their behavior and therefore each trigger different, complementary behaviors in the teacher, with, for instance, a child's cheerful behavior triggering warm behavior in the teacher or a child's aggressive behavior triggering harsh behavior in the teacher (cf. Roorda, Koomen, Spilt, Thijs, & Oort, 2013). Compared to boys, girls show more prosocial behavior and empathy, less aggressive behavior, or rough and tumble play (Martin & Ruble, 2010). These gender-typed behavior patterns may elicit complementary

behaviors in the kindergarten teacher, i.e., less warm and emotionally supportive behaviors towards boys than towards girls (cf. Hannover, Kreutzmann & Koeppen, 2021; Roorda, Zee & Koomen, 2020). Possibly as a result, boys are involved in lower quality attachment relationships.

As the teachers in our sample and the teachers examined in the above-mentioned studies were generally female, we do not know whether possibly, boys would form an equally high-quality relationship with a male teacher as girls do with female teachers. To our knowledge, there is only one published study in which attachment qualities were observed in interactive encounters between child and teacher and compared between female and male preschool teachers. Van Polanen, Colonnesi, Fukkink, and Tavecchio (2017) used the Attachment Q-Set to investigate teacher-child-relationships in day care groups with children who were on average 36.2 months ($SD$ = 1.4) old. They found that boys and girls experienced similar levels of high-quality attachment relationships to their teachers irrespective of the caregiver's gender and that teachers of both genders exhibited similarly sensitive behaviors towards girls and boys. Since we wanted to investigate the influence of relationship quality on the development of children's mathematics-related motivation, controlling for their mathematical precursor competencies, in our study we included children who were significantly older ($M$ = 71.4 months, $SD$ = 3.3) than those examined by van Polanen and colleagues. Furthermore, because gendered patterns of social interaction behaviors become more pronounced as preschool children grow older (Hannover et al., 2014; Martin & Ruble, 2010; Winer & Phillips, 2012), possibly, gender-typed interaction patterns, with the teacher responding with complementary behaviors to the child's behavior, and gender differences in the quality of the attachment relationship only emerge in the course of the preschool years. This could explain why van Polanen and colleagues (2017) did not find a similar gender difference in relationship qualities in 3-year-old children that became visible in our study investigating children at the end of their kindergarten years. It would be an interesting task for future studies to investigate longitudinally the emergence of differences in the quality of attachment relationships in which girls versus boys are engaged in with non-parental care providers.

## Limitations

The present study also displays some limitations that should be addressed in future research. We only used cross-sectional data for our analyses, yet in order to infer pedagogical implications for teachers it would be relevant to examine the long-term effects of their activity offerings in mathematics and science for children's mathematics-related motivation. Furthermore, we only measured a selection of mathematics- and science-related activities during a regular week in kindergarten. However, we do not know if the six items we provided really capture all of the relevant activities that kindergarten teachers provide in a typical week. Possibly, inclusion of an even broader range of activities would have improved our measurement's reliability. Finally, while our sample size is substantial given the extensive observation procedures, statistical power was limited regarding the application of the advanced analysis models. Future research to follow up on our findings should include a larger sample size.

## References


Ahnert, L., Pinquart, M., & Lamb, M. E., (2006). Security of children's relationships with nonparental care providers: a meta-analysis, *Child Development, 77* (3). 664 – 679.

Allison, P. D. (2009). Missing Data. In Roger E. Millsap, & Alberto Maydeu-Olivares (Eds.), *The SAGE Handbook of Quantitative Methods in Psychology* (pp. 72 – 89). Thousand Oaks, CA: Sage Publications Inc.

Anders, Y., Grosse, C., Roßbach, H.-G., Ebert, S., & Weinert, S. (2013). Preschool and primary school influences on the development of children's early numeracy skills between the ages of 3 and 7 years in Germany. *School Effectiveness and School Improvement, 24*, 195 – 211.

Anders, Y., Roßbach, H.-G., & Kuger, S. (2016). Early childhood learning experiences. In S. Kuger, E. Klieme, N. Jude, & D. Kaplan (Hrsg.), *Assessing contexts of learning* (pp. 179 – 208). Springer International Publishing.

Ambady, N., Shih, M., Kim, A., & Pittinsky, T. (2001). Stereotype susceptibility in children: Effects of identity activation on quantitative performance. *Psychological Science, 12*, 385 – 390.

Arens, A. K., Marsh, H. W., Craven, R. G., Yeung, A. S., Randhawa, E., & Hasselhorn, M. (2016). Math self-concept in preschool children: Structure, achievement relations, and generalizability across gender. *Early Childhood Research Quarterly, 36*, 391 – 403.

