The relation between global and specific mindset with reading outcomes for elementary school students

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Published 2017

Petscher, Y., Al Otaiba, S., Wanzek, J., Rivas, B., & Jones, F. (2017). The relation between global and specific mindset with reading outcomes for elementary school students. *Scientific Studies of Reading, 21*, 376-391.

Funding for this study was provided by the Institute of Education Sciences (R324A150269).

Abstract

An emerging body of research has evaluated the role of growth mindset in educational achievement, yet little work has focused on the unique role of mindset to standardized reading outcomes. Our study presents four key outcomes in a sample of 195 fourth-grade students. First, we evaluated the dimensionality of general and reading-specific mindset and found that a global factor of growth mindset (GGM) existed along with specific factors of general and reading mindset. Second, GGM and reading mindset strongly predicted word reading and reading comprehension. Third, GGM and reading mindset uniquely predicted reading comprehension after controlling for basic word reading skills. Fourth, GGM was more strongly associated with reading comprehension for those individuals with weaker reading comprehension skills while reading mindset was more strongly associated with reading comprehension for those with stronger reading comprehension skills. Our findings suggest the potential importance of assessing general and reading-specific mindset linked to reading.

Keywords: mindset, reading comprehension, word reading, effort beliefs

The influences on individual differences in literacy skills is wide-reaching in scope, inclusive of home literacy environment (Burgess, Hecht, & Lonigan, 2002), school (Hanushek, 1997), neighborhood (Aikens & Barbarin, 2008), policy (Shanahan, 2014), behavioral (Bental & Tirosh, 2007), neuropsychological (Fletcher, 1985), and behavioral genetic components (Little, Haughbrook, & Hart, 2016). As these influences on the reading process continue to be understood through descriptive, correlational, and experimental studies, there has been a theoretical resurgence as of late into the potential importance that implicit theories of intelligence and ability have on academic outcomes (e.g., Blackwell, Trzesniewski, & Dweck, 2007). Since the release of Dweck's (2006) work on mindset, numerous studies have been conducted to unpack the idea that a growth mindset (i.e., the belief that intelligence can grow) is important, malleable, and trainable. In the present study, we examined whether general and reading-specific growth mindsets are uniquely related to reading comprehension performance for upper elementary reading performance when accounting for word reading skills. We also explored whether such relations were stronger or weaker based on students' reading comprehension ability.

The evidence about what contributes to reading comprehension has been covered significantly in the literature (Garcia & Cain, 2013) such that it is mostly agreed upon that decoding and language comprehension largely explain individual differences in comprehension. Whether studies reported on correlations from observed measures (e.g., Gough & Tunmer, 1986; Hoover & Gough, 1990) or latent construct structural relations (e.g., Ahmed et al., 2016; Foorman, Koon, Petscher, Mitchell, & Truckenmiller, 2015; Kershaw & Schatschneider, 2012), studies typically report anywhere from 20% to 98% of the variance of reading comprehension can be explained by component reading skills inclusive of decoding, language comprehension,

background knowledge, learning strategies, and inference-making skills. The variability in reported effect sizes is partly a consequence of omitted variable bias, suggesting that other factors may be of value. Some research has evaluated the role of attitudes with reading achievement via meta-analysis (Petscher, 2010) as well as motivation with reading achievement (e.g., Guthrie, Wigfield, Metsala, & Cox, 1999), with varying findings about the unique relation of these constructs above reading component skills.

Growth Mindset

Growth mindset research finds it roots in the non-cognitive literature which broadly includes academic behaviors, academic perseverance, academic mindset, learning strategies and social skills (Farrington et al., 2012). These broader non-cognitive factors and relations to academic outcomes have been studied among students in middle school (Aidman & Malerba, 2015), high school (Mourgues, Hein, Tan, Diffley, & Grigorenko, 2016), community college (Robbins et al., 2004), and into adulthood (Kautz, Heckman, Diris, ter Weel, & Borghans, 2014). Specific non-cognitive factors, such as motivation, maintain a robust literature base with several meta-analyses finding positive relations with academic outcomes (e.g., Richardson, Abraham, & Bond, 2012; Robbins, Lauver, Le, Davis, Langley, & Carlstrom, 2004).

Mindset in particular has more recently permeated popular culture vernacular spurring on questions about the role of assessing mindset, grit, and joy in the classroom (Zernike, 2016). Mindset refers to a relation between students' motivation and their learning goals, and their beliefs about whether intelligence and academic skills are fixed (or inherent) or can be grown (malleable or incremental; e.g., Dweck & Leggett, 1988; Dweck, 1999; 2006; 2007). Students who hold a fixed mindset believe that an individual's IQ and academic ability is pre-determined and is therefore not malleable. Moreover, this mindset is consistent with a view that if one does

not learn something easily, it is because one is not intelligent and success is viewed as the result of talent or an innate ability. In contrast, students with a growth mindset believe that intelligence and academic ability are dynamic and can be changed and developed through practice; further corrective feedback can contribute to growth. To individuals with a growth mindset, success is partly the result of grit, perseverance, or sustained effort and practice; and failure is an integral part of developing one's abilities and growth. Dweck and colleagues have found that students who endorse the growth mindset believe that their intelligence, and academic ability, can be developed through effortful and challenging work (e.g., Hong, Chiu, Dweck, Lin & Wan, 1999; Yeager & Dweck, 2012; Yeager & Walton, 2011). A recent meta-analysis of over 28,000 participants in 10 different countries examined the relations of growth vs fixed mindset with three aspects of self –regulation processes: goal setting (focus on learning vs focus on a score or doing better than others), goal operating (focus on effort to mastery vs focus on avoidance or helplessness-orientation), and goal monitoring (focus on positive vs negative expectations; Burnette, O'Boyle, VanEpps, Pollack & Finkel, 2013). The authors reported a growth mindset had small but significant predictive relations with all three aspects, (r =.15, .19, and .24 respectively).

