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Reciprocal relations among motivational frameworks, math anxiety, and math achievement in early elementary school

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ABSTRACT

School-entry math achievement is a strong predictor of math achievement through high school. We asked whether reciprocal relations among math achievement, math anxiety, and entity motivational frameworks (believing that ability is fixed and a focus on performance) can help explain these persistent individual differences. We assessed 1st and 2nd graders' ($N = 634$) math achievement, motivational frameworks, and math anxiety 2 times, 6 months apart. Cross-lagged path analyses showed reciprocal relations between math anxiety and math achievement and between motivational frameworks and math achievement. Entity motivational frameworks predicted higher math anxiety. High math achievement was a particularly strong predictor of lower math anxiety and less entity-oriented motivational frameworks. We concluded that reciprocal effects are already present in the first 2 years of formal schooling, with math achievement and attitudes feeding off one another to produce either a vicious or virtuous cycle. Improving both math performance and math attitudes may set children onto a long-lasting, positive trajectory in math.

Why do some children succeed in math while others struggle, even from the start of formal schooling? Individual differences in math achievement at school entry persist and strongly predict later achievement in both math and reading (e.g., Duncan et al., 2007). The most straightforward explanation is the cumulative nature of math learning—in other words, children who struggle to grasp basic concepts have difficulty learning more advanced concepts that build on those basic ones. While this explanation is almost certainly part of the reason that early math knowledge differences persist, we propose that socioemotional factors also play an important role. Specifically, we argue that the development of math anxiety and motivational frameworks are linked to early math skills and to each other in a reciprocal manner, leading to cascading effects that perpetuate these early differences. Math anxiety is a negative affective reaction to situations involving math (Maloney & Beilock, 2012) that correlates with low math achievement and predicts avoidance of math-related courses, tasks, and careers (Hembree, 1990). A motivational framework incorporates both the belief that intelligence is malleable versus fixed and an orientation toward learning versus performance

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goals (Gunderson et al., 2013; Park, Gunderson, Tsukayama, Levine, & Beilock, 2016). Although researchers have identified other motivational factors relevant to math achievement, including mathematics self-concept, self-efficacy, intrinsic motivation, and valuing math (for a review, see Wigfield et al., 2015), we chose to focus on math anxiety and motivational frameworks because of evidence establishing their importance for math achievement among students of all ages (e.g., Foley et al., 2017; Ganley & McGraw, 2016; Park et al., 2016; Paunesku et al., 2015).

Understanding how these three factors—math anxiety, motivational frameworks, and math achievement—relate to one another in the first and second grades, the first 2 years of formal schooling, is of both theoretical and practical importance. Most research on these factors has focused on older students in late elementary school (e.g., fourth grade) and beyond. This focus on older ages has stemmed from research and theory suggesting that younger children's academic attitudes and beliefs are not yet stable enough to impact their achievement (Eccles, Midgley, & Adler, 1984; Wigfield et al., 1997) or that children in the first and second grades are overly optimistic about their own academic performance (Eccles, Wigfield, Harold, & Blumenfeld, 1993) and may therefore be unaffected by negative academic emotions and beliefs. Recently, these views have begun to shift, as both motivational frameworks and math anxiety have been shown to predict math achievement in early elementary school populations (e.g., first and second graders; Gunderson et al., 2017; Park et al., 2016; Ramirez, Chang, Maloney, Levine, & Beilock, 2016; Stipek & Gralinski, 1996; Vukovic, Kieffer, Bailey, & Harari, 2013). Rarely, if ever, have researchers investigated the relation among these three factors at an early age, and our effort to do so holds promise for understanding individual differences in math achievement and attitudes.

Further, we argue that it is crucial to investigate children's own math achievement as a predictor of their math anxiety and motivational frameworks. If first and second graders lack a realistic assessment of their own academic abilities, as some have argued (e.g., Freedman-Doan et al., 2000), then children's own math achievement is unlikely to affect their math anxiety and motivational frameworks. However, we advance a different view—that children's first years of formal schooling may be a time in which children are *especially* sensitive to cues about their own achievement and that children's perceptions of their academic achievement drive the initial development of math anxiety and motivational frameworks. The first and second grades typically represent children's first opportunity to assess their math performance relative to their peers and to receive feedback about their math skills from teachers and parents (Eccles et al., 1984). For these reasons, we expect that children's initial level of math achievement may be a particularly important predictor of math anxiety and motivational frameworks at this age.

Understanding potential reciprocal relations among motivational frameworks, math anxiety, and math achievement is also of major practical importance. If these factors are already interrelated in the first and second grades, it will establish the potential benefits of intervening on one or more of these factors at this early age. Further, examining the relative strength of these relations can help intervention researchers target factors in the cycle that are likely to have the greatest impact on children's achievement, motivation, and anxiety.

Motivational frameworks and math anxiety

Even in early elementary school, children differ in their beliefs about whether intelligence is fixed or malleable and their preferences for easy versus challenging tasks (Gunderson et al., 2013; Kinlaw & Kurtz-Costes, 2007; Smiley & Dweck, 1994). Children who believe their intelligence is fixed tend to prefer easy tasks that allow them to succeed and therefore display their high ability to others (Blackwell, Trzesniewski, & Dweck, 2007; Dweck & Leggett, 1988; Haimovitz, Wormington, & Corpus, 2011). Following previous work (Dweck, 2006; Gunderson et al., 2013), we refer to these children as holding an entity motivational framework. Children who believe their intelligence can change through their own effort tend to prefer challenging tasks because they provide opportunities to learn and improve their intelligence; we refer to these children as holding an incremental motivational framework. By combining theories of intelligence and learning goals, we sought to assess the coherent system of beliefs and behaviors associated with an entity or incremental theory of intelligence (Dweck & Leggett, 1988). We also expected that combining theories of intelligence and goal orientations would yield a more robust measure than either construct alone, given that these constructs can be difficult to assess reliably at our target age (Gunderson et al., 2013).

Although previous work has suggested that theories of intelligence and learning goals are related, most research has focused on only one of these two constructs and their respective relations to academic achievement (e.g., Elliott & Dweck, 1988; Gonida, Kiosseoglou, & Leondari, 2006; Grant & Dweck, 2003; McCutchen, Jones, Carbonneau, & Mueller, 2016; Meece, Blumenfeld, & Hoyle, 1988). For this reason and because these are related but distinct constructs (e.g., Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013; Robins & Pals, 2002), we thought it was important to also investigate the relations of theories of intelligence and goal orientations to math anxiety and math achievement when considered separately. Notably, however, our main hypotheses were based on the combined motivational frameworks construct, and our analyses of theories of intelligence and learning goals alone were considered exploratory.