Bachmann, K., & Burock, K. (2008). *Der Zusammenhang zwischen der Lernmotivation und den sprachlichen und mathematischen Kompetenzen von Jungen und Mädchen im Vorschulalter*. Unveröffentlichte Diplomarbeit, Freie Universität Berlin, Germany.

Barenthien, J., Oppermann, E., Anders, Y., & Steffensky, M. (2020). Preschool teachers' learning opportunities in their initial teacher education and in-service professional development – do they have an influence on preschool teachers' science-specific professional knowledge and motivation?. *International Journal of Science Education, 42*, 744 – 763.

Cvencek, D., Meltzoff, A. N., & Greenwald, A. G. (2011). Math-gender stereotypes in elementary school children, *Child Development, 82*, 766 – 779.

Diamantopoulos, A., Riefler, P., & Roth, K. P. (2008). Advancing formative measurement models. *Journal of Business Research, 61* (12), 1203 – 1218.

Enders, C. K., & Bandalos, D. L. (2001). The relative performance of full information maximum likelihood estimation for missing data in structural equation models. *Structural Equation Modeling, 8* (3), 430 – 457.

Ganzeboom, H. B. G., De Graaf, P. M., & Treiman, D. J. (1992). A standard international socio-economic index of occupational status. *Social Science Research, 21* (1), 1 – 56.

Glüer, M. (2013). *Beziehungsqualität und kindliche Kooperations- und Bildungsbereitschaft. Eine Studie in Kindergarten und Grundschule*. Wiesbaden: VS Verlag für Sozialwissenschaften

Glüer, M., & Lohaus, A. (2016). Typisch weiblich – typisch männlich? Erziehungsverhalten und Bildungsangebote von männlichen und weiblichen Fachkräften im Kindergarten. *Psychologie in Erziehung und Unterricht, 63*, 180 – 192.

Gropen, J., Kook, J. F., Hoisington, C., & Clark-Chiarelli, N. (2017). Foundations of science literacy: Efficacy of a preschool professional development program in science on classroom instruction, teachers' pedagogical content knowledge, and children's observations and predictions. *Early Education and Development, 28*, 607 – 631.

Hannover, B., Kreutzmann, M., & Koeppen, K. (2021). Die Qualität des Lehrkraftverhaltens in Lehrkraft-Kind-Dyaden. Unterschiede zwischen Kindern in Abhängigkeit ihres Geschlechts, ihrer sprachlichen Herkunft und eines sonderpädagogischen Förderbedarfs. *Zeitschrift für Pädagogische Psychologie* [Vorab-Onlinepublikation]. https://doi.org/10.1024/1010-0652/a000327

Hannover, B., Wolter, I., Drewes, J., & Kleiber, D. (2014). Geschlechtsidentität: Selbstwahrnehmung von Geschlecht. In D. Lück & W. Cornelißen (Hrsg.): *Geschlechterunterschiede und Geschlechterunterscheidungen in Europa* (S. 143 – 160). Stuttgart: Lucius & Lucius.

Kluczniok, K., & Roßbach, H. - G. (2014). Conceptions of educational quality for kindergartens. *Zeitschrift für Erziehungswissenschaft, 17*, 145 – 158.

Koepke, M. F., & Harkins, D. A. (2008). Conflict in the classroom: Gender differences in the teacher-child relationship. *Early Education and Development, 19*, 843 – 864.

Mantzicopoulos, P., French, B. F., & Patrick, H. (2019). The quality of mathematics instruction in kindergarten: Associations with students' achievement and motivation. *Elementary School Journal, 119*, 651 – 676.

Marsh, H. W., & Craven, R. G. (2006). Reciprocal effects of self-concept and performance from a multidimensional perspective. *Perspectives on Psychological Science, 1*, 133 – 163.

Marsh, H. W., & Martin, A. J. (2011). Academic self-concept and academic achievement: Relations and causal ordering. *British Journal of Educational Psychology, 81*, 59 – 77.

Martin, C. L., & Ruble, D. N. (2010). Patterns of gender development. *Annual Review of Psychology, 61*, 353 – 381.

Marx, D. M., & Ko, S. J. (2012). Superstars "like" me: The effect of role model similarity on performance under threat. *European Journal of Social Psychology, 42*, 807 – 812.

