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Parent Praise to Toddlers Predicts Fourth Grade Academic Achievement via Children's Incremental Mindsets

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Abstract

In a previous study, parent-child praise was observed in natural interactions at home when children were 1, 2, and 3 years of age. Children who received a relatively high proportion of process praise (e.g., praise for effort and strategies) showed stronger incremental motivational frameworks, including a belief that intelligence can be developed and a greater desire for challenge, when they were in 2nd or 3rd grade (Gunderson et al., 2013). The current study examines these same children's ($n = 53$) academic achievement 1–2 years later, in 4th grade. Results provide the first evidence that process praise to toddlers predicts children's academic achievement (in math and reading comprehension) seven years later, in elementary school, via their incremental motivational frameworks. Further analysis of these motivational frameworks shows that process praise had its effect on 4th grade achievement through children's trait beliefs (e.g., believing that intelligence is fixed versus malleable), rather than through their learning goals (e.g., preference for easy versus challenging tasks). Implications for the socialization of motivation are discussed.

Keywords

praise; theories of intelligence; incremental mindset; academic achievement; motivation

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Laboratory and field studies have shown that praising children for hard work, good strategies, focus, or perseverance (*process praise*) influences children's beliefs about human attributes, as well as their desire for challenge (Gunderson, et al., 2013; Kamins & Dweck, 1999; Mueller & Dweck, 1998). For example, in a recent study, children who heard a greater proportion of process praise at home from their parents when they were 1–3 years were more likely to believe traits such as intelligence are malleable and to prefer challenging activities at ages 7–8 years (Gunderson, et al., 2013). These findings show that early praise can predict later beliefs about intelligence and its malleability. In other work, beliefs about the malleability of intelligence have been shown to influence the academic achievement of middle-school (e.g., Blackwell, Trzesniewski, & Dweck, 2007) and elementary-school

(Park, Gunderson, Tsukayama, Levine, & Beilock, 2016; Stipek & Gralinski, 1996) children. Taken together, these findings raise a critical question: does the kind of praise children hear early in life relate to their academic achievement trajectories for years to come? The present study addresses this question, and explores the hypothesis that praise at home during the preschool years predicts children's beliefs about intelligence and its malleability—their *mindsets*—in early elementary school, which, in turn, predicts academic achievement in later elementary school.

Mindsets set in motion a coherent system of beliefs, attributions, and attitudes toward challenge that we refer to as *motivational frameworks* (e.g., Blackwell, Trzesniewski & Dweck, 2007; Dweck, 2006; Dweck & Legett, 1988). For example, children who believe that a trait like intelligence is malleable (an *incremental* mindset about intelligence) tend to focus on learning, believe in the efficacy of effort, attribute their setbacks and successes to their effort and strategies, and show resilience in the face of difficulty; that is, they have an *incremental motivational framework*. These beliefs and behaviors lead them to seek challenges and increase their abilities, which, in turn, have the potential to foster academic success. In contrast, viewing intelligence as unchangeable (a *fixed mindset*) leads children to be concerned about their level of fixed ability (e.g., how smart am I?) and to avoid challenges that might reveal that they have low ability (e.g., Blackwell et al., Dweck, 2007; Dweck & Leggett, 1988); that is, to have a *fixed motivational framework*. Such children may do well in subjects that come easily, but struggle to remain motivated when facing challenging material. Incremental motivational frameworks have been found to predict academic achievement in 1st and 2nd grade children (Park et al., 2016), as well as in older students (Blackwell, Trzesniewski & Dweck, 2007; Romero, Master, Paunesku, Dweck & Gross, 2014; Stipek & Gralinski, 1996). Moreover, teaching students an incremental motivational framework can improve academic performance in middle-school to college-age students by helping them remain engaged with academic material even when it becomes challenging and effortful (Blackwell, Trzesniewski & Dweck, 2007; Good, Aronson & Inzlicht, 2003; Aronson, Fried & Good, 2002; Paunesku et al., 2015).

Individual differences in motivational frameworks are seen as early as preschool (Giles & Heyman, 2003; Heyman, Dweck, & Cain, 1992; Kinlaw & Kurtz-Costes, 2007; Smiley & Dweck, 1994), and can be traced back, at least in part, to how children are praised. Laboratory studies have established that praise of children's process (e.g., "good job working hard") rather than ability (e.g., "you're good at that") encourages them to approach tasks with an incremental motivational framework (Mueller & Dweck, 1998; Kamins & Dweck, 1999; Corpus & Lepper, 2007; Zentall & Morris, 2010), even in children as young as 4–5 years (Cimpian, Arce, Markman & Dweck, 2007; Henderlong, et al., 2007). Importantly, the proportion of praise young children hear that is process praise has been found to predict incremental motivational frameworks in a naturalistic longitudinal study. Gunderson, et al. (2013) found that children who heard a relatively large proportion of process praise at home from their parents when they were 1–3 years were more likely to hold an incremental motivational framework five years later, at ages 7–8 years, than children who received a smaller proportion of this kind of praise from their parents (see also Pomerantz & Kempner, 2013, for an example of related effects with older children).

We therefore have evidence of links between process praise and incremental motivational frameworks, and between incremental motivational frameworks and academic achievement. However, to our knowledge, no single study has ever evaluated the full trajectory of these relations, from praise heard early in childhood, to mindsets in early elementary school, to academic achievement in later elementary school.

We know that process praise to toddlers predicts children's incremental motivational frameworks in 2^{nd} 3^{rd} grade (Gunderson, et al., 2013), and we hypothesized that these motivational frameworks would, in turn, predict children's academic achievement. Importantly, there is no reason to think that process praise would affect academic achievement directly without first facilitating the development of incremental motivational frameworks. If a direct relation exists between process praise and achievement, we predict that the relation will be reduced to non-significance when the indirect relations between process praise, incremental motivational frameworks, and achievement outcomes are accounted for. In other words, we expect that children's incremental motivational frameworks will fully account for any relations between early process praise and later academic achievement.

More specifically, one of our key hypotheses is that incremental motivational frameworks will predict *improvement* in children's academic achievement between 2^{nd} grade and 4^{th} grade. Studies that examine relations between single measures of incremental motivational frameworks and recurring longitudinal measures of academic achievement typically find that the relations can grow stronger over time (e.g., Blackwell et al., 2007; McCutchen, Jones, Carbonneau & Mueller, 2015). This increase in strength may be because children with *incremental* motivational frameworks are likely to capitalize on learning opportunities because they tend to seek learning as a primary goal, increase engagement in response to setbacks, and enjoy taking on challenging learning tasks. (For a detailed discussion of social-psychological processes that self-reinforce over time, see Yeager & Walton, 2011.) In contrast, children with *fixed* motivational frameworks are likely to miss learning opportunities due to their preoccupation with appearing smart (rather than learning), withdrawing effort in the face of setbacks, and avoiding challenges that might reveal low ability. Thus, we expect process praise and incremental motivational frameworks to predict 4^{th} grade academic achievement, even when 2^{nd} grade academic achievement is held constant.

While it is possible that students' 2^{nd}–3^{rd}-grade incremental motivational frameworks would correlate with their academic achievement in 2^{nd} grade, this was not one of our predictions. From a methodological perspective, in the present study, approximately half the children completed the motivational frameworks measure a year *after* we assessed 2^{nd} grade achievement (the other half completed the motivational framework measure during the same year as 2^{nd} grade achievement). Given that we expect motivational frameworks to predict later achievement, the relation between 2^{nd} grade achievement and 2^{nd}–3^{rd} grade motivational frameworks does not provide a clear test of this prediction. From a theoretical perspective, since individual differences in motivational frameworks begin to develop in preschool (e.g., Giles & Heyman, 2003; Heyman, Dweck, & Cain, 1992; Kinlaw & Kurtz-Costes, 2007; Smiley & Dweck, 1994), they may not stabilize and predict achievement until several years later. However, as just described, we have strong reasons to believe that motivational frameworks will predict *improvement* in academic achievement between 2nd and 4th grades (e.g., Blackwell et al., 2007; McCutchen et al., 2015; Stipek & Gralinski, 1996), and change in achievement over time provides stronger evidence for the impact of motivational frameworks than does a contemporaneous correlation.

We investigate these questions by examining academic achievement in the same sample of children described in Gunderson et al. (2013). These children were videotaped at home in naturalistic parent-child dyads at 1, 2 and 3 years of age, and completed an assessment of motivational frameworks at age 7–8 years. We used a broad measure of motivational frameworks, including items related to intelligence and sociomoral goodness, as children's motivational frameworks are typically consistent across these domains at this age (Heyman & Dweck, 1998), and items relating to intelligence and sociomoral goodness were significantly correlated in the present sample (Gunderson et al., 2013). As we have noted, early exposure to process praise was found to predict incremental motivational frameworks at age 7–8 in this sample (Gunderson, et al., 2013). Here we ask whether these incremental motivational frameworks, in turn, predict academic achievement 1–2 years later.