Motivational frameworks are important because they strongly predict later achievement (e.g., Blackwell et al., 2007; Gunderson et al., 2017), a relation we will review in more detail. However, a key novel hypothesis of the present study is that there is a longitudinal relation between motivational frameworks and *math anxiety*. Math anxiety is distinct from, though correlated with, general anxiety and test anxiety (Hembree, 1990; Malanchini et al., 2017). Math anxiety can involve both cognitive (e.g., worries) and emotional (e.g., physiological arousal) components, and it is present in everyday tasks, classroom learning situations, and mathematical testing situations (Ramirez, Shaw, & Maloney, 2018; Richardson & Suinn, 1972). Motivational frameworks have been hypothesized to form the conceptual foundation through which children interpret and react to academically relevant situations (Hong, Chiu, Dweck, Lin, & Wan, 1999), and there are strong theoretical reasons to believe that an individual's motivational framework, as well as each of its components—theories of intelligence and goal orientations—should relate to math anxiety (Burns & Isbell, 2007; Hong et al., 1999; Moore, Rudig, & Ashcraft, 2015). When performance goals were induced, students displayed negative affect toward challenging tasks and avoided the possibility of making mistakes in public (Elliott & Dweck, 1988). This combination of negative emotions and avoidance, especially in a performative context, are also hallmarks of high math anxiety (Hembree, 1990). In contrast, when

learning goals were induced, children maintained positive affect in the face of failure and sought opportunities to learn, even when others might have seen their mistakes (Elliott & Dweck, 1988). Thus, learning goals have led to behaviors that are the hallmarks of low math anxiety.

However, surprisingly little direct empirical evidence supports this claim. In one study with adults, entity-theory priming led to marginally higher anxiety than incremental-theory priming (Burns & Isbell, 2007). In addition, college women's entity theories about math were related to disengagement and avoidance of math course taking, signatures of math anxiety (Burkley, Parker, Stermer, & Burkley, 2010). However, as noted by Moore et al. (2015), research examining the relation between motivational frameworks and academic anxieties is sparse, and no single study has tested this link in children. In sum, although there are strong reasons to believe that entity motivational frameworks might predict the development of higher math anxiety over time, to our knowledge, our study is the first to directly test this prediction.

In addition, we examined a reverse relationship: whether higher math anxiety predicts higher entity motivational frameworks over time. However, in this case, we did not expect a reciprocal, bidirectional relation. Given the theorized role of motivational frameworks as the basis for other academically relevant attributions, behaviors, and affective reactions (Hong et al., 1999), we expected motivational frameworks to predict math anxiety, but we did not expect the reverse.

Math anxiety and math achievement

We also examined whether math anxiety and math achievement showed reciprocal relations in young children. Importantly, math anxiety is not simply a proxy for low math ability, but it can lead to poor math achievement through multiple pathways (Foley et al., 2017; Maloney, 2016; Maloney & Beilock, 2012). Students with math anxiety tend to avoid taking math classes (Hembree, 1990). In addition, math anxiety can lower math performance as it leads to verbal ruminations and worries that disrupt the working-memory resources needed to solve math problems (Ashcraft & Kirk, 2001; Beilock, 2008; Park, Ramirez, & Beilock, 2014). Studies involving experimentally decreasing anxiety have firmly established this causal path, at least among adults (Brunyé et al., 2013; Hembree, 1990; Park et al., 2014). Although evidence from young children concerning the math anxiety–achievement link is sparse, it also suggests that math anxiety may impact achievement over time. Several studies have shown contemporaneous negative correlations between math anxiety and math achievement in early elementary school (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015; Ramirez, Gunderson, Levine, & Beilock, 2013; Vukovic et al., 2013). In addition, one study showed that beginning-of-year general school worries and anxiety while completing math and reading tasks predicted end-of-year numerical skills among students in prekindergarten and kindergarten, while controlling for beginning-of-year numerical skills (Stipek & Ryan, 1997). Another study revealed that higher self-reported math anxiety in second grade predicted lower math performance in third grade among students high in working memory (Vukovic et al., 2013). Thus, there are strong reasons to believe that early math anxiety will lead to lower math achievement over time as early as first and second grade.

At the same time, it is quite possible that low math ability can lead to math anxiety if individuals recognize their poor performance and worry about its consequences (such as embarrassment in front of one's peers and failure to attain desired educational outcomes).

Math anxiety may stem, in part, from difficulties with specific building blocks of mathematical thinking (Maloney, 2016). Adults with math anxiety performed more poorly than non-math-anxious adults not only on working memory-intensive math problems (e.g., multidigit calculation), but also on more basic skills like counting, comparing quantities, and visualizing the rotation of three-dimensional objects (Ferguson, Maloney, Fugelsang, & Risko, 2015; Maloney, Ansari, & Fugelsang, 2011; Maloney, Risko, Ansari, & Fugelsang, 2010). Surprisingly, however, to our knowledge, no studies have directly tested whether low levels of math achievement predict higher math anxiety. Nevertheless, we can glean hints from studies of constructs related to math anxiety, such as task-avoidant behaviors and math interest, and of constructs related to math achievement, such as perceived math ability. In one study of seventh to ninth graders, higher perceived math ability led to lower math anxiety over time (Meece, Wigfield, & Eccles, 1990). Among first graders, low math skills predicted more task-avoidant behaviors in school over time, a signature of high math anxiety (Onatsu-Arvilommi & Nurmi, 2000). In preschool, students with initially high interest performed better over time, and those with initially high performance showed more interest over time—a reciprocal relation (Fisher, Dobbs-Oates, Doctoroff, & Arnold, 2012). In sum, theory and previous research strongly suggest that math anxiety may cause lower math achievement. Further, although some researchers have argued that poor math achievement can cause math anxiety, data to support this claim, particularly in young children, are lacking.

Motivational frameworks and math achievement

Like math anxiety, motivational frameworks (and their components, theories of intelligence and goal orientations) have important, well-established impacts on academic achievement. Among middle school and college students, experimentally increasing incremental theories of intelligence led to better grades and standardized test scores (Aronson, Fried, & Good, 2002; Good, Aronson, & Inzlicht, 2003). Children with stronger incremental theories of intelligence in the third through sixth grades tended to have higher math and social studies achievement during the course of one school year (McCutchen et al., 2016; Stipek & Gralinski, 1996), and they maintained higher math grades for 2 years during the difficult transition from elementary school to middle school (Blackwell et al., 2007). Similarly, learning goals among fifth and eighth graders predicted higher academic achievement in the math and language domains (Gonida & Cortina, 2014). Further, motivational frameworks in second/third grade predicted increases in both math and reading comprehension scores from second to fourth grade (Gunderson et al., 2017), and motivational frameworks in first and second graders predicted growth in math achievement across one school year (Park et al., 2016). Thus, there is strong evidence that incremental frameworks are related to higher academic achievement, including in math, from first grade through postsecondary school.