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 International Results in Mathematics and Science*. Retrieved December, 13th, 2020, from Boston College, TIMSS & PIRLS International Study Center website: https://timssandpirls.bc.edu/timss2019/international-results/

Muthén, L. K., & Muthén, B. O. (1998 – 2017). *Mplus User's Guide* (8th ed.). Los Angeles, CA: Muthén & Muthén.

Muzzatti, B., & Agnoli, F. (2007). Gender and mathematics: Attitudes and stereotype threat susceptibility in Italian children. *Developmental Psychology, 43*, 747 – 759.

Niklas, F., & Schneider, W. (2012). Die Anfänge geschlechtsspezifischer Leistungsunterschiede in mathematischen und schriftsprachlichen Kompetenzen. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 44*, 123 – 138.

OECD. (2017). *Starting strong 2017: Key OECD indicators on early childhood education and care*. Paris: OECD Publishing.

OECD. (2019). *PISA 2018 results: What students know and can do*. Paris: OECD Publishing.

Olsson, M., & Martiny, S. E. (2018). Does exposure to counterstereotypical role models influence girls' and women's gender stereotypes and career choices? A review of social psychological research. *Frontiers in Psychology, 9*, 2264.

Pianta, R. C., & Stuhlman, M. W. (2004). Teacher-child relationships and children's success in the first years of school. *School Psychology Review, 33*, 444 – 458.

Río, M., & Strasser, K. (2013). Preschool children's beliefs about gender differences in academic skills. *Sex Roles, 68*, 231 – 238.

Retelsdorf, J., Köller, O., & Möller, J. (2014). Reading achievement and reading self-concept – Testing the reciprocal effects model. *Learning and Instruction, 29*, 21 – 30.

Roorda, D. L., Koomen, H. M. Y., Spilt, J. L., Thijs, J. T., & Oort, F. J. (2013). Interpersonal behaviors and complementarity in interactions between teachers and kindergartners with a variety of externalizing and internalizing behaviors. *Journal of School Psychology, 51*, 143 – 158.

Roorda, D. L., Zee, M., & Koomen, H. M. Y. (2020). Don't forget student-teacher dependency! A meta-analysis on associations with students' school adjustment and the moderating role of student and teacher characteristics. *Attachment & Human Development* [Vorab-Onlinepublikation]. https://doi.org/10.1080/14616734.2020.1751987

Salminen, J., Pakarinen, E., Poikkeus, A.-M., & Lerkkanen, M.-K. (2018). Development of pre-academic skills and maotivation in kindergarten: A subgroup analysis between classroom quality profiles. *Research Papers in Education, 33*, 451 – 479.

Schipolowski, S., Wittig, J., Mahler, N., & Stanat, P. (2019). Geschlechtsbezogene Disparitäten. In P. Stanat, S. Schipolowski, N. Mahler, S. Weirich, & S. Henschel (Hrsg.), *IQB-Bildungstrend 2018. Mathematische und naturwissenschaftliche Kompetenzen am Ende der Sekundarstufe I im zweiten Ländervergleich* (S. 237 – 263). Münster: Waxmann.

Schipolowski, S., Wittig, J., Weirich, S., & Böhme, K. (2017). Geschlechtsbezogene Disparitäten. In P. Stanat, S. Schipolowski, C. Rjosk, S. Weirich, & N. Haag (Hrsg.), *IQB-Bildungstrend 2016. Kompetenzen in den Fächern Deutsch und Mathematik am Ende der 4. Jahrgangsstufe im zweiten Ländervergleich* (S. 187 – 211). Münster: Waxmann.

Solomon, J., & George, C. (2008). The measurement of attachment security and related constructs in infancy and early childhood. In J. Cassidy, & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (pp. 383 – 416). The Guilford Press.

Spilt, J. L., Koomen, H. M. Y., & Jak, S. (2012). Are boys better off with male and girls with female teachers? A multilevel investigation of measurement invariance and gender match in teacher-student relationship quality. *Journal of School Psychology, 50* (3), 363 – 378.

Statistisches Bundesamt (Destatis) (2020). *Statistiken der Kinder- und Jugendhilfe. Kinder und tätige Personen in Tageseinrichtungen und in öffentlich geförderter Kindertagespflege am 01.03.2020*. Retrieved December 13th, 2020 from https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Soziales/Kindertagesbetreuung/Publikationen/Downloads-Kindertagesbetreuung/tageseinrichtungen-kindertagespflege-5225402207004.pdf?__blob=publicationFile

Steffens, M. C., Jelenec, P., & Noack, P. (2010). On the leaky math pipeline: Comparing implicit math-gender stereotypes and math withdrawal in female and male children and adolescents. *Journal of Educational Psychology, 102*, 947 – 963.