Growth Mindset Relations to Academic Outcomes

Much of the research pertaining to mindset's relation to educational outcomes has been focused on middle school, secondary and post-secondary populations, rather than students in elementary. For example, Blackwell, Trzesniewksi and Dweck (2007) followed 373 students from four cohorts of students in seventh and eighth grades. They tested students' theories of intelligence, learning goals, effort beliefs, and responses to academic difficulty and found that students who had a growth mindset outperformed those with a fixed mindset on math grades

even after accounting for end of sixth grade math scores. Similarly, Henderson and Dweck (1998) observed that a growth mindset was associated with significantly higher grades in a study of students in their first year of junior high school. Converging evidence from a small but emerging set of experimental studies has also demonstrated that training older students (middle school through college) that their intelligence can be developed significantly improves grades and lowers drop-out rates (Aronson, Fried, & Good, 2002; Blackwell et al., 2007; Good, Aaronson, & Inzlicht, 2003; Paunesku et al., 2015). In one longitudinal study of elementary students in grades 3-6, mindset was linked to the development of normal curve equivalent (NCE) scores on the Iowa Test of Basic Skills such that the grow rate in math NCE scores was moderated by mindset scores. No significant relation was observed between mindset and reading outcomes (McCutchen, Jones, Carbonneau, & Mueller, 2016).

Limitations of Current Literature

Despite the corpus of literature that presently exists on mindset and its relation to educational outcomes, there are several gaps that remain. First, few studies on the relation between mindset and education outcomes in the elementary grades have been published. Such findings could be important during this critical time when students' reading and math skills are rapidly developing. A unique relation of mindset to these outcomes might inform when students begin to develop their understanding of intelligence and if this understanding could be malleable with early intervention.

Second, the literature base tends to focus on mindset relations to general academic achievement such as school grades and grade point average (Aronson, Fried, & Good, 2002; Dweck, 2008), with virtually no research evaluating mindset's relation to standardized measures of academic achievement. The few exceptions are Good et al. (2003) who used scores on a

statewide school-administered math assessment and found that students in the mindset training group showed significantly increased math scores relative to students in a control group and the work described earlier by McCutchen et al. (2016)

Third, few studies have focused on reading outcomes, which is problematic given that many students exit elementary school struggling to read and comprehend grade level texts. By and large students with the most persistent problems are not catching up to their proficient peers. Consequently, some children who do not respond to reading intervention display emotions of hopelessness and shame (Greulich, et al., 2014). Greulich et al. found that these students did not believe that perseverance could improve their reading and they acted out or avoided difficult tasks. Related to this third gap, exploring mindset's relation to standardized reading outcomes may hold promise for future intervention and individual differences research. However, traditional mindset survey items have focused on general intelligence and no published studies have examined students' growth mindset as it relates to a content specific academic domain like reading. Specifically, none of the studies to date have explored whether aspects of mindset pertaining to reading items would correlate more strongly with measures of reading comprehension.

Finally, a fourth gap in the literature is a need for measurement and psychometric work on mindset surveys. The importance of such efforts has recently been underscored by Duckworth and Yeager (2015). To date, no published studies have used confirmatory factor analysis to examine the factor structure or psychometric quality of items from various mindset surveys. Because the literature purports that theory of intelligence and mindset may be comprised of incremental theory (i.e., fixed/growth mindset), learning goals, and effort beliefs (Blackwell et al., 2007) as both unitary and multidimensional constructs, the measurement around mindset is,

at times, convoluted by its differential operationalization in measurement across studies. For example, Blackwell and colleagues (2007) used items from Dweck's theory of intelligence scale along with items from the Patterns of Adaptive Learning Survey, and author-developed items on effort beliefs and this survey is used as part of their research on Brainology™. Separately, Paunesku et al. (2015) used only two items from the theory of intelligence scale to measure mindset.

Despite the lack of strong psychometric evidence for the measures, growth mindset and associated constructs like joy and grit have emerged in popular outlets such as the New York Times (e.g., Zernike, 2016) and TED talks with over 8 million views (Duckworth, 2013), emphasizing the potential for positive psychology or socio-emotional skills to influence students' resilience. Indeed many schools have begun to teach social emotional learning, and books in the popular press emphasize the value of teaching children these skills (e.g., Duckworth, 2016). The convergence of popular media attention with these identified gaps in the literature underscores the importance of both extending previous work on older populations down to elementary school, and evaluating how a growth mindset about intelligence may be related to key cognitive achievement outcomes like reading.

Study Purpose

Therefore, we proposed three research aims in this study to extend and contribute uniquely to the literature. First, we evaluated the psychometrics of mindset as measured by Blackwell et al., 2007 via reliability and factor analysis for fourth-grade students. Relatedly, we added reading-specific items to evaluate whether they would make a unique contribution. Second, structural equation models tested the direct relation of latent growth mindset factor(s) to reading comprehension and word reading factors as well as whether a unique relation of mindset

to reading comprehension existed controlling for word reading. Third, we explored whether the structural relations were stronger or weaker based on students' reading comprehension ability.

Method

Participants

The participants for this study were 195 fourth-grade students in 6 public elementary schools in the southern United States; Female students made up 49% of the sample. This sample of schools were recruited for a larger project examining growth in reading comprehension for students who either score below the 30th percentile on reading comprehension or for students who were above the 30th percentile within relatively high needs schools. With regards to ethnicity, 66% of the students were identified as Hispanic. The racial composition of the sample was 25% African American, 43% Caucasian, 27% American Indian, 2% Asian, and 3% not reported. The vast majority (94%) of students in the sample were considered as low income, 58% were English learners, and 7% were identified as having a disability.

Measures

Growth Mindset. When we contacted the Brainology™ team, to request a copy of their measures, they provided us with the *Student Mindset Survey* (Blackwell et al., 2007) that is inclusive of 6 items from the Theory of Intelligence Scale (Dweck, 1999; original sample α = .78), 3 items of learning goals from the Patterns of Adaptive Learning Survey (PALS; Midgley et al., 1998; original sample α = .73 and .77), and 14 items on effort beliefs from Blackwell (2002; original sample α = .79 and .60). Because these items were written for an older participant pool, 13 of these 23 items were retained for the study (Table S1) as a number of the original items contained redundant wording. Of the selected 13 items to administer, four items were modified for language. Modifications were minor and included substituting words to be more

comprehensible for fourth graders (e.g., substituted “intelligent” for “smart” in items like: when I have to work hard at my schoolwork, it makes me feel like I am not very intelligent; no matter who you are, you can always change how intelligent you are). In addition, to assess students’ academic mindset about reading, 13 items were created that were analogous to the general intelligence items (e.g., Even if you’re not a good reader, you can always get better if you work hard). All 26 items (i.e., 13 items on general mindset and 13 items on reading mindset) were programmed and administered via SurveyMonkey. In order to orient students to the SurveyMonkey format and to help them understand the Likert scale, two sample items that were not part of the analyses were written and administered (i.e., I like cupcakes; I run fast). Students were asked to select one of six Likert-scaled responses options that remained constant across all items (disagree a lot, disagree, disagree a little, agree a little, agree, agree a lot). Through a series of psychometric analyses on the items (see supplemental online materials for associated description of edits and data reduction of scores), general mindset items were reduced from 13 items to 8 with $\alpha = .76$, and the reading mindset items were reduced from 13 items to 7 items with $\alpha = .74$.