What is less known, however, is whether having high math achievement leads to a more adaptive motivational framework over time. In other words, does high achievement make people more optimistic about the role of effort in ability and more oriented toward learning versus performance? Very little research to date has addressed this question, but we can gain hints from studies of specific aspects of motivation, such as academic self-concept, intrinsic motivation, and goal orientation. A substantial body of research supports the *reciprocal effects model* of relations between academic self-concept (perception and evaluation of oneself in an academic context) and academic achievement (for a

review, see Marsh & Martin, 2011). Although most evidence has come from older students and adults (e.g., Luo, Kovas, Haworth, & Plomin, 2011; Seaton, Parker, Marsh, Craven, & Yeung, 2014), one 2-year longitudinal study of second- through fourth-grade students showed reciprocal relations: Higher academic self-concept predicted higher achievement, and higher achievement predicted higher academic self-concept (Guay, Marsh, & Boivin, 2003). Another aspect of motivation, intrinsic motivation, has also been shown to relate to academic achievement in a reciprocal fashion among children as young as preschool through second grade (Aunola, Leskinen, & Nurmi, 2006). Further, these effects were stronger in math than in literacy (Viljaranta, Lerkkanen, Poikkeus, Aunola, & Nurmi, 2009). However, one study of first through fourth graders showed that math achievement predicted intrinsic motivation over time but that intrinsic motivation did not predict later math achievement, suggesting a directional rather than a reciprocal relation (Garon-Carrier et al., 2016). More closely related to motivational frameworks is a study on the impact of early academic achievement on later goal orientation; in this study, second graders' higher math skills were related to lower performance-avoidance goals one year later (Jögi, Kikas, Lerkkanen, & Mägi, 2015).

Thus, we found suggestive evidence that academic achievement predicts motivational frameworks, especially goal orientations. To our knowledge, however, only one study has shown that initial math achievement predicts later incremental motivational frameworks (Park et al., 2016), and it is not clear whether this effect was driven by the relation of math achievement to theories of intelligence, goal orientations, or both. Further, considering that motivational frameworks have been theorized to relate to both math achievement and math anxiety, it is important to examine whether any relations between motivational frameworks and math achievement still hold after accounting for the possible confound of math anxiety. We aimed to fill this important gap and, for the first time, address a broader question: Are there reciprocal relations among motivational frameworks, math anxiety, and math achievement in young children?

The present study

In the present study, we examined the reciprocal relations between one's motivational framework (along with its components, theory of intelligence and goal orientation), math anxiety, and math achievement in a 6-month longitudinal study of first and second graders, which took place during one academic year. Our first hypothesis was that stronger entity motivational frameworks would predict higher math anxiety over time, a relation that has been hypothesized but not empirically tested. Although it is possible that math anxiety could also predict motivational frameworks over time, we did not have strong reasons to believe this would be the case. Second, we expected to find reciprocal relations between math anxiety and math achievement over time. Finally, we examined reciprocal relations between entity motivational frameworks and math achievement. We investigated these effects in first and second graders based on evidence that motivational frameworks and math anxiety begin to form and relate to achievement by this young age (Gunderson et al., 2013; Park et al., 2016; Ramirez et al., 2013). In addition, early elementary school may represent a critical time in which beliefs and emotions about academic subjects develop, thereby setting the stage for children's academic engagement throughout schooling. In sum, our study sheds light on the relations between motivation,

anxiety, and achievement, which may explain why gaps in early math achievement often lead to persistent gaps in math achievement over time.

Method

Participants

Participants were 634 first and second graders (342 girls, 292 boys; 282 first graders, 352 second graders) from 72 classrooms in 23 elementary schools in a large urban area. During the first session, children were a mean age of 7;2 ($SD = 7.68$ months, range = 5;4–9;11; $n = 598$). Based on parental report, 32.0% of participants were Black or African American, 24.0% were White, 27.6% were Hispanic or Latino, 7.1% Asian, 0.5% were American Indian or Alaskan Native, and 5.2% were Other or two or more races; 3.6% did not report their ethnicity. Children were from socioeconomically diverse families, with an average annual family income of \$49,255 ($SD = \$35,000$, range = less than \$15,000 to more than \$100,000; $n = 567$). The maximum level of education reported for either parent was a mean of 14.82 years ($SD = 2.37$ years, $n = 598$), with a range of less than high school (recorded as 11 years) to a graduate degree (recorded as 18 years).

An additional 54 children were initially assessed but were excluded because they were enrolled in special education ($n = 25$) or had problems completing all the tasks during one or more of the sessions ($n = 29$). After meeting these minimum criteria, children were retained in all analyses for which they had relevant data; therefore, sample sizes were reduced from the maximum sample depending on the analysis. Missing data occurred because of children's failure to complete individual tasks and because of experimenter error in administering the math achievement measure (see sample sizes in Table 1). In our path analyses, we used full information maximum likelihood estimation, which uses all available data to estimate model parameters (Muthén & Muthén, 1998–2012). Full information maximum likelihood is more unbiased and more efficient compared with other methods of dealing with missing data (Enders & Bandalos, 2001).

Procedure

The data were collected as part of a larger study of academic achievement and emotions in first and second graders (Maloney et al., 2015; Park et al., 2016).¹ The procedures were approved by the institutional review board at the last author's institution. Children completed measures of motivational frameworks, math anxiety, and math achievement within the first 3 months of the school year (Time 1 [T1]) and again within the last 2 months of the school year (Time

¹These data are part of a larger project examining the relations between affective factors and success in math and reading. Subsets of these data are reported in Park et al. (2016) and Maloney et al. (2015); however, the focus of the present study is quite distinct from the previous studies (which examined the relation between teachers' instructional styles and children's motivational frameworks, and the relation between parent math anxiety, homework help, and student achievement, respectively). The present study is the only one to examine longitudinal relations between students' math anxiety and math achievement, and to examine longitudinal relations between students' math anxiety and motivational frameworks. In addition, it is the only study to examine the two components of a motivational framework (theories of intelligence and goal orientations) separately.

Table 1. Descriptive statistics for all measures.

	All participants		Grade Level		Cohen's <i>d</i>	Gender		Cohen's <i>d</i>
	<i>N</i>	<i>M</i> (<i>SD</i>)	First graders	Second graders		Girls	Boys	
			<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)		<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	
Time 1 measures (fall)								
1. Entity motivational framework	595	3.78 (0.85)	3.88 (0.85)	3.70 (0.85)	−0.21*	3.86 (0.82)	3.69 (0.89)	−0.20*
2. Entity theory	595	3.44 (1.12)	3.48 (1.13)	3.40 (1.11)	−0.07	3.51 (1.10)	3.35 (1.13)	−0.14
3. Performance goal	595	4.12 (1.01)	4.27 (0.95)	4.00 (1.05)	−0.27**	4.21 (0.95)	4.02 (1.07)	−0.19*
4. Math anxiety	594	2.45 (0.79)	2.58 (0.81)	2.35 (0.77)	−0.29***	2.48 (0.77)	2.42 (0.83)	−0.08
5. Math achievement	583	462.65 (20.48)	453.14 (17.48)	470.36 (19.48)	0.93***	462.56 (19.42)	462.77 (21.70)	0.01
6. Reading achievement	624	449.79 (36.06)	431.63 (35.00)	464.47 (29.68)	1.02***	450.11 (35.44)	449.41 (36.82)	−0.02
Time 2 measures (spring)								
7. Entity motivational framework	615	3.52 (0.99)	3.66 (0.93)	3.42 (1.03)	−0.24**	3.53 (0.97)	3.52 (1.01)	−0.01
8. Entity theory	615	3.17 (1.22)	3.31 (1.21)	3.06 (1.22)	−0.21**	3.14 (1.22)	3.21 (1.22)	0.06
9. Performance goal	615	3.88 (1.21)	4.00 (1.16)	3.77 (1.24)	−0.19*	3.91 (1.14)	3.83 (1.28)	−0.07
10. Math anxiety	612	2.29 (0.77)	2.46 (0.75)	2.16 (0.76)	−0.40***	2.35 (0.76)	2.22 (0.77)	−0.17*
11. Math achievement	589	473.75 (22.66)	464.46 (19.85)	481.35 (21.99)	0.80***	473.63 (21.62)	473.89 (23.86)	0.01
12. Reading achievement	618	471.16 (30.69)	459.66 (30.00)	480.38 (28.04)	0.72***	471.68 (29.98)	470.53 (31.55)	−0.04