We examined the relation of parent praise and motivational frameworks to academic growth in three academic domains: mathematics problem solving, reading comprehension, and reading decoding. We hypothesize that incremental motivational frameworks will robustly predict improvement in mathematics and reading comprehension; we did not expect this relation to hold for reading decoding, which we included to assess the divergent validity of our findings. Motivational frameworks have their strongest impact when students experience challenge or feelings of failure, and have less impact when students face low levels of challenge (e.g., Grant & Dweck, 2003; Paunesku et al., 2015). Both math and reading comprehension pose challenges to children in the 2nd to 4th grade age range; new skills are continuously introduced and students' beliefs in their own competence decline in both domains (e.g., Jacobs et al., 2002; Wigfield et al., 1997). In contrast, reading decoding is a challenging skill primarily in earlier grades, pre-k to 2nd grades, when children typically master skills such as phonological awareness and letter knowledge (Chapman & Tunmer, 1995; Storch & Whitehurst, 2002; Treiman, 2000). During our time period of interest, from 2nd to 4th grades, growth in reading decoding skill slows, a period during which growth in reading comprehension continues at a steady pace (Aarnoutse et al., 2001), suggesting that reading decoding no longer poses a major challenge compared to these other domains.

To summarize, we hypothesize that parents' process praise to 1–3-year-olds would have a significant indirect effect on 4th grade mathematics and reading comprehension (but not reading decoding) mediated by 2nd grade incremental motivational frameworks. If the predicted relations between process praise, incremental motivational frameworks, and math and reading comprehension are demonstrated empirically and longitudinally in a naturalistic setting, it will provide groundbreaking confirmation of predictions suggested by decades of research in social cognitive development.

Method

Participants

Participants were 53 children and their caregivers (29 boys, 24 girls; 34 White, 9 African-American; 6 Latino[a]; 4 mixed racial background; mean age at final academic achievement outcome 10.4 years, *sd* = .37) from the greater Chicago area, drawn from a larger sample of 64 families (Goldin-Meadow, Levine, Hedges, Huttenlocher, Raudenbush & Small, 2014). The primary caregiver's highest level of education was measured at the time of entry into the longitudinal study. Years of education were converted from categorical responses to numerical values (e.g., less than high school = 10 years; graduate degree = 18 years). Primary caregivers were diverse in terms of their highest level of education (M=15.9 years, SD=2.09 years, range=10 to 18 years). Parents also reported their annual family income at the time of entry into the study (categorical responses were converted to numerical values at the midpoint of the category). Participants were also diverse in terms of annual family income at time of entry into the study (M=$61,698, SD=$31,328, range=less than $15,000 to more than $100,000).

Missing Data

Following Gunderson et al. (2013), we included in our main analyses the *N*=53 families who had completed all three praise observations and the measure of children's motivational frameworks. Eleven families were excluded from the initial sample due to incomplete observations of parents' praise (*n*=6) or a missing measure of children's motivational frameworks (*n*=5)[1]. Because the academic achievement measures were taken across several different sessions over a period of years, 6 of these 53 children are missing at least one achievement score. We wanted to avoid further restricting our already small sample, so we retained children with missing measures of academic achievement in the final sample. We note that the degrees of freedom for zero-order correlations vary due to differences in missing data across achievement domains and time points. (See supplemental materials for a complete summary of missing data for each measure.)

Our main analyses use full information maximum likelihood (FIML) (Muthèn & Muthèn, 1998–2012). In contrast to traditional techniques for dealing with missing data, such as listwise deletion, FIML uses all available data to estimate the model parameters. FIML is both more unbiased and more efficient than other methods of dealing with missing data, such as listwise deletion and pairwise deletion (Enders & Bandalos, 2001). FIML estimation leads to unbiased estimates when data are missing completely at random (MCAR) and when data are missing at random (MAR) (e.g., Enders & Bandalos, 2001; Graham, Hofer, & MacKinnon, 1996). To test whether these conditions were met, we assessed the pattern of missing data following the guidelines of Tabachnick and Fidell (2007). For each endogenous variable, we tested mean differences between missing and non-missing dummy variables for each predictor variable. All *p*s > .05. We also ran logistic regression analyses for each

[1]For consistency with prior work, we chose to restrict our sample to the N=53 parent-child dyads reported in Gunderson et al. (2013). This subsample included only dyads who had complete data for praise and motivational frameworks. However, we also repeated our main path analyses including all available data (i.e., N=60 parent-child dyads who had at least some data on dependent variables). The pattern of results remained the same.

endogenous variable predicting missingness from all of its predictor variables. All *p*s > .05. Finally, Little's (1988) MCAR test (obtained using SPSS MVA [missing values analysis]) also was nonsignificant. These results indicate that there is no evidence for a relationship between missingness and the observed data, and the missing data can best be characterized as MCAR (missing completely at random).

Procedure

See Table 1 for a summary of the timing of assessments. All measures were collected at children's homes.

Measures

Parent praise—Parent praise was sampled during 90-minute naturalistic observations in children's homes at child ages 14, 26, and 38 months, during which children and caregivers carried out their daily activities. Parents and researchers were blind to the current study's hypotheses. Praise utterances were further coded as belonging to three praise categories—process praise, person praise, and other praise. (For more details on this coding scheme and inter-coder reliability, see supplemental materials.)

Process praise: Process praise was defined as praise emphasizing children's effort (e.g., "good job trying to put that back"), strategies (e.g., "I like it when you do it all different colors"), or specific actions (e.g., "great catch"). Process praise accounted for 18.0% (*SD*=16.3%) of praise across ages. We considered process praise as a proportion of total praise (arcsine transformed) to control for overall amount of praise.

Person praise: Person praise indicated that the child had a fixed, positive quality, for example, "Good girl" and "Let's show her how smart you are." Person praise accounted for 16.0% (SD=14.4%) of praise, and was considered as a proportion of total praise (arcsine transformed) in our analyses.

Other praise: Other praise was not clearly person- or process-directed, for example, "Good!" and "Yay!" Other praise accounted for 66.0% (SD=19.8%) of praise, and was considered as a proportion of total praise (arcsine transformed) in our analyses.

Motivational frameworks—Children's motivational frameworks were assessed using questions about belief in the stability of intelligence and sociomoral traits (e.g., "Imagine a kid who believes that you can get smarter and smarter all the time. How much do you agree with this kid?"), orientation towards learning goals (e.g., "How much would you like to do math problems that are very hard so you can learn more about doing math?"), and attributions (e.g., "Think of kids in your class who get a lot right on their schoolwork. Why do you think they get a lot right?"). All items were adapted from Heyman & Dweck (1998) and Kinlaw & Kurtz-Costes (2007). (For a full list of items, see supplemental materials).

Each child completed these questions out loud with an in-person experimenter during two separate sessions in order to minimize task time and accommodate the other testing these children were completing as part of the larger language development study (Goldin-Meadow et al., 2014). The questionnaires were administered approximately 3 months apart, in Fall and Winter of a single academic year (2009–2010), when children were either in 2nd or 3rd grade. Although children were in different grades during this academic year, they were no more than 1 year apart in chronological age at the time of the assessment.

Given that motivational frameworks may be difficult to assess in children this young, we were interested in assessing motivational frameworks broadly, rather than assessing a single subcomponent. Therefore, we chose to create a composite measure that would encompass the suite of inter-related beliefs, goal orientations, and attribution styles that are associated with incremental motivational frameworks (e.g., Blackwell, Trzesniewski, & Dweck, 2007). Items were standardized and averaged to create a composite, where higher scores represent more incremental motivational frameworks (Cronbach's $\alpha = .70$).

Although we used the overall motivational framework score in our main analyses, we also examined two theoretically-distinct subscores: a "trait beliefs" subscore, which was composed of 14 items that assessed the belief that traits are fixed versus malleable (Cronbach's $\alpha = .65$), and a "learning goals" subscore composed of 8 items that assessed preference for challenging versus easy tasks in service of learning goals (Cronbach's $\alpha = .69$). (See supplementary materials for items; 2 open-ended items could not be grouped into either category).