Woodcock-Johnson III Tests of Achievement (WJIII; Woodcock, McGrew, & Mather, 2001. Students’ word reading ability was assessed via the word attack and letter-word identification subtests. Word attack is a pseudoword test that measures students’ decoding skill; letter-word identification requires students to name individual letters, and read real words presented. Reading comprehension was partly measured by the passage comprehension subtest. This subtest utilizes a cloze procedure wherein students are presented with several sentences with a missing word(s), and students are asked to supply the missing word. Test-retest reliabilities for the three subtests range from .81-.86 for fourth grade. Median concurrent

validity correlations for the passage comprehension are reported as .62 and .79 with the reading comprehension subtests from the Kaufman Test of Educational Achievement and the Wechsler Individual Achievement Test, respectively.

Gates-MacGinitie Reading Test (**GMRT; MacGinitie et al., 2006**). The GMRT is a group-administered, norm-referenced test. The reading comprehension subtest was administered. Students are presented with multiple paragraph-length reading passages and related multiple-choice questions. Passages include both narrative and expository text. Test-retest reliabilities are above .85; alternate-form reliability is .86 for the fourth grade level.

Test of Silent Reading Efficiency and Comprehension (TOSREC; Wagner, Torgesen, Rashotte, & Pearson, 2010). The TOSREC is a brief group-administered, three minute normed assessment designed to measure reading comprehension. Students are asked to silently read short sentences and determine if each statement is accurate by responding yes or no. Fluency, or efficiency in reading of connected texts for comprehension is then determined based on the responses. The average standard score for the TOSREC is 100, with an SD of 15, and the alternate-forms reliability is .86 for fourth grade.

Procedure

Over a three and a half week period of time, trained research staff administered the reading assessments to students in a quiet area of their schools. The staff also administered the Mindset survey using the online survey platform SurveyMonkey. Members of the research team read standardized instructions aloud the students, then read each item aloud as the students read along silently. The first set of items consisted of practice prompts designed to ensure participants understood the survey format and response patterns. In case any students had struggled with the online format or use of the mouse or keyboard, teams were provided an identical paper version

of the survey. Participants took approximately 10 minutes to complete the survey, and no students elected to or were identified as needing the paper version. Because researchers were present to read all items and response options aloud, students were encouraged not to work ahead of the small group and, thus, completion times had little variability.

Data Analyses

We used a combination of confirmatory factor analysis (CFA), structural equation modeling (SEM), and quantile regression in the study. CFA was first used to test the factor structure of the items from the modified student mindset survey along with the developed reading mindset items (see supplemental online materials for more details). Figure 1 displays three configurations that increase in complexity from both theoretical and statistical perspectives. The first model tested was a single factor model whereby all items were best described by one latent construct, a global growth mindset (GGM), that characterized the reading and general growth mindset items. Figure 1b expands the unidimensional perspective by specifying that items may load on one of two correlated variables. Each construct in Figure 1b describes a set of items reflecting either general growth mindset (i.e., based on the original/edited set of items taken from Blackwell et al. (2007) or reading growth mindset (i.e., new items describing student mindset related to reading). Lastly, a bi-factor model was considered (Figure 1c). The bi-factor model (DeMars, 2013, Reise, Moore, & Haviland, 2010) incorporates theoretical perspectives from both Figures 1a and 1b whereby each item is related to an item-specific construct (i.e., the general or reading growth mindset items) as well as a global construct reflecting the commonality in general and reading growth mindset. Note that the factors in the bi-factor model, unlike those in Figure 1b, are uncorrelated. This feature is typically inherent to the structure of bi-factor models (Reise, Moore, & Haviland, 2010). Fit from the factor models was evaluated

using the comparative fit index (CFI) and Tucker-Lewis index (TLI) where values > .95 are acceptable, as well as the root mean square error of approximation (RMSEA; < .10 acceptable). Following the selection of the most appropriate structure for growth mindset items, a full CFA was tested that included the mindset items and multiple assessments of reading comprehension (WJ-III Passage Comprehension, TOSREC, and GMRT) and word reading (WJ-III Word Attack and Letter-Word Identification). Structural equation modeling (SEM) then tested specific effects: 1) the relation between growth mind factor(s) and reading comprehension, 2) the relation between growth mindset factor(s) and word reading, and 3) the unique relation of growth mindset factor(s) to reading comprehension when controlling for word reading skills.

The third research question in the study was concerned with the extent to which relations between mindset and reading scores varied according to one's reading level. Models such as SEM are not well equipped to test for such relations as they are rooted in a conditional mean framework. It is plausible that mindset might demonstrate stronger, weaker, or consistent relations to reading comprehension at other points of the conditional distribution of reading comprehension. For example, for individuals who are at the lower portion of the conditional distribution of reading comprehension, mindset may be more strongly related to lower reading comprehension whereas a weaker relation between the two constructs might exist at the upper portion of the reading comprehension conditional distribution. Testing such hypotheses are not explicitly plausible using conditional means models (e.g., ordinary least squares, SEM, traditional mixed modeling) as estimation and practical issues are raised when attempting to probe differential relations using methods such as decile analysis on the outcome (e.g., restricted data range and sample size; Petscher, 2016).