Note. For Cohen's *d*, positive values indicate that second graders scored higher than first graders and that boys scored higher than girls. * $p < .05$. ** $p < .01$. *** $p < .001$.

2 [T2]), on average 6 months apart. Children completed all measures in one-on-one sessions with an experimenter, who read the items to the child and recorded his or her responses. Each child completed two sessions at each time point; math achievement was measured in the first session, and motivational frameworks and math anxiety were measured in the second session.

Measures

Motivational frameworks

Students' motivational frameworks were assessed using a six-item questionnaire adapted from previous work (see Appendix Table A1; Gunderson et al., 2013; Kinlaw & Kurtz-Costes, 2007; Park et al., 2016).² The questionnaire assessed *entity theories* about intelligence, math ability, and reading ability and *performance goals* about math, spelling, and mazes. Items were presented in a single, pseudorandom order with the item types intermixed. Children responded by pointing to a five-point circle scale ranging from 1 = "not at all" (smallest circle) to 5 = "really a lot" (largest circle). We report reliability using McDonald's omega, which requires fewer assumptions and is less biased than Cronbach's alpha (Dunn, Baguley, & Brunsden, 2014). Because our motivational framework measure is composed of two factors (entity theories and performance goals), we used omega-total (ω_T), which is an estimate of the proportion of test variance due to all common factors (Revelle & Zinbarg, 2009). Reliability was good for the motivational framework measure, $\omega_{T(T1)} = .70$, $\omega_{T(T2)} = .81$. In addition, reliability was moderate for *entity theories* (three items), $\omega_{(T1)} = .63$, $\omega_{(T2)} = .75$, and *performance goals* (three items), $\omega_{(T1)} = .60$, $\omega_{(T2)} = .73$.

Math anxiety

Math anxiety was assessed using the 16-item Child Math Anxiety Questionnaire-Revised (CMAQ-R), a revised version of the CMAQ (Ramirez et al., 2013; Suinn, Taylor, & Edwards, 1988). The CMAQ-R is designed for use with first and second graders and begins with an explanation and nonmath example item describing what it means to feel nervous. Items ask children how nervous they would feel during situations involving math; for example, "How do you feel when you have to sit down and start your math homework?" Children responded using five smiley faces displaying emotions ranging from "not nervous at all" to "very, very nervous" (1–5 scale). Reliability was good, $\omega_{(T1)} = .83$, $\omega_{(T2)} = .84$.

Math achievement

We assessed math achievement using the Applied Problems subtest of the Woodcock-Johnson III Tests of Achievement (Woodcock, McGrew, & Mather, 2001). On this test, children answer orally presented word problems of increasing difficulty involving simple arithmetic, monetary calculations, and measurement until both basal (six items in a row correct) and ceiling (six items in a row incorrect) are established. For all analyses, we used the

²The original scale had 12 items with relatively low internal reliability. Half of these items were incrementally-oriented and half were entity-oriented. Following prior work (Park et al., 2016), we chose to use only the 6 entity-oriented items for two reasons. Prior research indicates that entity-oriented items lead to greater individual variability and reduce positive response bias (Hong et al., 1999). In addition, preliminary factor analyses indicated that incrementally- and entity-oriented items formed separate factors, and that internal reliability was higher within the 6 entity-oriented items than within the total 12 item scale.

W score, a transformation of the raw score into a Rasch-scaled score with equal intervals that is especially suitable for analyzing change over time (Woodcock, 1999). A W score of 500 is the average performance of a 10-year-old; median reliability of the norming sample is .93.

Reading achievement

As a divergent measure, we assessed children's reading-decoding achievement using the nationally normed Woodcock-Johnson III Tests of Achievement Letter-Word Identification subtest (Woodcock et al., 2001). In this test, students read letters and words of increasing difficulty. As with math achievement, we used the W score in our analyses. Median reliability based on the norming sample is .94.

Results

Preliminary analyses

Developmental differences

Descriptive statistics for all measures for the full sample and within each grade level are shown in Table 1. Second graders had significantly less entity-oriented motivational frameworks, lower math anxiety, and higher math achievement than first graders at T1 and T2. Within motivational frameworks, second graders were less likely to adopt performance goal orientations than were first graders at T1 and T2, and they were less likely to endorse entity theories of intelligence at T2. The same developmental pattern was apparent within students across time. Students had less entity-oriented motivational frameworks, $t(579) = 6.34, p < .001, d = 0.26$, lower math anxiety, $t(575) = 4.75, p < .001, d = -0.20$, and higher math achievement, $t(542) = 20.09, p < .001, d = 0.86$, at T2 than at T1.

We conducted preliminary multiple-group path analyses in MPlus Version 7.11 to test whether grade level moderated the relations between our key measures. However, these analyses did not reveal any significant difference between grade levels in the relations among motivational frameworks, math anxiety, and math achievement. Therefore, we treated grade level as a covariate in our main analyses.

Gender differences

Descriptive statistics within each gender are shown in Table 1. Girls reported stronger entity motivational frameworks than boys at T1, $t(593) = 2.53, p = .012, d = 0.20$, an effect that was driven by girls' stronger performance goal orientations compared with those of boys at T1, $t(593) = 2.23, p = .026, d = 0.19$. Girls also reported higher math anxiety than boys at T2, $t(610) = 2.07, p = .039, d = -0.17$. There were no other statistically significant gender differences (independent-samples t tests on each variable, $ps > .35, ds < 0.08$) and no Grade $\times$ Gender interactions on any variable (univariate analyses of variance on each variable, interaction term $ps > .10$). Further, preliminary multiple-group path analyses established that there were no significant differences between genders in the relations among motivational frameworks, math anxiety, and math achievement. Therefore, we treated gender as a covariate in our main analyses.

Correlations

Correlations between all measures are shown in Table 2 (see Appendix Table A2 for correlations within grade level). More entity-oriented motivational frameworks, particularly stronger

Table 2. Correlations among all measures.