Academic achievement—As noted, we measured achievement in three domains: mathematics, reading comprehension, and reading decoding. These measures were taken in 2nd and 4th grades to assess how process praise and incremental motivational frameworks influence improvement in academic achievement, controlling for previous achievement. These tasks were part of the primary focus of the larger study of language development (Goldin-Meadow et al., 2014), and were therefore collected, as part of that study, for all children in the study in both 2nd and 4th grades. All tasks came from the Woodcock-Johnson III Tests of Achievement (Woodcock, McGrew, & Mather, 2001) and the Gates-MacGinitie Reading Tests (MacGinitie & MacGinitie, 1989).

When more than one measure was available for a single domain, as was the case for math achievement and reading decoding, scores were standardized and averaged to create a *composite*. Given our relatively small sample, we chose composite scores instead of latent variables for our path models to avoid adding model parameters.

Mathematics achievement: The Woodcock-Johnson III Applied Problems subtest, in which children solve math word problems, and Calculation subtest, in which children solve arithmetic problems, were used to measure mathematics achievement. Correlations between these subtests were $r(39) = .53$, $p < .001$ for 2nd grade, and $r(48) = .62$, $p < .001$ for 4th grade.

Reading comprehension: The Woodcock-Johnson III Passage Comprehension, in which children read passages and supply missing words, was used to assess 2nd grade reading comprehension. The Gates-MacGinitie Reading Test, in which children silently read passages and answer multiple-choice questions, was used to assess 4th grade reading comprehension.

Reading decoding: The Woodcock-Johnson III Word Attack task, in which children read phonetically plausible non-words, and Word Identification task, in which children read English words, were used to measure reading decoding achievement. Correlations between subtests were high, $r(50) = .81$, $p<.001$ for 2nd grade, and $r(48) = .80$, $p < .001$ for 4th grade.

Control measures

Parents' socioeconomic status (SES): Because SES predicts academic achievement (e.g., Chatterjee, 2006; Duncan & Magnuson, 2005), our analyses controlled for parent SES, as assessed by family income and the primary caregiver's years of education at child age 14 months. Principal components analysis yielded one factor that weighted income and education positively and equally, accounting for 72% of the variance, which served as our measure of SES.

Overall parent talk: We considered the quantity of parents' child-directed speech as an additional control for parent-child engagement. We measured parent talk during the same 90-minute home observations in which parents' praise was measured, at child ages 14, 26, and 38 months. As noted earlier, children and caregivers carried out typical daily activities in these sessions. The total number of utterances the parent directed to the child during the three 90-minute sessions was recorded. Utterances consisted of a word, phrase, or sentence within a single conversational turn, with separate utterances demarcated by voice intonation contours. Intonation patterns were used to demarcate utterances because in naturalistic speech, grammatical and semantic boundaries are often ambiguous (Huttenlocher, Vasilyeva, Waterfall, Vevea & Hedges, 2007).

Results

Preliminary analyses

Table 2 presents zero-order correlations between variables. As reported previously, process praise (as a proportion of total praise) given to children ages 1–3 years predicted incremental motivational frameworks at age 7–8 years, $r(51) = .34$, $p = .011$ (Gunderson, et al., 2013). As reported by Gunderson et al. (2013), parents' person and other praise were not significantly related to children's incremental motivational frameworks in 2nd or 3rd grade, ps > .05 (or to any of the academic achievement measures in 4th grade, ps > .05) and are not discussed further (although Pomerantz & Kempner, 2013, found that parents' person praise to their children at age 10 did predict fixed motivational frameworks over a 6-month period).

Importantly, our new analyses showed that incremental motivational frameworks in 2nd or 3rd grade predicted children's 4th grade achievement in math, $r(48) = .49$, $p < .001$, and reading comprehension, $r(48) = .32$, $p = .02$, but not reading decoding, $r(48) = .19$, $p = .19$. We used a test very similar to Fisher's r-to-z transformation that uses a t-statistic and accounts for shared variability among paired correlations [Revelle, 2015] to determine whether there were any significant differences between these correlations. The correlation between motivational frameworks and 4th grade math achievement significantly differed from the correlation between motivational frameworks and 4th grade reading decoding (t=2.20, p=.03); no other differences between these correlations were significant (ps>.10).

Motivational frameworks also significantly related to 2nd grade math achievement (r[49] = .40, p = .004), but not reading comprehension or reading decoding achievement (r[50] = .14, p = .33, and r[50] = .20, p = .16 respectively). However, it is worth noting that all of the correlations between incremental motivational frameworks and 2nd grade achievement scores are positive; moreover, none of these correlations differed significantly from the correlations between motivational frameworks and 4th grade achievement. We tested whether the correlation between motivational frameworks and 2nd grade achievement differed from the correlation between motivational frameworks and 4th grade achievement in the same domain, for those students who completed all three measures. The difference in correlations was not significant for math, t = .59, p = .56; for reading comprehension, t = 1.19, p = .24; or for reading decoding, t = .12, p = .90.

Overall, 2nd–3rd grade motivational frameworks were positively related to achievement in 2nd grade, and the relations to achievement, particularly to math and reading comprehension, became directionally more consistent by 4th grade. This pattern is consistent with other studies that find motivational frameworks become stronger, rather than weaker, predictors of achievement over time (e.g., Blackwell et al., 2007; McCutchen, et al., 2015). The fact that about half of the sample completed its motivational framework questionnaire nearly a year *after* their 2nd grade achievement measures may also explain why the relations between motivational frameworks and 2nd grade achievement were less consistent than the relations between motivational frameworks and 4th grade academic achievement.

We did not necessarily expect a direct relation between early process praise and later academic achievement, and we did not find direct relations between process praise and 2nd grade academic achievement, rs < .22, ps > .10. We also found non-significant direct relations between early process praise and 4th grade reading comprehension (r[48] = −.02, p = .86) and reading decoding (r[48] = −.07, p = .64). However, we did find a direct relation between early childhood process praise and 4th grade math achievement, r(48) = .33, p = .02. Our main analyses, reported below, test our prediction that this direct relation will be rendered non-significant when the indirect path from process praise to incremental motivational frameworks to 4th grade math achievement is accounted for.

We also examined whether our control measures (SES, overall parent talk, and child gender) related to praise, motivational framework, and achievement. SES was not significantly related to parents' process praise (r[51] = .09, p = .53) or children's incremental motivational frameworks (r[51] = .03, p = .82), but SES was significantly and positively related to all child achievement measures, rs > 0.27, ps < .05, consistent with previous research (e.g., Chatterji, 2006). Overall amount of parent talk was positively related to process praise (as a percent of total praise), r(51)=0.28, p = .045, but parent talk was not significantly related to children's incremental motivational frameworks, r(51)=0.18, p=0.21, which suggests that the relation between process praise and incremental motivational frameworks is not merely a function of children hearing more overall talk. Overall parent talk was also significantly and positively related to all achievement measures in 2nd and 4th grades, *r*s > 0.27, *p*s < .05, which is consistent with other research (e.g., Weisleder & Fernald, 2013) and highlights the importance of controlling for overall talk in our main analyses.

We also found gender differences. Boys received a larger proportion of process praise as toddlers than girls, $t(51) = 3.20$, $p = .002$, $d = 0.90$, and had marginally stronger incremental motivational frameworks in 2nd–3rd grade than girls, $t(51) = 1.69$, $p = .097$, $d = 0.48$ (see Gunderson, et al., 2013). Boys also had significantly higher 4th grade math scores than girls, $t(48) = 2.83$, $p = .007$, $d = 0.82$, a finding that may be specific to our sample as gender differences in math achievement are generally reported only at older ages (Hyde, Lindberg, Linn, Ellis & Williams, 2008; Hyde, Fennema & Lamon, 1990). No other significant gender differences were found. All path models therefore control for the effect of gender on process praise, 2nd grade achievement, and 4th grade achievement.

Prior to conducting our main path analyses, we conducted regression diagnostics to ensure that all model assumptions were met. We examined these with respect to the key linear regression in each model (i.e., regressing 4th grade achievement on praise, motivational framework, 2nd grade achievement, gender, and SES). As detailed below, we did not find evidence for any violation of these assumptions.

Influential points—Visual inspection of scatter plots between all variables did not suggest the presence of any influential points. We also examined the potential presence of multivariate outliers using Cook's distance, with values greater than 1 considered influential (Stevens, 2009), and Mahalanobis distance, with values greater than 20.52 considered influential (20.52 is the critical value for χ^2, with α=.001 and df=5; Tabachnick & Fidell, 2007). No influential points were found (all Cook's distances < 0.32, all Mahalanobis distances < 14.25).

Normality of residuals—Visual inspection of P-P plots of residuals did not indicate any violations of the normality of residuals.