Evaluating heteroscedastic relations between predictors and outcomes can be done via quantile regression. Quantile regression is considered to be a special case of conditional median regression (Koenker & Bassett, 1978; Petscher & Logan, 2014) such that it may be used to test for relations between variables at points other than the conditional mean. Although quantile regression cannot be used in a latent variable framework, we opted to use estimated factor scores from the best fitting CFA model. An important analytic consideration that was first tested was the level of factor score determinacy. That is, factors from a latent variable model and estimated factor scores are not identical constructs. The latter is designed to approximate the former when the two are highly correlated. Estimated factor scores are known to be influenced by both the reliability of the observed measures as well as the level of missing data (Estabrook & Neale, 2013), to the point that the means, variances, and correlations of the estimated factor scores may be different from the factor model itself (Lawley & Maxwell, 1971). The appropriateness of using estimated factors in the present study was evaluated in a two-fold manner. First, the factor score determinacy index (i.e., correlation between the estimated factor score and the factor) was estimated. Values of at least .90 were considered as sufficient to suggest that the estimated factor score could be used in the quantile regression as a correlation of .90 is very strong. Second, the correlations between the two latent reading-related measures (i.e., word reading and reading comprehension) were evaluated from the SEM and when using the estimated factor score. If the correlation matrices approximated each other well, this provided converging evidence that the correlational structure was well preserved in the estimated factor scores from the original model. Following this sequence of testing, quantile regression was run retesting the unique effect of mindset construct(s) to reading comprehension controlling for word reading.

Results

Preliminary Analyses and Missing Data

Descriptive statistics and correlations are reported for the sample in Table 1. A preliminary review of data for missingness across the measures showed that a maximum of 3% of data were missing across measures. Little's test of data missing completely at random (MCAR) was supported [$\chi^2(10) = 6.52$, $p > .500$], suggesting that the mechanism by which data were missing was ignorable. Both multiple imputation and maximum likelihood estimation procedures are useful techniques for treating MCAR data; however, because quantile regression implements listwise deletion for missing data, multiple imputation was selected for use on the full sample with 100 total imputations. Means from the observed measures reflected a low-achieving sample compared to a normative population; means on all of the WJ-III tasks presented with standard scores less than 100 and the GMRT reading comprehension scores were also lower than the mean for the normative population for this age group. Correlations among the variables ranged from moderate ($r = .35$ between Mindset with both the GMRT reading comprehension) to strong ($r = .79$ between WJ-III word attack and letter-word identification).

Reliability and Factor Structure of Mindset

Preliminary item analysis suggested that several items could be removed to improve scale reliability (see supplemental materials, Table S3). From the initial 26 administered items (13 general mindset and 13 reading mindset), 11 items were deleted (5 general mindset items and 6 reading mindset items) leaving 15 items (8 general mindset items and 7 reading mindset items). Overall scale reliability for the reduced set of items (see supplemental materials Table S1 for actual items) was estimated at $\alpha = .76$, along with $\alpha = .76$ for the general mindset items and $\alpha = .74$ for the reading mindset items.

The factor model fit to the mindset items was the single-factor model (Figure 1a). Fit for this model was poor [$\chi^2(77) = 334.84$, CFI = .54, TLI = .45, RMSEA = .131 (.117, .146)], as was fit from the correlated two-factor model [Figure 1b; $\chi^2(76) = 123.15$, CFI = .92, TLI = .90, RMSEA = .056 (.037, .074)]. Conversely, the bi-factor model (Figure 1c) provided excellent fit to the data [$\chi^2(63) = 83.63$, CFI = .96, TLI = .95, RMSEA = .041 (.007, .063)], fitting statistically better than the two-factor model ($\Delta\chi^2 = 39.52$, $\Delta df = 13$, $p < .001$), and suggesting that growth mindset as assessed in this sample was not unidimensional, but rather best represented by a global growth mindset (GGM) construct with specific constructs related to general- and reading-based mindset. A full CFA including the latent mindset structure, reading comprehension, and word reading was fit to the data with results suggesting acceptable model fit [$\chi^2(131) = 162.54$, CFI = .97, TLI = .96, RMSEA = .035 (.011, .052); see Table S4 for factor correlations].

Structural Equation Models

Following the CFA testing, reading comprehension and word reading factors were set as outcomes to evaluate the standardized relation between the general and specific factors of mindset with the reading outcomes. In order to test the unique relations of the growth mindset factors, a set of three SEMs were used that differentially constrained paths from the growth mindset factors to the reading outcomes. Model 1 in this set freely estimated the path of GGM to reading comprehension and word reading while also constraining the paths of the general and reading mindset paths to 0 [$\chi^2(153) = 192.78$, CFI = .96, TLI = .95, RMSEA = .037 (.017, .052)]. Model 2 tested for the unique relation of reading mindset above that of GGM in Model 1 by freeing the path constraints from the reading mindset factor to reading outcomes [$\chi^2(151) = 185.27$, CFI = .97, TLI = .96, RMSEA = .035 (.014, .051)]. Model 3 tested for an additional unique path of general mindset above GGM and reading mindset by freeing the constraints from

the general mindset factor to the reading outcomes [$\chi^2(149) = 182.01$, CFI = .97, TLI = .96, RMSEA = .034 (.010, .050)]. The comparisons among these models indicated that Model 2 fit statistically better than Model 1 ($\Delta\chi^2 = 7.51$, $\Delta df = 2$, $p = .023$); the freed path from general mindset in Model 3 did not improve model fit ($\Delta\chi^2 = 3.26$, $\Delta df = 2$, $p = .196$). Figure 2 shows the standardized results for Model 2; GGM strongly predicted student differences in both latent reading comprehension (.93) and word reading (.76) outcomes, with reading mindset adding a moderate unique effect for both reading comprehension (.35) and word reading (.32). The combination of GGM and reading mindset resulted in 99% of the variance in reading comprehension explained, along with 67% of the variance explained in word reading.

The secondary set of SEMs tested the unique relation of mindset to reading comprehension controlling for word reading. These analyses repeated the model building process from the last set whereby four models were specified, each with differentially freed and constrained paths for estimation. Model 1 tested the direct effect of word reading on reading comprehension while constraining the paths from the mindset factors to reading comprehension at 0 along with the covariances between word reading and the mindset factors at 0 [$\chi^2(137) = 221.13$, CFI = .91, TLI = .89, RMSEA = .056 (.041, .070)]. Model 2 freed the constraints of GGM on reading comprehension and the covariance between GGM and word reading [$\chi^2(135) = 177.60$, CFI = .96, TLI = .95, RMSEA = .040 (.021, .056); $\Delta\chi^2 = 43.53$, $\Delta df = 2$, $p < .001$]. Model 3 additionally freed the constraints of reading mindset predicting reading comprehension and covarying with word reading [$\chi^2(133) = 167.37$, CFI = .97, TLI = .96, RMSEA = .036 (.014, .053); $\Delta\chi^2 = 10.23$, $\Delta df = 2$, $p = .006$], and Model 4 freed the similar general mindset paths [$\chi^2(131) = 162.54$, CFI = .97, TLI = .96, RMSEA = .035 (.011, .052); $\Delta\chi^2 = 4.83$, $\Delta df = 2$, $p = .089$]. Because the freed constraints in Model 4 did not result in a better fitting model, Model 3