	1	2	3	4	5	6	7	8	9	10	11
Time 1 measures (fall)											
1. Entity motivational framework	—										
2. Entity theory	0.82***	—									
3. Performance goal	0.78***	0.29***	—								
4. Math anxiety	−0.00	−0.05	0.05	—							
5. Math achievement	−0.25***	−0.13**	−0.28***	−0.29***	—						
6. Reading achievement	−0.21***	−0.13**	−0.22***	−0.22***	0.68***	—					
Time 2 measures (spring)											
7. Entity motivational framework	0.45***	0.32***	0.40***	0.13**	−0.37***	−0.33***	—				
8. Entity theory	0.35***	0.31***	0.25***	0.10*	−0.26***	−0.24***	0.82***	—			
9. Performance goal	0.38***	0.21***	0.40***	0.11*	−0.33***	−0.29***	0.82***	0.33***	—		
10. Math anxiety	0.12**	0.04	0.15**	0.50***	−0.38***	−0.28***	0.14***	0.06	0.16***	—	
11. Math achievement	−0.28***	−0.15***	−0.30***	−0.28***	0.83***	0.67***	−0.38***	−0.29***	−0.33***	−0.42***	—
12. Reading achievement	−0.20***	−0.14**	−0.19***	−0.25***	0.61**	0.87***	−0.32***	−0.26***	−0.26***	−0.31***	0.67***

* $p < .05$. ** $p < .01$. *** $p < .001$.

performance goal orientations, were associated with higher math anxiety at T2 but not at T1. More entity-oriented motivational frameworks (both entity theories of intelligence and performance goals) were associated with lower math achievement at both T1 and T2. Math anxiety was also associated with lower math achievement at both T1 and T2. These associations were also evident across time points (e.g., T1 entity motivational frameworks were positively related to T2 math anxiety and negatively related to T2 math achievement, etc.). Finally, each T1 measure was positively related to the same measure at T2.

We again conducted preliminary multiple-group path analyses to test whether gender moderated the relations between our key measures. However, no significant difference was found between genders in the relations between motivational frameworks, math anxiety, and math achievement. Therefore, we treated gender as a covariate in our main analyses.

Main analyses

To test our main hypotheses, we conducted cross-lagged path analyses in MPlus Version 7.11 (Muthén & Muthén, 1998–2012). We first examined the predicted relations of math anxiety and math achievement to motivational frameworks (Model 1). Next, to pin down whether any effect was derived from children's general theories of intelligence or concrete goal orientations, we conducted two parallel models and replaced motivational frameworks with each subcomponent in a separate model (entity theories of intelligence in Model 2 and performance goals in Model 3). Finally, to examine divergent validity, we examined whether replacing math with reading achievement in Model 1 would change the pattern of results (Model 4).

For each model, we used the estimator TYPE = COMPLEX to account for the shared student-level variance due to clustering of students within classrooms. (Note that none of our independent or dependent variables were measured at the classroom level.) We included grade and gender as controls predicting the T1 and T2 variables. We modeled motivational frameworks as a higher-order latent variable composed of entity theories and performance goals and modeled math anxiety as a latent variable to account for measurement error in these self-report constructs. We modeled math and reading achievement W scores as manifest variables.

Motivational frameworks, math anxiety, and math achievement (Model 1)

Model 1 was a cross-lagged path analysis that included all reciprocal relations between our key variables (motivational frameworks, math anxiety, and math achievement; see Figure 1). The model had good fit: root mean square error of approximation (RMSEA) = .029, Comparative Fit Index (CFI) = .902, Tucker-Lewis Index (TLI) = .895, and standardized root mean square residual (SRMR) = .046. We interpreted the path coefficients for each pair of variables in turn.

Motivational frameworks and math anxiety. Supporting our first hypothesis, T1 entity motivational frameworks significantly predicted higher T2 math anxiety ($\beta = 0.12$, $p = .013$), whereas T1 math anxiety did not significantly predict T2 entity frameworks ($\beta = 0.10$, $p = .152$).

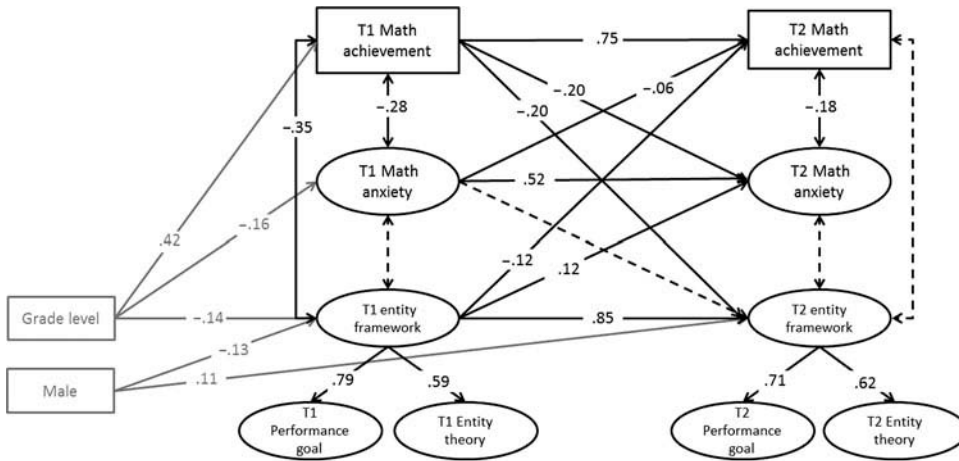


Figure 1. Model 1: Path analysis showing longitudinal relations among entity motivational frameworks, math anxiety, and math achievement. Solid lines indicate significant paths ($p < .05$) and are labeled with standardized coefficients. Dashed lines indicate nonsignificant paths. Control variables and their relations to key measures are shown in gray. For simplicity, item loadings and nonsignificant paths from control variables to key measures are not shown. *Note.* T1 = Time 1; T2 = Time 2.

Math anxiety and math achievement. Supporting our second hypothesis, we found significant reciprocal relations between math anxiety and math achievement. Time 1 math anxiety significantly predicted lower T2 math achievement ($\beta = -0.06$, $p = .028$), and T1 math achievement significantly predicted lower math anxiety at T2 ($\beta = -0.20$, $p < .001$).

Motivational frameworks and math achievement. Finally, we found reciprocal relations between motivational frameworks and math achievement. Time 1 entity motivational frameworks significantly predicted lower T2 math achievement ($\beta = -0.12$, $p = .003$), and T1 math achievement predicted lower entity motivational frameworks at T2 ($\beta = -0.20$, $p = .014$).

Theories of intelligence, math anxiety, and math achievement (Model 2)

We next examined a model with motivational frameworks replaced by entity theories of intelligence (see Appendix Figure A1). The model had good fit: RMSEA = .032, CFI = .894, TLI = .886, and SRMR = .046. We focused on the relations involving theories of intelligence. (The longitudinal relations between math anxiety and math achievement were very similar to those in Model 1.)

Theories of intelligence and math anxiety. In contrast to Model 1, Model 2 showed that T1 entity theories of intelligence alone did not significantly predict T2 math anxiety ($\beta = 0.06$, $p = .243$). Time 1 math anxiety did not significantly predict T2 entity theories of intelligence ($\beta = 0.11$, $p = .052$), although this relation nearly reached significance.