Linearity and homogeneity of variance—Visual inspection of scatter plots between all variables did not suggest any violations of linearity. To assess multivariate linearity and homogeneity of variance, we plotted the standardized residuals against the standardized predicted values for each model. For each model, the residuals were centered around zero, with relatively uniform variance, indicating no violations of linearity or homogeneity of variance. In addition, visual inspection of residual plots regressing motivational frameworks on process praise and regressing 4th grade achievement on process praise, indicated that the arcsine transformation of process praise as a proportion of total praise was successful in yielding approximately constant variance.

Collinearity—To assess collinearity, we examined the variance inflation factors (VIFs) in each model, with VIFs greater than 10 indicating potential collinearity (Stevens, 2009). We found no evidence for collinearity (all VIFs < 1.5).

Path analyses

Path analysis models tested our key prediction that process praise early in development predicts improvements in later academic achievement via incremental motivational frameworks. Because incremental motivational frameworks did not predict reading decoding, we do not report path analyses for reading decoding (see supplemental materials for a summary of this model). All models were estimated using Mplus version 7.11, which uses full information maximum likelihood (FIML) to estimate model parameters using all available data (Muthèn & Muthèn, 1998–2012).

Main path analyses

We first report results from our main analyses, and then examine the robustness of these results in alternative specifications. Figure 1 summarizes the main analyses' structure and standardized coefficients for significant paths. These models controlled for effects of parent SES and child gender on 2nd and 4th grade achievement, and for effects of 2nd grade achievement on 4th grade achievement. Controlling for 2nd grade achievement while predicting 4th grade achievement allows us to investigate whether early process praise and incremental motivational frameworks predict improvement in academic achievement over time.

For direct effects, we estimated standard errors and confidence intervals using percentile bootstrap estimation with 1,000 draws, using the BOOTSTRAP command in MPlus version 7.11 (see Table 3). Bootstrapping is a nonparametric resampling procedure, in which each "draw" creates a new random sample, with replacement, from the existing dataset (Bollen & Stine, 1990). The parameter estimates are calculated for each resampled data set, and the 95% confidence interval is created by finding the values of the 2.5th percentile and 97.5th percentile of the resulting parameter estimates. Bootstrap confidence intervals do not assume that the distribution is symmetric, and therefore can more accurately capture potentially asymmetric distributions, especially with small sample sizes (Bollen & Stine, 1990).

Fit indices suggest a well fit model for math: χ^2 (4) = 1.93, p = .75, comparative fit index (CFI) = 1.00, root mean square error of approximation (RMSEA) = .00 (90% CI = [.00 to .15]); and for reading comprehension: χ^2 (4) = 1.09, p = .90; CFI = 1.00, RMSEA = .00 (90% CI = [.00 to .09]).

As reported by Gunderson et al. (2013), process praise at ages 1–3 years predicted children's incremental motivational frameworks in 2nd or 3rd grade in both the math and reading comprehension models (see Figure 1a–b). In line with our new hypothesis, children's incremental motivational framework in 2nd or 3rd grade predicted their 4th grade math and reading comprehension achievement (Figure 1a–b). Although early process praise is correlated with 4th grade mathematics achievement, this direct relation became non-significant when we controlled for children's incremental motivational framework in 2nd grade (as well as their prior achievement in the same domain, gender, and family SES), consistent with the hypothesis that praise has an indirect effect on math achievement via incremental motivational frameworks.

Our main hypotheses involve testing the indirect relation from process praise to motivational frameworks to 4th grade math and reading comprehension achievement. Statisticians currently recommend directly testing for hypothesized indirect effects regardless of whether a direct effect (i.e., a relation between process praise and 4th grade achievement) is present (Cerin & MacKinnon, 2009; Hayes, 2013; MacKinnon, 2008; Shrout and Bolger, 2002; Zhao et al., 2010). Indirect relations can hold between independent and dependent variables even in the absence of direct relations—especially in cases of small samples and large temporal distance between these variables, as is the case in our dataset (Cerin & MacKinnon, 2009; Fritz & MacKinnon, 2007; MacKinnon, et al., 2002; Shrout & Bolger, 2002). As the temporal distance between variables increases, it becomes more likely that any actual direct effect will be influenced by random noise, additional unmeasured steps in the causal chain, or by competing causes (e.g., suppressor effects) (Shrout & Bolger, 2002). Further, in cases of full mediation, the statistical power to detect each path in a mediational causal chain (e.g., process praise to motivational framework and motivational frameworks to 4th grade achievement) is higher than the power to detect the direct effect (Shrout & Bolger, 2002; Wolf, Harrington, Clark, & Miller, 2013).

Indirect paths were tested using bias-corrected bootstrap estimation (MacKinnon, 2008; MacKinnon, Lockwood, & Williams, 2004; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002), which estimates the indirect effect by calculating the product of the connected paths (e.g., the path from praise to motivational framework, and the path from motivational framework to achievement) and then tests its significance based on an empirical approximation of the sampling distribution. Bias-corrected bootstrap estimation is similar to percentile bootstrap estimation, but incorporates a correction for bias in the central tendency of the indirect effect (MacKinnon, Lockwood, & Williams, 2004). Bias-corrected bootstrap estimation is recommended for testing indirect effects because it substantially increases power while maintaining accurate confidence intervals, especially in small samples (Fritz & MacKinnon, 2007; MacKinnon, Lockwood, & Williams, 2004). We used bias-corrected bootstrap estimation with 10,000 draws to compute 95% confidence intervals around the indirect effects.

Using this technique, we found that the indirect path from early process praise to motivational frameworks in 2nd–3rd grade to academic achievement in 4th grade was significant in the mathematics model (Figure 1a; bias-corrected bootstrap $CI_{95\%}$ = .03 to .35) and the reading comprehension model (Figure 1b; bias-corrected bootstrap $CI_{95\%}$ = 2.57 to 19.83). These relations held controlling for family SES, gender, and 2nd grade achievement as predictors of 4th grade achievement in the same domain.[2]

Additional path analyses

As reported previously, we found significant gender differences in the proportion of process praise received (boys received a higher proportion than girls), marginal differences in motivational frameworks (boys had marginally stronger incremental motivational frameworks than girls, see also Gunderson et al., 2013), and significant differences in 4th

[2]To address any concern that controlling for a posttreatment covariate (2nd grade achievement) would introduce bias in the results, we also ran the same path analyses excluding 2nd grade achievement. The pattern of results remained the same.

grade math achievement (boys showed higher achievement than girls). Path analyses revealed that the indirect paths going from gender to process praise, incremental motivational frameworks, and finally to 4th grade math achievement and reading comprehension achievement were both significant (bias-corrected bootstrap $CI_{95\%} = -.15$ to $-.01$ and -9.02 to $-.79$, respectively). However, these findings should be interpreted with caution because (1) gender differences in math achievement do not typically appear until high school (Hyde, Fennema & Lamon, 1990) or even post-secondary school (Hyde, Lindberg, Linn, Ellis & Williams, 2008), and so our observed gender difference in 4th grade math achievement may reflect sample characteristics; and (2) the significant indirect path from gender to reading comprehension is unpredicted and may also be specific to this sample.

We also conducted two sets of follow-up analyses to test the robustness of the effects in our main analyses. First, we examined these effects using total parent talk as an additional control for parent engagement. The models were the same as our main analyses, with the addition of parent utterances as a predictor of 2nd grade and 4th grade achievement. We again ran separate models for math and for reading comprehension. These models were well-fit for math (χ^2 (6) = 3.02, $p = .81$; CFI = 1.00, RMSEA = .00 (90% CI = [.00 to .11]) and reading comprehension (χ^2 (6) = 2.39, $p = .88$; CFI = 1.00, RMSEA = .00 (90% CI = [.00 to .09]). In both models, the direct paths from process praise to motivational framework, and from motivational framework to 4th grade achievement remained significant (ps < .05, percentile bootstrap $CIs_{95\%}$ did not include zero). Importantly the indirect path from process praise to motivational framework to 4th grade achievement was significant for both math (bias-corrected bootstrap $CI_{95\%} = .03$ to .35) and reading comprehension (bias-corrected bootstrap $CI_{95\%} = 2.35$ to 19.44). Thus, the results remained the same even after controlling for overall parent talk, reducing the possibility that general parent engagement could account for the effects we report.