was selected for the presentation of results (Figure 3). The results reflected a moderate, unique relation of GGM to reading comprehension (.43) controlling for the effects of word reading (.52), as well as a small, unique relation of reading mindset to reading comprehension. Note that in addition to these direct effects, word reading was positively correlated with GGM (.53) and reading mindset (.37), but had a 0 relation with general mindset in keeping with the model constraint. By including both GGM and reading mindset as predictors of reading comprehension, 15% unique variance was explained in reading comprehension skills above that of word reading (i.e., 67% variance explained) for a total of 82% variance explained in reading comprehension by the combination of the predictors.

Quantile Regression

Though findings suggested that global growth mindset and reading mindset uniquely related to reading comprehension when accounting for word reading skills, the magnitude and importance of the effects are contextualized under the auspices of *average* relations. That is, at the conditional mean of reading comprehension, GGM had a moderate, unique relation and reading mindset had a small, unique relation in explaining differences in reading comprehension. Individual differences in reading skills and, more specifically, a concern for students struggling to read motivated an evaluation of whether the relations between mindset and reading comprehension varied as a function of the conditional distribution of reading comprehension. This evaluation necessitated the use of quantile regression. As previously noted, it was first important to evaluate the factor score determinacy for the quality of estimated factor scores resulting from the CFA. Determinacy scores were found to be quite strong for the sample (i.e., .95) suggesting a very strong association between the factors from the CFA and the estimated factor scores. Further, a review of the correlation matrices (see supplemental materials Table S4)

demonstrated a strong correspondence in magnitude between the CFA and estimated factor scores relations. Given the quality of the estimated factor scores via the determinacy and correlations, it was deemed reasonable to use the scores in the quantile regression. To facilitate interpretation of the results, the GGM, reading mindset, word reading, and reading comprehension factor scores were standardized. Figure 4 displays the results for the testing of the unique role of mindset controlling for word reading. The four quadrants of the graph illustrate the conditional relation between each of the predictors with reading comprehension, along with the intercept. The *x*-axis of each quadrant in Figure 4 represents the quantile, which is conceptually similar to a percentile, for the estimated, conditional factor score of reading comprehension (e.g., .20 quantile ~= 20th percentile). The *y*-axis is the range of coefficients for the standardized relation between the variable of interest (i.e., word reading, GGM, and reading mindset) with reading comprehension. The dark line is the estimated coefficient for the relation between each variable and reading comprehension at each quantile, and the shading is the confidence interval around each coefficient. Lastly, the solid horizontal line reflects the estimated standardized coefficient resulting from an ordinary least squares (OLS) multiple regression. When considering the word reading-reading comprehension relation at the .50 quantile on the *x*-axis, the coefficient is.46, a value that approximates what was estimated in the SEM (i.e., .52; Figure 3). This comparison demonstrates a property of quantile regression. Specifically, when data are normally distributed with constant variance, the expectation is that the mean is equal to the median value. As such, the results between a conditional mean model (such as multiple regression or SEM) should closely approximate a result from a conditional median/quantile regression model. The lack of strict equality between the SEM and the analysis of estimated factor scores may be attributed to factor score indeterminacy (i.e., the factor score

determinacy was not 1.0).The quantile plot in Figure 4 shows that for word reading, the relation between word reading and reading comprehension is fairly consistent both between quantile regression and OLS (i.e., ~.48)., as well as across the conditional distribution of reading comprehension Although it may be seen that the relation between word reading and reading comprehension varies slightly across the quantiles of reading comprehension, these differences are not statistically differentiated. That is, the weakest relation between word reading and comprehension is observed at the .60 quantile (.43) and the strongest relation at the .90 quantile (.54), but magnitude of this difference in coefficients is not reliable [$\chi^2(1) = 2.09$, $p = .079$] although there may be a small, practically important difference ($\phi = 0.12$).

Conversely, the relation between GGM and reading comprehension (Figure 4) appeared to vary across the conditional distribution of reading comprehension. For children at lower levels of reading comprehension, the standardized relation between GGM and comprehension was stronger (e.g., .62 at the .25 quantile) compared to a weaker association for children at higher levels of reading comprehension (e.g., .48 at the .75 quantile). A statistical comparison between the .25 and .75 quantiles suggested that the GGM-reading comprehension relations were reliably distinguished from each other as a moderate effect size [$\chi^2(1) = 12.65$, $p < .001$, $\phi = 0.25$]. This finding suggests that global growth mindset is a more robust, reliable predictor of poor reading comprehension compared to good reading comprehension skills when controlling for word reading and reading mindset.

When accounting for the relations of word reading and GGM to reading comprehension, reading mindset also demonstrated varying relations with reading comprehension. However, compared to GGM that showed stronger relations for students with lower levels of comprehension, the unique effect of reading mindset was strong for students with higher levels

of reading comprehension. At the .25 quantile of reading comprehension, the standardized relation between the constructs was .16 compared to a coefficient of .22 at the .75 quantile. Although this difference is not statistically differentiated [$\chi^2(1) = 3.81$, $p = .051$], a small effect size difference exists ($\phi = 0.14$) in estimation, suggesting that reading mindset may hold greater predictive power for individuals with stronger versus weaker reading comprehension skills controlling for GGM and word reading.

Discussion

The purpose of this study was to understand the dimensionality of mindset and its relation to reading outcomes. Results suggested that rather than one global factor, or even separate correlated factors, a more complex structure to the mindset items was observed. First, a factor of global growth mindset was estimated that describes mindset pertaining to both general and reading skills. Second, specific factors also emerged including general growth mindset regarding basic abilities, intelligence, and talents, and reading-specific growth mindset that was distinctive to general mindset in the content area of reading learning and achievement. It was further found that students' global growth mindset and reading mindset were positively and significantly related to their achievement in reading comprehension and word reading.

This study is the first to examine the structure of the mindset survey developed (Blackwell et al., 2007) and the first to extend the work to test for content-area mindset in elementary students. Importantly, scores from the reduced item-set held together reliably and demonstrated reasonable internal consistency for measuring the same characteristic. The resulting bi-factor structure further suggested that a mindset dimension specific to the content area of reading can also be measured reliably and accounts for unique variance in mindset.