Theories of intelligence and math achievement. Time 1 entity theories of intelligence did not significantly predict T2 math achievement ($\beta = -0.05$, $p = .113$). However, T1 math

achievement did negatively predict entity theories of intelligence at T2 ($\beta = -0.21$, $p < .001$).

Performance goals, math anxiety, and math achievement (Model 3)

Next, we tested a model in which motivational frameworks were replaced by performance goals (see Appendix Figure A2). The model had good fit: RMSEA = .031, CFI = .899, TLI = .891, and SRMR = .046. We focused on the relations involving performance goals. (Relations between math anxiety and math achievement were similar to those in Model 1; the path from T1 math anxiety to T2 math achievement was similar in magnitude but was not statistically significant, $\beta = -0.05$, $p = .054$).

Performance goals and math anxiety. Similar to Model 1, Model 3 showed that T1 performance goals significantly predicted T2 math anxiety ($\beta = 0.09$, $p = .024$). However, T1 math anxiety did not predict T2 performance goals ($\beta = 0.02$, $p = .661$).

Performance goals and math achievement. Model 3 showed reciprocal relations between performance goals and math achievement: T1 performance goals significantly predicted lower T2 math achievement ($\beta = -0.10$, $p = .002$), and T1 math achievement significantly predicted lower T2 performance goals ($\beta = -0.24$, $p < .001$).

Divergent validity: Motivational frameworks, math anxiety, and reading achievement

Finally, we assessed divergent validity of these findings by repeating Model 1 except that math achievement was replaced with reading-decoding achievement at T1 and T2 (Model 4; see Appendix Figure A3). The model had good fit: RMSEA = .029, CFI = .905, TLI = .899, and SRMR = .046. We focused on the relations involving reading achievement. (The relations between math anxiety and motivational frameworks were consistent with those in Model 1).

Math anxiety and reading achievement. Model 4 showed that T1 math anxiety significantly predicted lower T2 reading achievement ($\beta = -0.06$, $p = .009$). However, T1 reading achievement did not significantly predict T2 math anxiety ($\beta = -0.11$, $p = .055$).

Motivational frameworks and reading achievement. In Model 4, T1 motivational frameworks did not significantly predict T2 reading achievement ($\beta = -0.04$, $p = .162$). Time 1 reading achievement did significantly predict T2 motivational frameworks ($\beta = -0.19$, $p = .009$).

Discussion

We present, for the first time, a full developmental picture of the reciprocal relations among motivational frameworks, math anxiety, and math achievement in young children. During a 6-month time period encompassing most of the school year, each of the three key factors significantly predicted the others, with one exception (initial math anxiety did not significantly predict later motivational frameworks). Overall, these results strongly support our hypothesis that early individual differences in math achievement can snowball into later disparities through their reciprocal effects on motivational frameworks and math

anxiety. In other words, children who start school with lower levels of math achievement not only lack some of the foundational math concepts that set the stage for later math development, but they are also more likely to develop math anxiety and less adaptive motivational frameworks. In turn, those who have higher math anxiety and more entity motivational frameworks are more likely to achieve less in math over time.

Importantly, these reciprocal relations that we found were not symmetrical in magnitude. The size of these effects was strongest for the impact of initial math achievement on later motivational frameworks and math anxiety. Although both directional relations were statistically significant, the magnitude of the effect of initial math achievement predicting later math anxiety ($\beta = -0.20$) was more than 3 times as large as the effect of initial math anxiety predicting later math achievement ($\beta = -0.06$). Similarly, the effect of initial math achievement predicting later motivational frameworks ($\beta = -0.20$) was nearly twice as large as the effect of initial motivational frameworks predicting later math achievement ($\beta = -0.12$). These findings are inconsistent with the argument that children in first and second grades are overly optimistic, unaware of their own levels of achievement, and therefore unaffected by them. Rather, these findings are consistent with our proposal that entry into formal schooling may be an especially important time in which children first observe their own relative achievement levels and form motivational and affective responses. This theory suggests that the paths from math achievement to motivational frameworks and math anxiety might actually be stronger in the first and second grades than in later elementary school. Although we did not see a significant difference between first and second graders in the magnitude of these relations, future research using similar methods including children up to fifth grade could test this hypothesis. Our data suggest that school-entry math achievement is crucial for establishing whether a child will start down a positive path of high achievement, adaptive motivational frameworks, and positive affect or a negative path of low achievement, maladaptive motivational frameworks, and high math anxiety.

Further, an important, novel finding of this study is that entity motivational frameworks predict higher levels of math anxiety over time. Although researchers have speculated that such a link might exist (Moore et al., 2015), to our knowledge, this study is the first to empirically demonstrate this relation. Importantly, this relation held even after accounting for math achievement, which is known to be related to both motivational frameworks and math anxiety. Children who started the year with more entity-oriented motivational frameworks had higher math anxiety at the end of the year than did children who started with more incremental frameworks. This effect was driven primarily by students' goal orientations in the fall: Students who reported performance goals—preferring to do easy tasks to get a lot right—had higher math anxiety by the end of the year. A focus on high performance left children vulnerable to inevitable challenges and setbacks (Dweck, 2006). Children with an entity framework are also more likely to interpret failure as a sign of low ability (Dweck & Leggett, 1988) and therefore may be more susceptible to developing math anxiety after experiencing challenge, failure, or criticism (Maloney et al., 2015). However, initial math anxiety did not predict later motivational frameworks, consistent with the theory that motivational frameworks are a foundational belief system on which related academic attitudes and beliefs are built (e.g., Blackwell et al., 2007; Dweck, 2006).

Notably, one recent study investigating the relations among math anxiety, math motivation, and math achievement revealed a more complex interaction among these factors than is reported here (Wang et al., 2015). Students with high math motivation showed a U-shaped

relation between math anxiety and achievement (i.e., optimal achievement occurred in the presence of a moderate level of anxiety), whereas students low in motivation showed the typical negative relation (Wang et al., 2015). However, our data did not replicate these interactive effects³ and showed only linear, negative effects of motivational frameworks and math anxiety on math achievement. One possibility is that this discrepancy resulted from differences in the age groups studied, which were younger here than in Wang et al.'s (2015) study of 8- to 15-year-olds and adults; these more complex relations may emerge with age and educational experience. Alternately, intrinsic motivation and valuing math may interact with math anxiety to influence achievement in a way that motivational frameworks do not. Further research is needed to tease apart these interesting possibilities.

We also asked whether these relations were similar for the two components of a motivational framework—theories of intelligence and goal orientations. Having stronger performance goal orientations in the fall (a more maladaptive orientation) was related to higher math anxiety and lower math achievement in the spring; however, fall theories of intelligence did not significantly predict spring math anxiety or math achievement. At the same time, higher fall math achievement predicted more adaptive theories of intelligence (less entity-oriented) and goal orientations (less performance-oriented) in the spring. In other words, we found reciprocal relations between math achievement and goal orientations but a unidirectional relation in which earlier math achievement predicted later theories of intelligence, but not the reverse.