Finally, we examined whether the indirect path via motivational frameworks was driven by children's beliefs about trait stability or by their preference for challenge. We first conducted two path analyses (one for math, and one for reading comprehension) that were the same as the main analyses except that we replaced the overall motivational framework score with the "trait beliefs" subscore. These models were well fit (math: χ^2 (4) = 1.18, $p = .88$; CFI = 1.00, RMSEA = .00 (90% CI = [.00 to .10]); reading comprehension: χ^2 (4) = 0.50, $p = .97$; CFI = 1.00, RMSEA = .00 (90% CI = [.00 to .00]). The direct paths from process praise to trait beliefs were significant in each model (ps < .05, percentile bootstrap $CIs_{95\%}$ did not include zero), and the direct paths from trait beliefs to 4th grade achievement were also significant (ps < .01, percentile bootstrap $CIs_{95\%}$ did not include zero). Finally, the indirect paths from process praise to trait beliefs to 4th grade achievement were significant as well (math: bias-corrected bootstrap $CI_{95\%} = .02$ to .33; reading comprehension: bias-corrected bootstrap $CI_{95\%} = 1.52$ to 20.25). Thus, the results remained the same when the overall motivational framework measure was replaced with only those items assessing children's beliefs about trait stability.

However, when we conducted the same path analyses, replacing the overall motivational framework score with the "learning goals" subscore, the results were not the same. Although the models were well fit (math: χ^2 (4) = 2.15, p = .71; CFI = 1.00, RMSEA = .00 (90% CI = [.00 to .15]); reading comprehension: χ^2 (4) = 1.10, p = .90; CFI = 1.00, RMSEA = .00 (90% CI = [.00 to .09]), the direct paths from process praise to learning goals were not significant (ps > .10, percentile bootstrap $\text{CIs}_{95\%}$ included zero), and the direct paths from learning goals to 4th grade achievement were not significant (ps > 0.70, percentile bootstrap $\text{CIs}_{95\%}$ included zero). The indirect paths from process praise to learning goals to 4th grade achievement were also not significant (bias-corrected bootstrap $\text{CIs}_{95\%}$ included zero). In other words, the indirect path linking parents' process praise to children's 4th grade achievement is driven primarily by children's 2nd 3rd grade beliefs about whether traits are stable or malleable, rather than their reported preference for challenging versus easy tasks.

Discussion

To our knowledge, these findings present the first demonstration that an assessment of caregiver praise during naturalistic parent-child interactions between child ages 1–3 years indirectly predicts academic achievement *seven years later*, in 4th grade, via children's incremental motivational frameworks. We found this pattern in two critical academic domains: mathematics and reading comprehension. More specifically, a greater proportion of caregivers' praise that emphasized process (e.g., "good job working hard") predicted the child's incremental motivational framework 5 years later, which, in turn, predicted the child's achievement two years after that.

Importantly, process praise only predicted achievement insofar as it predicted children's development of an incremental motivational framework—we found no direct relation between process praise and achievement after accounting for this indirect relation. Furthermore, the path from early process praise to 2nd or 3rd grade incremental motivational frameworks, and finally to 4th grade math achievement and reading comprehension, remained significant controlling for SES, gender, overall parent talk between 1 and 3 years of age, and 2nd grade scores in the same academic domain. These control measures provide evidence that process praise and incremental motivational frameworks do not merely correlate with overall ability. Rather, the findings suggest that process praise leads children to form incremental motivational frameworks, which, in turn, improves their academic achievement over time.

We also examined two theoretically-distinct subscores of the motivational framework measure: trait beliefs and learning goals. We found evidence that trait beliefs alone formed a link between parents' process praise and children's 4th grade achievement, but failed to find evidence that learning goals alone formed such a link. This intriguing finding suggests that trait beliefs can form a powerful "lens" through which children interpret and react to the challenges they encounter over time, such as challenges in math or reading comprehension. In contrast, children's reported learning goals may speak more specifically to their taste for challenge at the time and in the situation in which they report them. However, given our small sample, this null finding should not be interpreted as conclusive evidence that early learning goals are unimportant for children's academic achievement.

It is important to note that we took relatively brief snapshots of parents' early praise behavior. It is, of course, possible that parents who use more process praise (as a proportion of total praise) when their children were very young continue to do so as their children grow older. The fact that parents' use of process praise was correlated across the three observations when children were 1, 2, and 3 years old (Gunderson et al., 2013) does suggest that parents may establish a consistent praise style early on. Thus, it may be parents' continued use of process praise that leads to children's incremental motivational frameworks and achievement. However, it is unlikely that parents' concerns about and reactions to their toddlers is entirely similar to their concerns about and reactions to their school age children, who are now confronting academic work and getting grades and test scores that may be seen by parents as reflecting their children's efforts and abilities. Thus, new parental concerns may come into play over time to change the nature of their praise to their children. Whether or not this change occurs, our conclusion would be similar: assessments of parents' early praise predict children's later motivational frameworks, which, in turn, predict their achievement.

Relatedly, we did not find a relation between parents' person praise (e.g., "you're so smart") and children's motivational frameworks or achievement. At least one previous study found that parents' person praise was more predictive of children's motivational frameworks than their process praise (Pomerantz & Kempner, 2013); our study found the opposite pattern, that process praise was more predictive of later outcomes than person praise. However, our study examined parents' praise to 1–3-year-olds in naturalistic home settings, whereas Pomerantz and Kempner (2013) examined parents' self-reported praise to 5th-graders specifically regarding their school work, leaving open several possible reasons for the discrepancy between studies. In our study, person praise to toddlers occurred in response to a variety of non-academic situations and commonly included phrases like "good girl" and "big boy" (Gunderson et al., 2013). Person praise in these contexts may have a smaller impact on motivational frameworks than statements like "you're so smart" in response to children's school work. In addition, in our study, parents' person praise to their 1–3-year-olds was less stable over time than their process praise (Gunderson et al., 2013). It is possible that parents form stable patterns of process praise early on when children are 1–3-years old, but form stable patterns of person praise later and only after children enter school. Our analysis of early praise may not have captured this later-developing pattern. These results raise interesting questions for future research regarding the relative stability of person versus process praise in parent-child interactions, as well as the relative impact of person versus process praise at different ages and in different contexts.

As anticipated, we did not find relations between process praise, motivational frameworks, and academic achievement in the domain of reading decoding. Children typically learn challenging reading decoding skills during the first few years of schooling (i.e., before 2nd grade; Treiman, 2000). We therefore did not necessarily expect motivational frameworks to predict growth in decoding achievement between 2nd and 4th grades. It is possible that children who struggle with decoding in later elementary school would benefit from adaptive incremental motivational frameworks, but our sample did not include enough struggling readers to test this prediction. It is also possible that incremental motivational frameworks would have predicted growth in reading decoding achievement at earlier ages in our sample, for example, between kindergarten and second grade.

One limitation of this study is that parents who give a higher proportion of process praise might also engage in some other beneficial behavior that our study does not account for—and it may be this unobserved behavior that shapes incremental motivational frameworks and academic achievement. Controlling for overall parent talk and parent SES offsets this possibility somewhat, but not entirely. However, given the substantial evidence from randomized laboratory experiments showing that process praise causes children to approach tasks with an incremental motivational framework (e.g., Cimpian et al., 2007; Corpus & Lepper, 2007; Kamins & Dweck, 1999; Mueller & Dweck, 1999; Zentall & Morris, 2010; Zentall & Morris, 2012), we think it is unlikely that a third variable wholly accounts for these results.

A second limitation of the present study is the relatively small sample size. One concern stemming from a small sample size is generalizability. Although the sample was diverse in terms of family income, parents' education, and race/ethnicity, future research using larger, nationally- (or internationally-) representative samples would increase the generalizability of these findings. Another concern is that small samples can lead to a lack of power to detect true effects. To avoid issues with low power, our path analyses utilized bias-corrected bootstrap estimation, which greatly increases power to detect indirect effects, especially in small samples (Fritz & MacKinnon, 2007; MacKinnon, Lockwood, & Williams, 2004), and we did find significant indirect effects from praise to motivational frameworks to achievement in the expected domains (math and reading comprehension). However, we are cautious in interpreting the non-significant indirect effect for reading decoding (even though it was expected based on differences between domains). It is possible that a larger study may find an effect of praise and motivational frameworks on reading decoding as well.

A third potential concern is that a small sample size can lead to low positive predictive value (PPV), the probability that a statistically significant result reflects a true effect (Button et al., 2013). We estimate, conservatively, that the PPV for the key indirect effect in our math model is at least 73.2% and for reading comprehension, at least 80.5%, and both may be as high as 95% (see supplemental materials Table S2 for details). Although these results suggest that our results are likely to reflect true effects, it is nevertheless important for future work to replicate these effects in a sample with greater power.