Future research into content-area specific mindset domains could provide valuable information for determining effective content area interventions for students.

The finding that global growth mindset and reading mindset are significantly related to reading comprehension over and above students' word reading achievement may demonstrate the importance of the mindset construct to reading achievement. Prior research has noted the relation between students' mindset and their general achievement (e.g., Blackwell et al., 2007; Yeager & Dweck, 2012) and their mindset to self-regulation (Burnette et al., 2013). Two studies have also noted that students' mindset may be related to increased math scores on a statewide standardized test (Good et al., 2003; McCutchen et al., 2016). However, ours is the first study to find a unique relation of mindset and content-specific mindset to standardized, reading specific measures. We found that students who have lower reading comprehension achievement at the end of fourth grade also tend to have a more fixed mindset about their abilities. Part of students' reading comprehension achievement is explained by their word reading abilities, but both global mindset and reading-specific mindset continue to uniquely and significantly predict reading comprehension achievement even when these word reading abilities are taken into account. This unique concurrent relationship suggests additional research examining the predictive relationship of mindset to future reading achievement is warranted and could provide possible intervention targets for incorporating student mindset in students' reading instruction.

We also examined whether the relation between mindset and reading achievement differed according to student reading ability levels. In general, there was some indication that the reading mindset-reading achievement relation was stronger for students with higher reading comprehension achievement while the relation between global mindset and reading comprehension was stronger for students with lower reading comprehension achievement. Thus,

for the lowest performing students, a stronger global growth mindset regarding their abilities may be necessary to have the grit and perseverance needed to persist when progress in reading is challenging. Students with a fixed mindset, by contrast, may feel that effort and practice will not improve their reading ability or help them catch up to their peers; but, by contrast, if their mindset is malleable, these students may learn to persevere, and through effortful practice, their performance could improve. Alternatively, at higher levels of reading achievement, a stronger reading specific mindset may be needed for motivation to improve further In fact, previous research has demonstrated that students who are gifted who have a fixed mindset can lose interest in further learning and may benefit from instruction in growth mindset (Esparza, Shumow, & Schmidt; Haimovitz, Wormington, & Orpus, 2011). The findings in this study are timely in light of the interest in mindset within popular culture (e.g., Duckworth, 2016; Zernike, 2016) and the findings hold promise for future research in the study of individual differences in educational and psychological outcomes, as well as for experimental studies.

Limitations

We acknowledge that our findings and recommendations are limited in a number of ways. A larger sample size would enhance and give greater stability to the findings. Importantly, by design, the sample was comprised of a diverse, but mostly low-SES students with average word reading skills but a majority had poor reading comprehension. The average performance for students in this study on the GMRT Reading Comprehension assessment corresponded to the 33rd normative percentile, along with approximately one standard deviation below the mean on the WJ-III Passage Comprehension. Both the mean relations found in the SEM and the quantile regression results should be understood in the light of a poor comprehenders sample while still acknowledging that a distribution of scores existed in the sample (i.e., 1st to 62nd percentiles

within one standard deviation of the GMRT mean). Another limitation is that even as our findings shed light on the relations between mindset and reading, they do not speak to causal relations. Pertaining to the student mindset surveys, the reduction of items from the original survey may have implications for the construct validity of scores that deviate from the authors' original assessment. Further, as the reading mindset survey was created for this study, research is needed to validate the scores. The use of estimated factor scores in the quantile regression necessitates the caveat that factor score indeterminacy precludes an exact correspondence between factors and the factor scores; thus, the estimated relations may be biased proportional to the indeterminacy. Lastly, the role of omitted variable bias in this study is such that the strength of mindset may weaken in the presence of other cognitive and non-cognitive traits that were not part of this study.

Implications and Conclusions

That mindset is multidimensional and maintains moderate predictive relations has implications for the malleability of growth mindset related to reading outcomes for elementary students. Yet, we are cautious in our interpretation of the results to not jump on a bandwagon that may suggest resources should be allocated to interventions to remediate mindset in lieu of those effective interventions that address the important component skills of reading comprehension. The understanding of the malleability of global and reading mindset for elementary students is in a stage of infancy. With calls being made that educational policy in the United States should take advantage of mindset interventions to improve educational achievement (Rattan, Savani, Chugh, & Dweck, 2015), it is imperative that how mindset relates to reading is better understood. As such, future research may extend this work in a number of areas. First, replication of the findings across multiple grade levels is important. The extent to

which mindset may uniquely relate could be conditional on the developmental nature of reading skills. Second, it will be important to understand how mindset as a construct may be similar to, or differentiated from related, specific non-cognitive constructs including effort, motivation, interest, and learning orientations. A broad literature base has explored the causal impact of non-cognitive interventions on reading outcomes including motivation (Guthrie et al., 2004), self-efficacy (Schunk, 2003), and learning skills (Hattie, Biggs, & Purdie, 1996). To the extent that mindset maintains psychometrically unique factor and construct validity has implications for ongoing non-cognitive intervention research.

Third, understanding whether there are clusters of students who present with varying types and reading and mindset skills and the extent to which such clusters can be explained by background or other characteristics may enhance our ability to better predict and explain individual differences in reading comprehension. Fourth, longitudinal studies could evaluate the co-development of mindset and reading skills to identify the extent to which one construct is a leading or lagging indicator of the other. Lastly it may be important to identify how mindset interventions may supplement reading interventions in comparison to reading-only interventions in relation to performance differences on standardized measures of reading.