In addition, the relation of children's fall motivational frameworks to their spring math anxiety was driven by goal orientations. Taken together, these results suggest that goal orientations (e.g., being motivated to do easy tasks to get a lot right vs. being motivated to do challenging tasks to learn more) are particularly important in shaping children's anxiety and achievement in math. Although many studies have shown that theories of intelligence are related to later academic achievement (e.g., Blackwell et al., 2007), we found this to be the case for motivational frameworks but not for theories of intelligence in particular. One possible reason is that the first and second graders in our study were younger than those in most studies of theories of intelligence. It may be difficult for children this age, especially early in the school year, to reason and report their views about abstract concepts such as whether intelligence is changeable; in contrast, reporting whether they like to do hard or easy tasks is more self-relevant and concrete.

One limitation of the present study was its correlational design. Although we found longitudinal relations even after controlling for prior scores on all measures, gender, and grade, the data cannot prove a causal relation. It is possible that unmeasured variables may contribute to the relations we found. For example, we did not control for domain-general factors, leaving open the possibility that our results may (at least partially) reflect relations between general anxiety or test anxiety and achievement (Erzen, 2017; Kestenbaum & Weiner, 1970). Similarly, we did not measure theories of intelligence across domains. However,

³Wang et al. (2015) reported that the relation between math anxiety and math achievement was negative for students with low motivation, but quadratic (inverted U-shaped) for students with high motivation. We assessed whether this pattern was present in our data. Following Wang et al. (2015), we regressed math achievement on math anxiety, motivational framework, math anxiety², math anxiety x motivational framework, and math anxiety² x motivational framework, all assessed in the fall, with gender and grade as covariates. The key interaction term, math anxiety² x motivational framework, was not significant, $\beta = .05$, $p = .940$. The same analysis using spring data was also not significant (math anxiety² x motivational framework, $\beta = .15$, $p = .793$).

previous research has shown that children and adults hold domain-specific theories about the stability of traits across the intelligence and personality domains (Bempechat, London, & Dweck, 1991; Heyman & Dweck, 1998; Schroder, Dawood, Yalch, Donnellan, & Moser, 2016), suggesting that our results may be specific to the intelligence domain.

We were able to establish some degree of divergent validity by assessing whether the pattern of results remained the same if math achievement was replaced by achievement in reading-decoding skill. The pattern of reciprocal relations was not the same as that for math achievement: Reading achievement did not predict math anxiety, and entity motivational frameworks did not predict reading-decoding achievement. The fact that motivational frameworks relate to later math achievement but not to later reading-decoding achievement is consistent with recent work in elementary school students (Gunderson et al., 2017), and it may reflect the fact that math is more challenging than reading decoding for most students in this age range. However, we did find some relations to reading achievement (that math anxiety predicted reading achievement and reading achievement predicted motivational frameworks), suggesting that both domain-specific and domain-general components of children's emotions and beliefs may be involved in these processes. Future research including domain-general measures and additional domains would help to pinpoint to what extent these results are specific to mathematics. Despite these limitations, these longitudinal, correlational results set the stage for future studies using randomized intervention methods to establish causal links between math achievement, motivational frameworks, and math anxiety.

Several randomized studies have already shown that encouraging students to adopt incremental theories of intelligence (Aronson et al., 2002; Blackwell et al., 2007; Good et al., 2003) or reducing the impact of math anxiety through expressive writing (Park et al., 2014) can lead to higher math achievement. However, these studies have, to our knowledge, focused only on middle school through college-aged students. An important future direction will be to experimentally intervene to improve younger students' motivational frameworks to definitively establish causal relations with lower math anxiety and higher math achievement at this age. Young children's motivational frameworks are themselves influenced by the behaviors of their parents and teachers (Gunderson et al., 2017; Park et al., 2016; Pomerantz & Kempner, 2013). Thus, experimental interventions could be designed to improve children's motivational frameworks either by directly intervening with children or by targeting parents' and/or teachers' behaviors. Although these results suggest that interventions that reduce children's focus on performance goals and encourage learning goals may be particularly helpful, other recent work has shown that second and third graders' theories of intelligence are a stronger predictor than learning goals of their later math achievement (Gunderson et al., 2017). From a theoretical perspective, attempting to disentangle the relative contributions of theories of intelligence and goal orientations to student's achievement during the elementary school period may be a fruitful direction for research. From a practical perspective, interventions that attempt to increase both incremental theories of intelligence and learning goals hold promise for reducing math anxiety and increasing math achievement.

In addition, our finding that initial math achievement levels are a significant predictor of later math anxiety and motivational frameworks (both theories of intelligence and goal orientations) suggests that improving math achievement for young children is also critical for setting children onto a positive path. School-entry math achievement is influenced by

large variations in how frequently parents and preschool teachers engage children in math talk (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; Levine, Gunderson, & Huttenlocher, 2011; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010). Specific types of math talk, such as counting and labeling cardinal values of sets (e.g., “there are three dogs”; Gunderson & Levine, 2011; Mix, Sandhofer, Moore, & Russell, 2012), and specific activities, such as playing with linear board games (Ramani & Siegler, 2008) and engaging with playful word problems (Berkowitz et al., 2015), are particularly helpful for math learning and can be used both at home and at school. Common to these activities is that they are challenging, engaging for children of this age, and low-stakes. Nevertheless, preschool and kindergarten classrooms, in which teachers already spend minimal time on math instruction, often spend this time teaching children basic skills, such as counting, which they already know (Engel, Claessens, & Finch, 2013). Our findings suggest that implementing research-based methods of improving math achievement prior to school entry may start children on a virtuous cycle of positive motivational frameworks, low math anxiety, and high math achievement.

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Appendix

Table A1. Items on the motivational framework questionnaire.

					
	1	2	3	4	5
	Not at all	A little	Medium	Kind of a lot	Really a lot
Item #	Question				Subscale
1.	How much would you like to do mazes that are very easy so you can get a lot right? (show child picture of easy maze)				Performance goal
2.	How much would you like to do math problems that are very easy so you can get a lot right?				Performance goal
3.	How much would you like to spell words that are very easy so you can get a lot right?				Performance goal
4.	Imagine a kid who thinks that people have a certain amount of math ability and stay pretty much the same. How much do you agree with this kid?				Entity theory
5.	Imagine a kid who thinks that a person is a certain amount smart and stays pretty much the same. How much do you agree with this kid?				Entity theory
6.	Imagine a kid who thinks that people have a certain amount of reading ability and stay pretty much the same. How much do you agree with this kid?				Entity theory

Note. Items were intermixed and presented in a single pseudorandom order. Children responded by pointing to one of five circles of increasing size.