Regarding possible concerns with multiple comparisons, we note that our main analyses consisted of three key tests of our core hypotheses, namely, the indirect effects from process praise to motivational frameworks to 4th grade achievement in math, reading comprehension, and reading decoding. These tests supported our hypotheses, showing significant effects in math and reading comprehension, but not reading decoding. Additional tests were presented to provide a richer understanding of the data, and we believe that a complete report of the results of the study—especially given the rarity of such long-term data—is most helpful for advancing research. In sum, although our study has limitations, we believe that its strengths—including the 10-year-long time span, the diverse sample, the rich observational measures of parent praise, and use of carefully-selected control variables (SES, gender, prior achievement)—make it important to communicate these results to the field.

Our results converge with evidence from numerous experimental studies showing that process praise fosters incremental motivational frameworks, and that incremental motivational frameworks play a causal role in improving learning and achievement. Causal evidence from experimental studies supports both legs of the developmental path that we found in our naturalistic data. In terms of the first leg, studies manipulating praise have found that process praise causes children to adopt an incremental motivational framework with respect to specific tasks (e.g., Mueller & Dweck, 1999; Kamins & Dweck, 1998; Cimpian et al., 2007; Zentall & Morris, 2010; Corpus & Lepper, 2007; Zentall & Morris, 2012). In terms of the second leg, interventions that instill incremental motivational frameworks through lessons about the brain's ability to grow and change reveal that acquiring incremental motivational frameworks can lead to greater academic achievement, at least among students in middle school through college (Blackwell, et al., 2007; Aronson, et al., 2002; Good, et al., 2003; Paunesku et al., 2015). Our research makes the important point that these relations, established in experimental research, play out in naturalistic child development: children who hear a higher proportion of process praise at home from their parents are more likely to develop an incremental motivational framework, which, in turn predicts their higher growth in academic achievement. In sum, we present the first long-term developmental picture of the relations between naturalistic parent praise at home prior to school entry and incremental motivational frameworks and academic achievement during the elementary school years. These findings confirm predictions made by years of experimental research in social and developmental psychology about how praise, motivational frameworks, and achievement operate in real world learning environments—home and school.

Further, our results make a strong case for testing the relationships between process praise, motivational frameworks, and academic achievement more directly through interventions with elementary-school-aged students and through interventions with parents and teachers of young children. While interventions encouraging an incremental motivational framework have been quite successful in middle school and above (e.g., Blackwell et al., 2007), to our knowledge no studies have attempted such interventions among elementary school students. Our correlational results suggest that motivational frameworks may already impact student achievement by 2nd grade, creating a strong case for testing this causal relation directly. Our results also indicate that intervention studies aimed at parents and teachers may be fruitful. Such interventions should take care to guide parents on *how* to give process praise. Although the current research shows that naturalistic process praise predicts incremental motivational frameworks and achievement, an intervention addressing parent praise needs to avoid certain pitfalls. For example, consoling a child who is struggling but not learning by saying "it's ok, you tried your best!" without connecting effort to a positive learning outcome might *seem* to promote effort, but in fact could deflate the child's self-efficacy (Schunk, 1983; Dweck, 2015), and could disincentivize children from seeking new strategies or input from others that would help them learn. Similarly, praising children too much or with hyperbolic praise ("that was an incredibly amazing catch!") can discourage children from taking on challenges —especially children with low self-esteem (e.g., Brophy, 1981; Brummelman, Thomaes, Orobio de Castro, Overbeek & Bushman, 2014). It might also be easy for parents to misinterpret instructions to increase the *proportion* of praise that emphasizes process as an instruction to give very frequent praise. Any intervention to increase parents' proportion of process praise should be careful to clarify this distinction. Nevertheless, our results suggest that interventions constructed to increase the proportion of praise children hear that emphasizes how their effort and strategies lead to learning may be a fruitful way to foster incremental mindsets and long-term academic achievement.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

Aarnoutse C, van Leeuwe J, Voeten M, Oud H. Development of decoding, reading comprehension, vocabulary and spelling during the elementary school years. Reading and Writing. 2001; 14(1):61–89. DOI: 10.1023/a:1008128417862

Anderman LH, Anderman EM. Social predictors of changes in students' achievement goal orientations. Contemporary Educational Psychology. 1999; 24(1):21–37. DOI: 10.1006/ceps.1998.0978 [PubMed: 9878206]

Aronson J, Fried CB, Good C. Reducing the Effects of Stereotype Threat on African American College Students by Shaping Theories of Intelligence. Journal of Experimental Social Psychology. 2002; 38(2):113–125. DOI: 10.1006/jesp.2001.1491

Blackwell LS, Trzesniewski KH, Dweck CS. Implicit theories of intelligence predict achievement across an adolescent transition: a longitudinal study and an intervention. Child Development. 2007; 78(1):246–63. DOI: 10.1111/j.1467-8624.2007.00995.x [PubMed: 17328703]

Bollen KA, Stine R. Direct and indirect effects: Classical and bootstrap estimates of variability. Sociological Methodology. 1990; 20:115–140.

Brophy J. Teacher Praise: A Functional Analysis. Review of Educational Research. 1981; 51(1):5–32. DOI: 10.3102/00346543051001005

Brummelman E, Thomaes S, Overbeek G, Orobio de Castro B, van den Hout Ma, Bushman BJ. On feeding those hungry for praise: Person praise backfires in children with low self-esteem. Journal of Experimental Psychology: General. 2014; 143(1):9–14. DOI: 10.1037/a0031917 [PubMed: 23421441]

Cerin E, Mackinnon DP. A commentary on current practice in mediating variable analyses in behavioural nutrition and physical activity. Public Health Nutrition. 2009; 12(8):1182–8. DOI: 10.1017/S1368980008003649 [PubMed: 18778534]

Chapman JW, Tunmer WE. Development of young children's reading self-concepts: An examination of emerging subcomponents and their relationship with reading achievement. Journal of Educational Psychology. 1995; 87(1):154–167. DOI: 10.1037/0022-0663.87.1.154

Chatterji M. Reading Achievement Gaps, Correlates, and Moderators of Early Reading Achievement: Evidence From the Early Childhood Longitudinal Study (ECLS) Kindergarten to First Grade Sample. Journal of Educational Psychology. 2006; 98(3):489–507. DOI: 10.1037/0022-0663.98.3.489

Cimpian A, Arce HMC, Markman EM, Dweck CS. Subtle linguistic cues affect children's motivation. Psychological Science. 2007; 18(4):314–6. DOI: 10.1111/j.1467-9280.2007.01896.x [PubMed: 17470255]

Corpus JH, Lepper MR. The Effects of Person Versus Performance Praise on Children's Motivation: Gender and age as moderating factors. Educational Psychology. 2007; 27(4):487–508. DOI: 10.1080/01443410601159852

Diprete TA, Jennings JL. Social and behavioral skills and the gender gap in early educational achievement. Social Science Research. 2012; 41(1):1–15. DOI: 10.1016/j.ssresearch.2011.09.001 [PubMed: 23017693]

Dweck C. Growth mindset, revisited. Education Week. 2015; 35(5):24–20.

Dweck CS, Leggett EL. A social-cognitive approach to motivation and personality. Psychological Review. 1988; 95(2):256–273. DOI: 10.1037/0033-295X.95.2.256

Enders CK, Bandalos DL. The relative performance of full information maximum likelihood estimation for missing data in structural equation models. Structural Equation Modeling: A Multidisciplinary Journal. 2001; 8(3):430–457. DOI: 10.1207/s15328007sem0803_5

Fritz MS, MacKinnon DP. Required sample size to detect the mediated effect. Psychological Science. 2007; 18:233–239. DOI: 10.1111/j.1467-9280.2007.01882.x.Required [PubMed: 17444920]

Hayes AF. Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. Communication Monographs. 2009; 76(4):408–420. DOI: 10.1080/03637750903310360

Hayes, AF. Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. New York, New York: Guilford Press; 2013.