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Table 1

Descriptive statistics and correlations among measures

	Variable	1	2	3	4	5	6
1	GMRT Reading Comp	1.00					
2	WJIII LWID	.54	1.00				
3	WJIII PC	.63	.72	1.00			
4	WJIII WA	.42	.79	.56	1.00		
5	TOSREC Raw	.65	.64	.64	.56	1.00	
6	Student Mindset Survey	.35	.49	.44	.42	.39	1.00
	Mean	467.35	96.99	88.50	98.42	25.78	129.50
	Std. Deviation	30.11	10.43	10.19	9.87	9.00	17.34

Note. GMRT = Gates-McGinitie Reading Test, WJIII LWID = Letter-Word Identification, WJIII PC = Passage Comprehension, WJIII WA = Word Attack. All correlations statistically significant $p < .001$

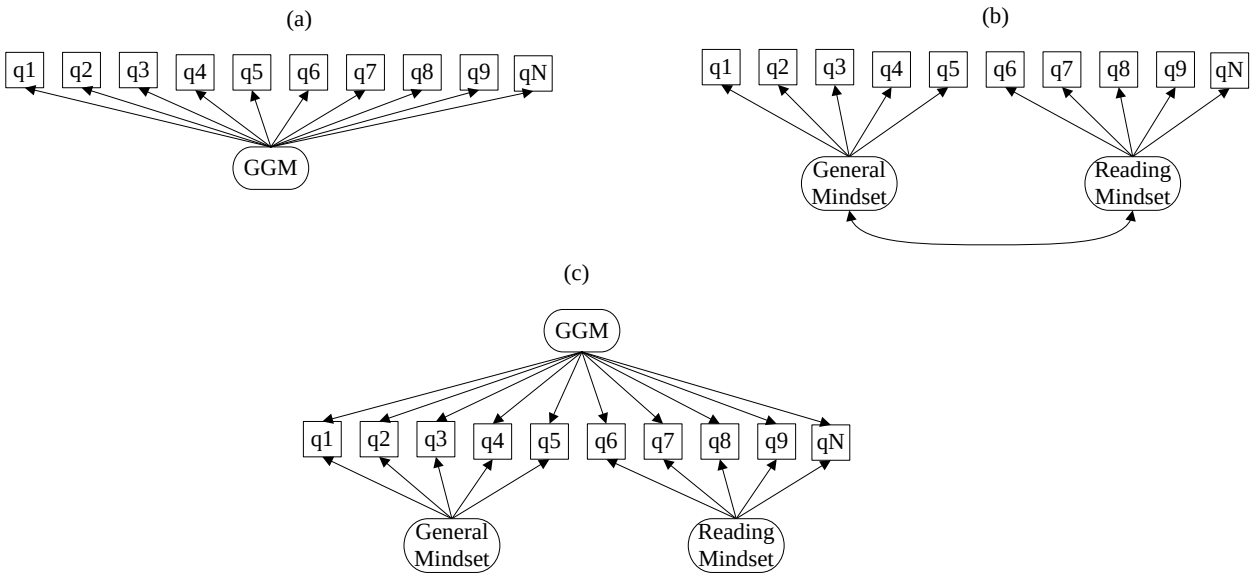

Figure 1. Confirmatory factor analysis model specifications for global growth mindset (GGM) including a) a single factor model, b) a correlated factor model of general and reading mindset, and c) a bi-factor model with a construct of global growth mindset (GGM) and specific constructs of general and reading mindset.

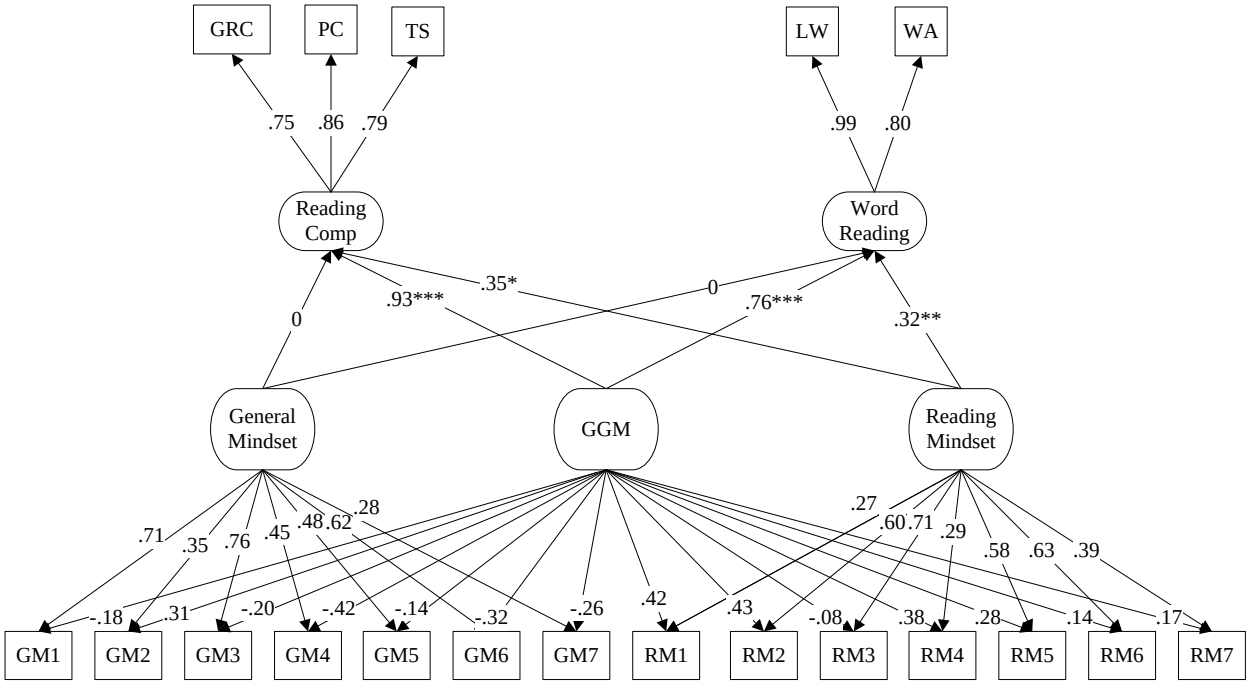

Figure 2. Structural equation model of global growth mindset (GGM) and reading mindset predicting reading comprehension and word reading outcomes.