Sylva, K., Sammons, P., Chan, L., Melhuish, E., Siraj-Blatchford, I., & Taggart, B. (2013). The effects of early experiences at home and pre-school on gains in English and mathematics in primary school: A multilevel study in England. *Zeitschrift für Erziehungswissenschaft, 16*, 277 – 301.

Susperreguy, M. I., Di Lonardo Burr, S., Xu, C., Douglas, H., LeFevre, J., & LeFevre, J.-A. (2020). Children's home numeracy environment predicts growth of their early mathematical skills in kindergarten. *Child Development, 91*, 1663 – 1680.

Tomasetto, C., Alparone, F. R., & Cadinu, M. (2011). Girls' math performance under stereotype threat: The moderating role of mothers' gender stereotypes. *Developmental Psychology, 47*, 943 – 949.

Tsigilis, N., Gregoriadis, A., Grammatikopoulos, V., & Zachopoulou, E. (2018). Applying exploratory structural equation modeling to examine the student-teacher relationship scale in a representative Greek sample. *Frontiers in Psychology, 9*, 733.

Ulferts, H., Wolf, K. M., & Anders, Y. (2019). Impact of process quality in early childhood education and care on academic outcomes: Longitudinal meta-analysis. *Child Development, 90*, 1474 – 1489.

van Luit, J. E. H., van de Rijt, B. A. M., & Hasemann, K. (2001). *Osnabrücker Test zur Zahlenbegriffsentwicklung*. Göttingen: Hogrefe.

van Polanen, M., Colonnesi, C., Fukkink, R. G., & Tavecchio, L. W. C. (2017). Is caregiver gender important for boys and girls? Gender-specific child-caregiver interactions and attachment relationships. *Early Education and Development, 28*, 559 – 571.

Verschueren, K., & Koomen, H. M. (2012). Teacher–child relationships from an attachment perspective. *Attachment & Human Development, 14*, 205 – 211.

Waters, E., & Deane, K. (1985). Defining and assessing individual differences in attachment relationships: Q-methodology and the organization of behavior in infancy and early childhood. In I. Bretherton & E. Waters (Eds.), *Growing Points of Attachment Theory and Research, Monographs of the Society for Research in Child Development* (pp. 41 – 65), 50, nos. 1 – 2.

Winer, A. C., & Phillips, D. A. (2012). Boys, girls, and "two cultures" of child care. *Merrill-Palmer Quarterly, 58* (1), 22 – 49.

Wolter, I., Braun, E., & Hannover, B. (2015). Reading is for girls!? The negative impact of preschool teachers' traditional gender role attitudes on boys' reading related motivation and skills. *Frontiers in Psychology, 6*, 1267.

Wolter, I., Glüer, M., & Hannover, B. (2014). Gender-typicality of activity offerings and child-teacher relationship closeness in German "Kindergarten". Influences on the development of spelling competence as an indicator of early basic literacy in boys and girls. *Learning and Individual Differences, 31*, 59 – 65.

**History**
Received December 15, 2020
Accepted June 5, 2021
Published online August 6, 2021

**Funding**
This research was supported by a grant from the Deutsche Forschungsgemeinschaft allocated to the second author, Bettina Hannover (HA 2381/8-1, HA 2381/8-2). The research project was jointly conducted with Lieselotte Ahnert, Faculty of Psychology, Universität Wien, Wien, Austria.
Open access publication enabled by the University of Bamberg.

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# Appendix

Items of the scale "mathematics-related motivation" measured in kindergarten:

1. How much do you like counting? For example, in games (Ludo) or the number of plates or other things when setting the table?
2. How much do you try tackling difficult counting tasks, for example, counting to higher numbers?
3. How much do you like counting without someone helping you?
4. How much to you like to do something related to sorting different objects, for example, sorting card decks or something else related to sorting for a game?
5. How much do you try to recognize numbers, for example, on a clock or a calendar or house numbers?
6. There are easier numbers such as 1 or 2 and somewhat more difficult numbers, for example 12 or 25 with multiple numbers in series. How much do you like to recognize those numbers, too?
7. How much do you like to recognize numbers without someone helping you?
8. How much do you like to calculate, for example in games or riddles or when adding up money?
9. There are easier calculation tasks, for example the sum of two smaller numbers, and more difficult calculation tasks in adding bigger numbers. How much do you like to try more difficult calculation tasks?
10. How much do you like to calculate without someone helping you?