Heyman GD, Dweck CS. Children's thinking about traits: Implications for judgments of the self and others. Child Development. 1998; 69(2):391–403. DOI: 10.2307/1132173 [PubMed: 9586214]

Giles JW, Heyman GD. Preschoolers' Beliefs About the Stability of Antisocial Behavior: Implications for Navigating Social Challenges. Social Development. 2003; 12(2):182–197. DOI: 10.1111/1467-9507.00228

Goldin-Meadow S, Levine SC, Hedges LV, Huttenlocher J, Raudenbush S, Small S. New evidence about language and cognitive development based on a longitudinal study: Hypotheses for intervention. American Psychologist. 2014; 69(6):588–599. DOI: 10.1037/a0036886 [PubMed: 24911049]

Good C, Aronson J, Inzlicht M. Improving adolescents' standardized test performance: An intervention to reduce the effects of stereotype threat. Journal of Applied Developmental Psychology. 2003; 24(6):645–662. DOI: 10.1016/j.appdev.2003.09.002

Graham JW, Hofer SM, MacKinnon DP. Maximizing the usefulness of data obtained with planned missing value patterns: An application of maximum likelihood procedures. Multivariate Behavioral Research. 1996; 31(2):197–218. DOI: 10.1207/s15327906mbr3102_3 [PubMed: 26801456]

Grant H, Dweck CS. Clarifying achievement goals and their impact. Journal of Personality and Social Psychology. 2003; 85(3):541–553. DOI: 10.1037/0022-3514.85.3.541 [PubMed: 14498789]

Gunderson EA, Gripshover S, Romero C, Dweck CS, Goldin-Meadow S, Levine S. Parent Praise to 1–3 year-olds predicts children's motivational frameworks 5 years later. Child Development. 2013; 84(5):1526–1541. DOI: 10.1111/cdev.12064 [PubMed: 23397904]

Heyman GD, Dweck CS, Cain KM. Young Children's Vulnerability to Self-Blame and Helplessness: Relationship to Beliefs about Goodness. Child Development. 1992; 63(2):401–415. DOI: 10.1111/j.1467-8624.1992.tb01636.x [PubMed: 1611943]

Huttenlocher J, Vasilyeva M, Waterfall HR, Vevea JL, Hedges LV. The varieties of speech to young children. Developmental Psychology. 2007; 43(5):1062–83. DOI: 10.1037/0012-1649.43.5.1062 [PubMed: 17723036]

Jacobs JE, Lanza S, Osgood DW, Eccles JS, Wigfield A. Changes in children's self-competence and values: Gender and domain differences across grades one through twelve. Child Development. 2002; 73(2):509–527. DOI: 10.1111/1467-8624.00421 [PubMed: 11949906]

Kamins ML, Dweck CS. Person versus process praise and criticism: Implications for contingent self-worth and coping. Developmental Psychology. 1999; 35:835–847. 0012-1649/99/S3.00. [PubMed: 10380873]

Kinlaw CR, Kurtz-Costes B. Children's theories of intelligence: Beliefs, goals, and motivation in the elementary years. Journal of General Psychology. 2007; 134(3):295–311. DOI: 10.3200/GENP.134.3.295-312 [PubMed: 17824400]

Little RJA. A test of missing completely at random for multivariate data with missing values. Journal of the American Statistical Association. 1988; 83(404):1198–1202. DOI: 10.1080/01621459.1988.10478722

MacGinitie & MacGinitie. Gates-MacGinitie Reading Tests. Chicago: Riverside; 1989.

MacKinnon, DP. Introduction to statistical mediation analysis. New York, NY: Routledge; 2008.

MacKinnon DP, Lockwood CM, WIlliams J. Confidence limits for the indirect effect: Distribution of the product and resampling methods. Multivariate Behavioral Research. 2004; 39(1):99–128. DOI: 10.1207/s15327906mbr3901_4 [PubMed: 20157642]

MacKinnon DP, Lockwood CM, Hoffman JM, West SG, Sheets V. A comparison of methods to test mediation and other intervening variable effects. Psychological Methods. 2002; 7(1):83–104. DOI: 10.1037/1082-989x.7.1.83 [PubMed: 11928892]

McCutchen KL, Jones MH, Carbonneau KJ, Mueller CE. Mindset and standardized testing over time. Learning and Individual Differences. 2015; :6–11. DOI: 10.1016/j.lindif.2015.11.027

Mueller CM, Dweck CS. Praise for Intelligence Can Undermine Children's Motivation and Performance. Journal of Personality and Social Psychology. 1998; 75(1):33–52. 0022-3514/98. [PubMed: 9686450]

Muthén, LK., Muthén, BO. Mplus User's Guide. 7. Los Angeles, CA: Muthén & Muthén; 1998–2012.

Park D, Gunderson EA, Tsukayama E, Levine SC, Beilock SL. Young children's motivational frameworks and math achievement: Relation to teacher-reported instructional practices, but not teacher theory of intelligence. Journal of Educational Psychology. 2016; 108(3):300–313. DOI: 10.1037/edu0000064

Paunesku D, Walton GM, Romero C, Smith EN, Yeager DS, Dweck CS. Mind-Set Interventions Are a Scalable Treatment for Academic Underachievement. Psychological Science. 2015; 26(6):784–793. DOI: 10.1177/0956797615571017 [PubMed: 25862544]

Penner AM, Paret M. Gender differences in mathematics achievement: Exploring the early grades and the extremes. Social Science Research. 2008; 37(1):239–253. DOI: 10.1016/j.ssresearch.2007.06.012

Pomerantz EM, Kempner SG. Mothers' daily person and process praise: implications for children's theory of intelligence and motivation. Developmental Psychology. 2013; 49(11):2040–6. DOI: 10.1037/a0031840 [PubMed: 23398552]

Revelle, W. psych: Procedures for Psychological, Psychometric, and Personality Research. Evanston, Illinois: 2015. Retrieved from http://cran.r-project.org/package=psych

Romero C, Master A, Paunesku D, Dweck CS, Gross JJ. Academic and emotional functioning in middle school: the role of implicit theories. Emotion. 2014; 14(2):227–34. DOI: 10.1037/a0035490 [PubMed: 24512251]

Schrank, FA., Becker, KA., Decker, S. Calculating ability/achievement discrepancies between the Wechsler Intelligence Scale for Children Third Edition and the Woodcock-Johnson III Tests of Achievement. Itasca, IL: Riverside Publishing; 2001. (Woodcock-Johnson III Assessment Service Bulletin No. 4)

Shrout PE, Bolger N. Mediation in experimental and nonexperimental studies: new procedures and recommendations. Psychological Methods. 2002; 7(4):422.doi: 10.1037//1082-989X.7.4.422 [PubMed: 12530702]

Smiley PA, Dweck CS. Individual differences in achievement goals among young children. Child Development. 1994; 65:1723–1743. DOI: 10.2307/1131290 [PubMed: 7859551]

Stevens, J. Applied Multivariate Statistics for the Social Sciences, Fifth Edition. New York, NY: Taylor & Francis Group; 2009.

Stipek D, Gralinski JH. Children's beliefs about intelligence and school performance. Journal of Educational Psychology. 1996; 88(3):397–407. DOI: 10.1037/0022-0663.88.3.397

Storch SA, Whitehurst GJ. Oral language and code-related precursors to reading: Evidence from a longitudinal structural model. Developmental Psychology. 2002; 38(6):934–947. DOI: 10.1037/0012-1649.38.6.934 [PubMed: 12428705]

Tabachnick, B., Fidell, LS. Using Multivariate Statistics. 5. Boston, MA: Pearson; 2007.

Treiman R. The foundations of literacy. Current Directions in Psychological Science. 2000; :89–92. DOI: 10.1111/1467-8721.00067

Wigfield A, Eccles JS, Yoon KS, Harold RD, Arbreton AJA, Freedman-Doan C, Blumenfeld PC. Change in children's competence beliefs and subjective task values across the elementary school years: A 3-year study. Journal of Educational Psychology. 1997; 89(3):451–469. DOI: 10.1037/0022-0663.89.3.451

Wolf EJ, Harrington KM, Clark SL, Miller MW. Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. Educational and Psychological Measurement. 2013; 73(6):913–934. DOI: 10.1177/0013164413495237

Woodcock, RW., McGrew, KS., Mather, N. Woodcock- Johnson III Tests of Achievement. Itasca, IL: Riverside; 2001.