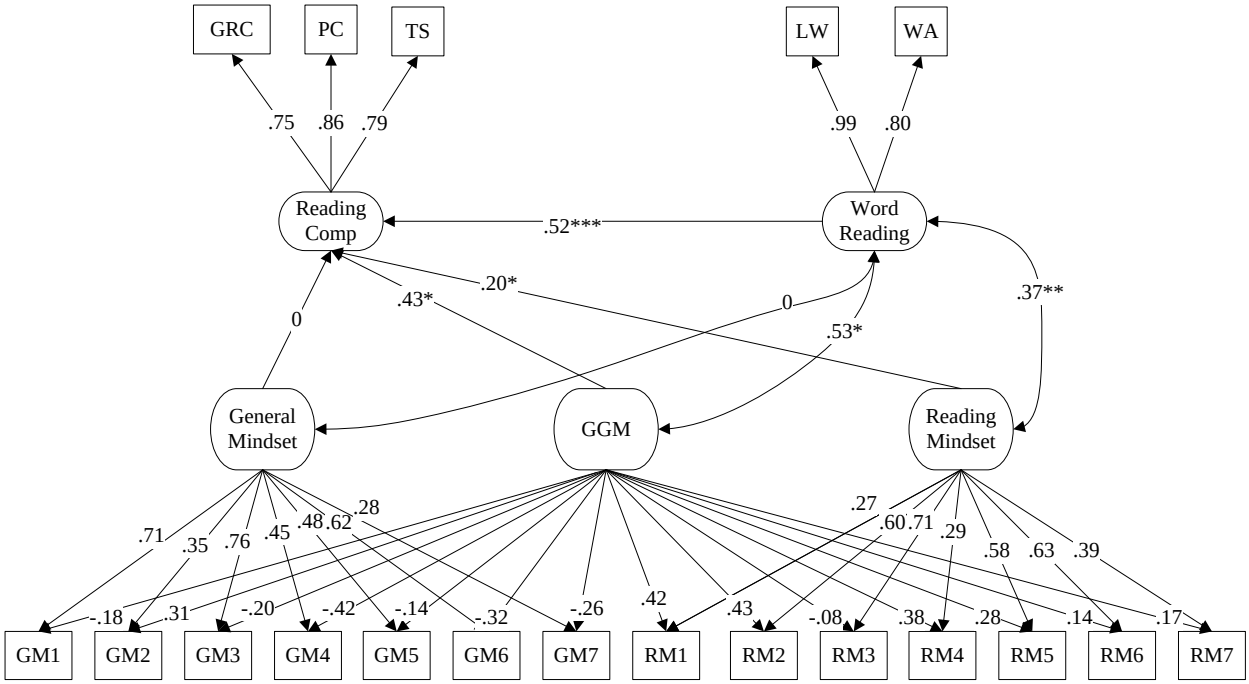

Figure 3. Testing the unique effect of global growth mindset (GGM) to reading comprehension when GGM relations are constrained to 0 (top figure) and freed for estimation (bottom figure).

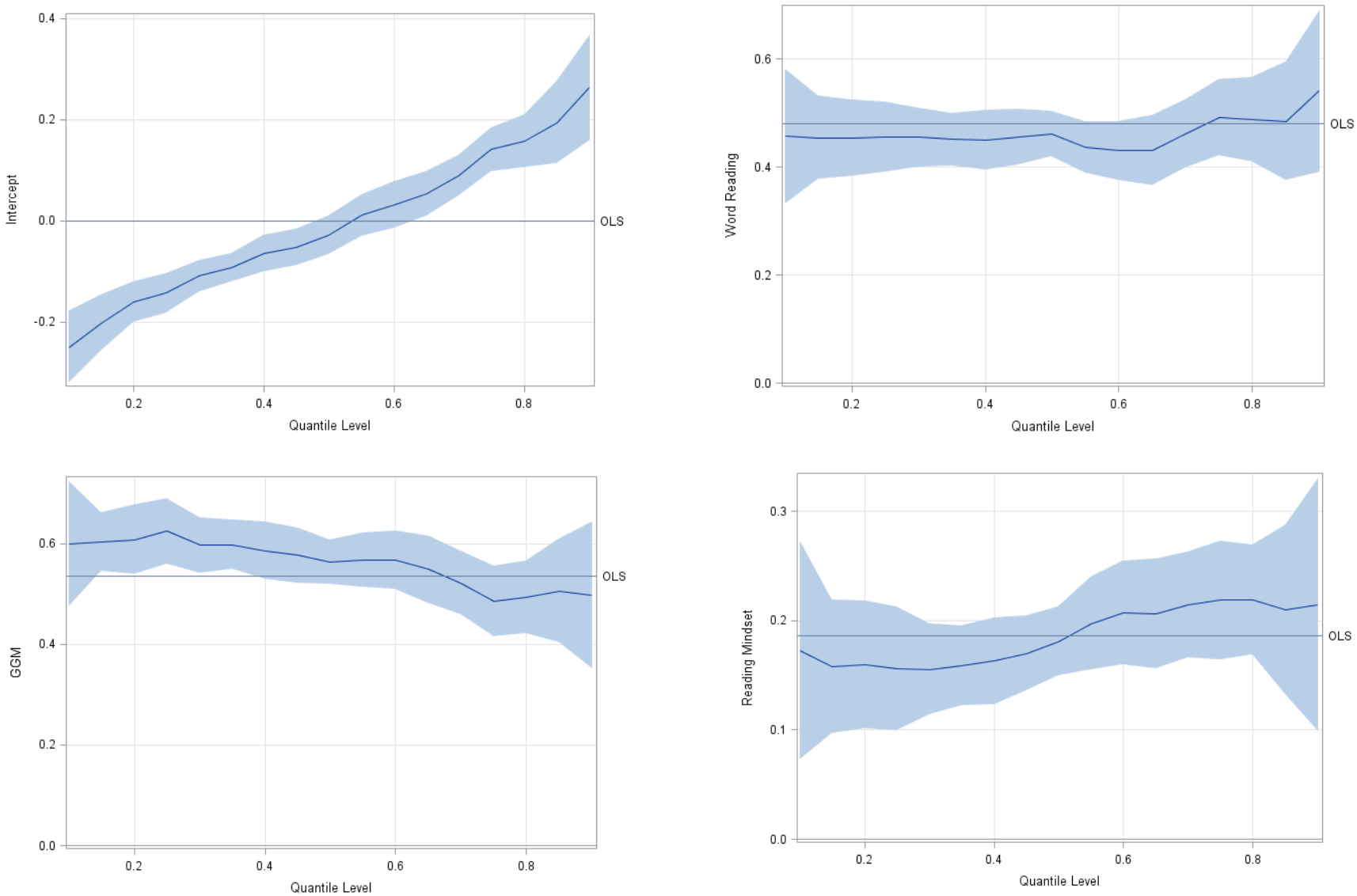

Figure 4. Quantile regression of estimated factor scores for the relation of word reading (upper right), global growth mindset (GGM; lower left), and reading mindset (lower right) to reading comprehension. OLS = oridinal least squares.