Table A2. Correlations among all measures within grade.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Time 1 measures (fall)												
1. Entity motivational framework	—	.85***	.78***	-.07	-.20**	-.20**	.39***	.31***	.30***	.06	-.23***	-.18**
2. Entity theory	.81***	—	.33***	-.07	-.15*	-.12*	.35***	.33***	.22***	.03	-.15*	-.13*
3. Performance goal	.78***	.25***	—	-.05	-.19*	-.20***	.28***	.16*	.28***	.08	-.23***	-.17**
4. Math anxiety	.03	-.04	.10	—	-.19**	-.14*	.03	.01	.04	.40***	-.17***	-.14*
5. Math achievement	-.25***	-.12*	-.29***	-.31***	—	.57***	-.24***	-.14*	-.24***	-.25***	.76***	.49***
6. Reading achievement	-.19***	-.14*	-.17**	-.22***	.64***	—	-.30***	-.20***	-.26***	-.13*	.58***	.83***
Time 2 measures (spring)												
7. Entity motivational framework	.48**	.29***	.47***	.18*	-.42***	-.32***	—	.79***	.78***	-.00	-.27***	-.25***
8. Entity theory	.37***	.28***	.30***	.16**	-.32***	-.24**	.83***	—	.23***	-.08	-.21***	-.20***
9. Performance goal	.43***	.21***	.48***	.14*	-.38***	-.29***	.84***	.39***	—	.07	-.21***	-.19**
10. Math anxiety	.13*	.04	.17**	.56***	-.40***	-.30***	.20***	.14*	.20***	—	-.27***	-.17**
11. Math achievement	-.29***	-.15*	-.31***	-.32***	.82***	.63***	-.43***	-.32***	-.40***	-.46***	—	.59***
12. Reading achievement	-.18**	-.14**	-.13*	-.29***	.61***	.87***	-.34***	-.27***	-.29***	-.35***	.65***	—

Note. Numbers above the diagonal are correlations among first graders ($n = 282$). Numbers below the diagonal are correlations among second graders ($n = 352$). * $p < .05$. ** $p < .01$. *** $p < .001$.

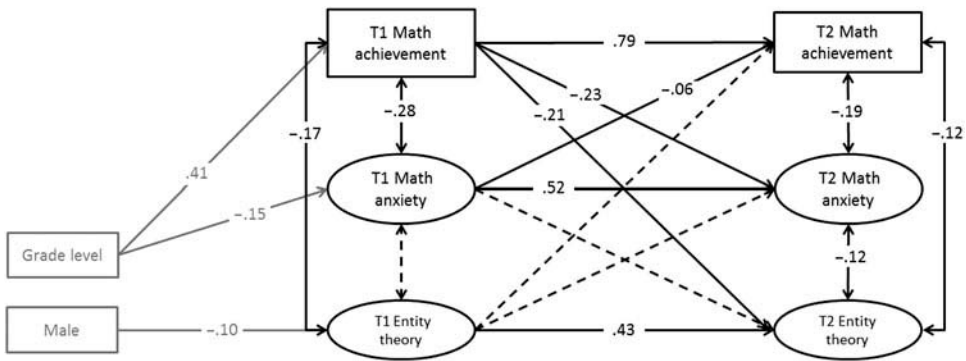


Figure A1. Model 2: Path analysis showing longitudinal relations among entity theories of intelligence, math anxiety, and math achievement. Solid lines indicate significant paths ($p < .05$) and are labeled with standardized coefficients. Dashed lines indicate nonsignificant paths. Control variables and their relations to key measures are shown in gray. For simplicity, item loadings and nonsignificant paths from control variables to key measures are not shown. *Note.* T1 = Time 1; T2 = Time 2.

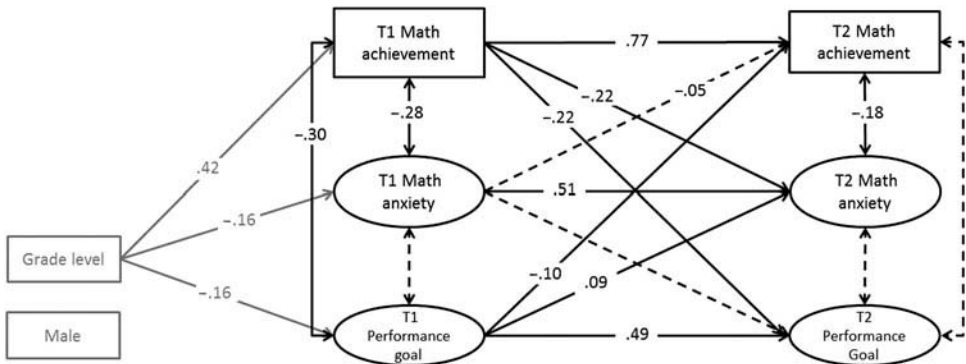


Figure A2. Model 3: Path analysis showing longitudinal relations among goal orientations, math anxiety, and math achievement. Solid lines indicate significant paths ($p < .05$) and are labeled with standardized coefficients. Dashed lines indicate nonsignificant paths. Control variables and their relations to key measures are shown in gray. For simplicity, nonsignificant paths from control variables to key measures are not shown. *Note.* T1 = Time 1; T2 = Time 2.

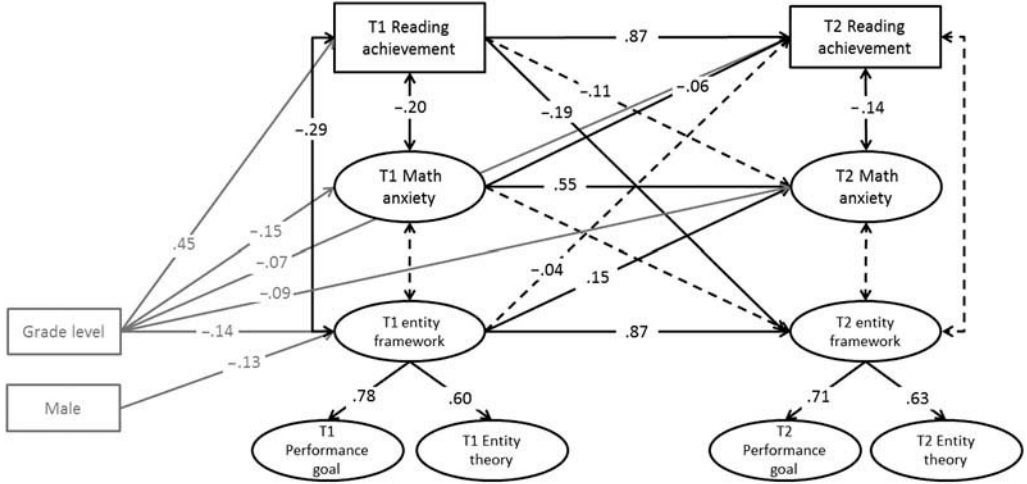


Figure A3. Model 4: Path analysis showing longitudinal relations among entity motivational frameworks, math anxiety, and reading achievement. Solid lines indicate significant paths ($p < .05$) and are labeled with standardized coefficients. Dashed lines indicate nonsignificant paths. Control variables and their relations to key measures are shown in gray. For simplicity, item loadings and nonsignificant paths from control variables to key measures are not shown. *Note.* T1 = Time 1; T2 = Time 2.