Zentall SR, Morris BJ. Journal of Experimental Child "'Good job, you're so smart": The effects of inconsistency of praise type on young children's motivation. Journal of Experimental Child Psychology. 2010; 107:155–163. DOI: 10.1016/j.jecp.2010.04.015 [PubMed: 20570281]

Zentall SR, Morris BJ. A critical eye: Praise directed toward traits increases children ' s eye fixations on errors and decreases motivation. 2012; doi: 10.3758/s13423-012-0294-y

Zhao X, Lynch JG, Chen Q. Reconsidering Baron and Kenny: Myths and truths about mediation analysis. Journal of Consumer Research. 2010; 37(2):197–206. DOI: 10.1086/651257

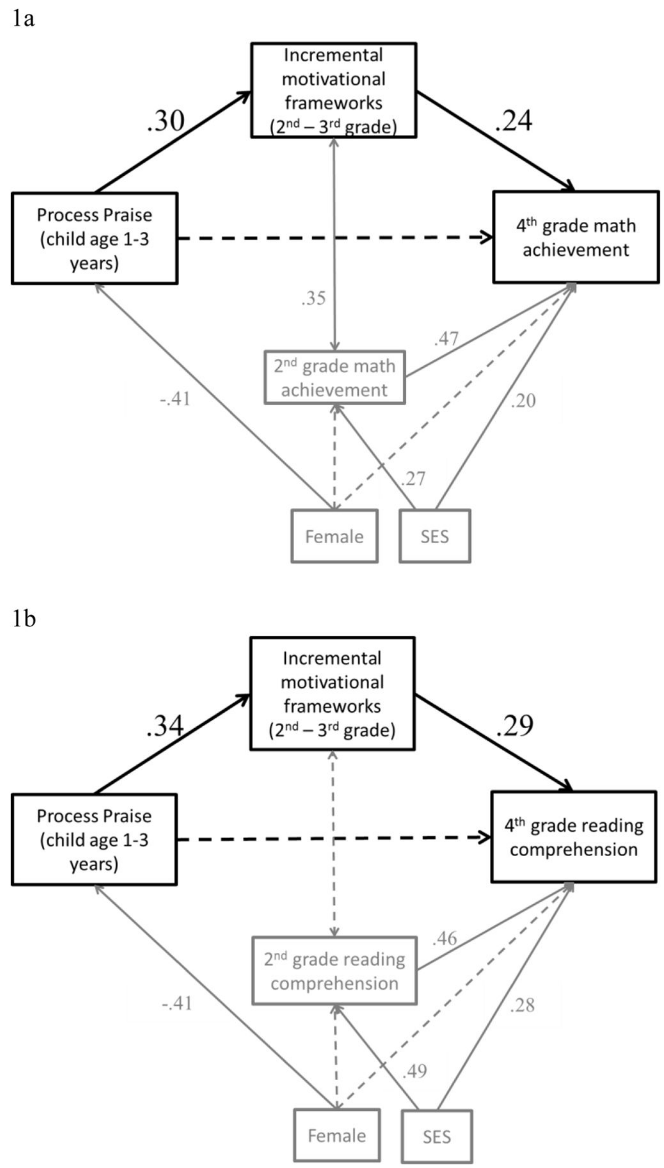

Figure 1.

A summary of path analyses of the effects of process praise on academic achievement through incremental motivational framework after controlling for prior achievement, child gender, and family SES. Significant paths (paths with 95% bootstrap CIs that do not include zero, see Table 3) are labeled with standardized coefficients. Control variables and their relations to other variables are in grey. Results are shown separately for math (top) and reading comprehension (bottom). Single-headed arrows represent paths of influence. Double-headed arrows represent correlations. Solid lines indicate significant effects, and dashed lines indicate non-significant effects.

Table 1

Summary of content, children's chronological ages, and timing of assessments

	Ages 1–3 years	2nd Grade			3rd Grade		4th Grade	
		Autumn	Winter	Spring	Autumn	Winter	Winter	Spring
Socioeconomic Status (SES)	Child age 14 months	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Proportion of process praise	Child ages 14, 26, and 38 months	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Motivational Frameworks	n/a	Questionnaire Part 1 (n = 36 children, M_{age} = 8.0, sd = .20)*	Questionnaire Part 2 (n = 31 children, M_{age} = 8.3, sd = .20)*	n/a	Questionnaire Part 1 (n = 17 children, M_{age} = 8.2 years, sd = .15)*	Questionnaire Part 2 (n = 12 children, M_{age} = 8.6 years, sd = .17)*	n/a	n/a
Mathematics achievement	n/a	n/a	WJ-III Applied Problems	WJ-III Calculation	n/a	n/a	WJ-III Applied Problems	WJ-III Calculation
Reading Comprehension Achievement	n/a	n/a	n/a	WJ-III Passage Comprehension	n/a	n/a	n/a	Gates-MacGinitie Reading Test
Reading Decoding Achievement	n/a	n/a	n/a	WJ-III Word Identification and WJ-III Word Attack	n/a	n/a	n/a	WJ-III Word Identification and WJ-III Word Attack
Child chronological age	1–3 years	M = 8.0 years sd = .20 years	M = 8.1 years sd = .37 years	M = 8.4 years sd = .38 years	M = 8.2 years sd = .15 years	M = 8.6 years sd = .17 years	M = 10.1 years sd = .38 years	M = 10.4 years sd = .37 years

*Note: some children received the motivational frameworks measure in second grade, others in third grade because the original sample of infants recruited in 2002 who entered the study at age 14 months entered kindergarten during different academic years according to their schools' entrance requirements, e.g., children with spring and summer birthdays usually entered kindergarten a year earlier than children with late autumn birthdays. These different kindergarten-entry dates meant that our sample was split between second and third grades during the academic year 2009–2010 when motivational frameworks were measured.

Table 2

Zero-order Pearson's correlation coefficients for each variable (N=53).

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**
1. Process praise[a]	-										
2. Person praise[a]	−0.14	-									
3. Other praise[a]	−0.70***	−0.58***	-								
4. Incremental motivational frameworks (2nd–3rd grade)	0.34*	−0.05	−0.26	-							
5. Math (2nd grade)	0.21	−0.15	−0.06	0.40**	-						
6. Reading comprehension (2nd grade)	0.12	−0.15	0.01	0.14	0.36**	-					
7. Reading decoding (2nd grade)	0.03	0.03	−0.03	0.20	0.39**	0.64***	-				
8. Math (4th grade)	0.33*	−0.23	−0.13	0.49***	0.67***	0.48***	0.49***	-			
9. Reading comprehension (4th grade)	−0.02	−0.24	0.19	0.32*	0.33*	0.64***	0.52***	0.63***	-		
10. Reading decoding (4th grade)	−0.07	−0.00	0.08	0.19	0.34*	0.57***	0.89***	0.44**	0.51***	-	
11. Socioeconomic status (SES)	0.09	−0.16	0.08	0.03	0.28*	0.49*	0.35*	0.36*	0.52***	0.35*	-
12. Overall parent talk	0.28*	−0.25	−0.01	0.18	0.34*	0.32*	0.28*	0.44**	0.37**	0.35*	0.46***

[a]Percent of total praise, arcsine transformed, measured at child ages 1–3 years.

Table 3

Coefficients for direct effects in path analyses.

Model	Path	Standardized coefficient	Unstandardized coefficient (S.E.)	95% CI of unstandardized coefficient (percentile bootstrap with 1,000 draws)
Predicting 4th grade math achievement				
Main analyses				
	Process praise -> motivational framework	0.30	0.25* (0.11)	[0.02, 0.44]*
	Motivational framework -> 4th grade math	0.24	0.57* (0.24)	[0.04, 1.02]*
	Process praise -> 4th grade math	0.07	0.14 (0.25)	[−0.35, 0.63]
Controls				
	SES -> 2nd grade math	0.27	0.24* (0.10)	[0.05, 0.44]*
	SES -> 4th grade math	0.20	0.18* (0.09)	[0.01, 0.37]*
	Female -> process praise	−0.41	−0.37** (0.11)	[−0.58, −0.15]*
	Female -> 2nd grade math	−0.14	−0.26 (0.23)	[−0.73, 0.18]
	Female -> 4th grade math	−0.15	−0.27 (0.23)	[−0.71, 0.17]
	2nd grade math -> 4th grade math	0.47	0.46** (0.16)	[0.19, 0.78]*
Predicting 4th grade reading comprehension				
Main analyses				
	Process praise -> motivational framework	0.34	0.28* (0.11)	[0.04, 0.47]*
	Motivational framework -> 4th grade reading comp.	0.29	32.20** (10.82)	[8.77, 50.25]*
	Process praise -> 4th grade reading comp.	−0.24	−22.00 (12.04)	[−45.24, 0.69]
Controls				
	SES -> 2nd grade reading comp.	0.49	6.22*** (1.68)	[2.88, 9.54]*
	SES -> 4th grade reading comp.	0.28	11.72* (5.17)	[0.13, 20.70]*
	Female -> process praise	−0.41	−0.37** (0.11)	[−0.58, −0.15]*
	Female -> 2nd grade reading comp.	−0.01	−0.23 (3.40)	[−7.32, 5.96]
	Female -> 4th grade reading comp.	−0.10	−8.18 (10.69)	[−29.59, 10.22]
	2nd grade reading comp. -> 4th grade reading comp.	0.46	1.52** (0.52)	[0.71, 2.75]*

* p<.05 (or 95% CI does not include zero),

** p<.01,

*** p<.001