Intergenerational framework of math:
Disentangling parental contribution to children's word problem performance

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BACKGROUND

Children's math abilities are linked to an interaction of individual, biological, and environmental mechanisms[1]:

- Children's math calculation (**MC**) and oral language (**OL**) are associated with their word problem (**WP**) performance[2].
- Math disabilities are moderately heritable (43%)[3].
- Parents' level of educational attainment[4] and math skills[5] predict children's math abilities.

This study aimed to disentangle the effects of parents' math risk and environmental factors on known predictors (MC, OL) of WP outcome in children cross-sectionally (**RQ1**) and longitudinally (**RQ2**).

RQ1: Does parents' risk for math difficulties have direct and/or indirect effects on children's MC and OL and, in turn, WP, via environmental factors?

***H**: Parents' math risk will have direct and indirect effects via children's MC. Math- and literacy-related environmental factors will differentially relate to known predictors (MC, OL) of WP.*

RQ2: Does the extent to which parental factors contribute to child outcomes differ as children become older?

***H**: Similar pattern of direct effects will be present at both earlier and later grades; however, the magnitude of the parental factors' contribution to child outcomes will vary across time points.*

METHODS & APPROACH

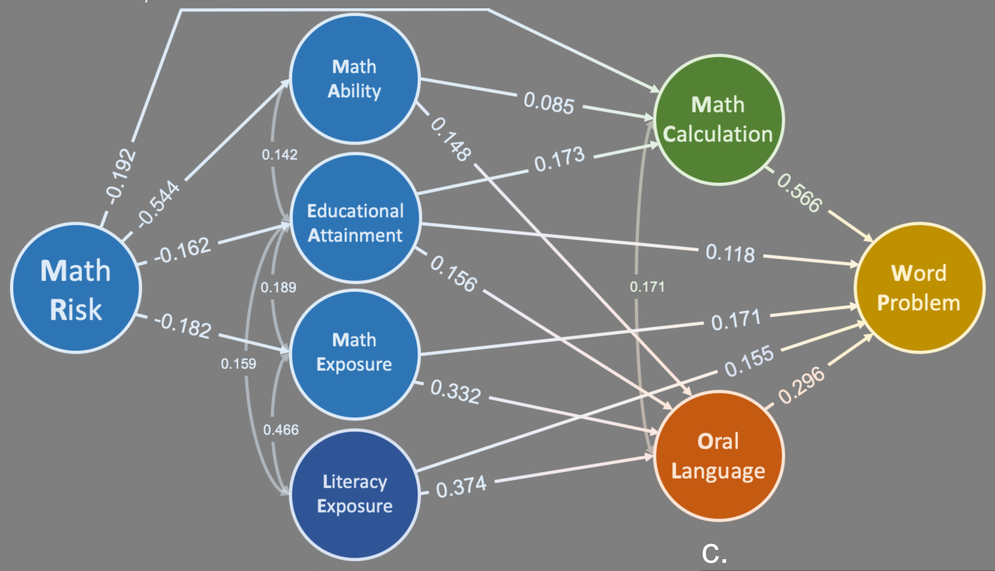
Children (***N*** = 183) [and their parents] were enrolled into the study after first grade; and completed annual visits after second (***n*** = 145 returned), third (***n*** = 128) and fourth grades (***n*** = 60).

- **RQ1:** data from all children were collapsed across *all* four visits.
- **RQ2:** data were grouped into 1st and 2nd visits (Early) versus 3rd and 4th visits (Late), focusing on children who visited ≥ 3 times.

CHILDREN	***N*** = 183 | ages (6.4–10.9) | 54% females	
Calculation	**Calculation** subtest	*Woodcock-Johnson*[8]
Oral **L**anguage	**Receptive Vocabulary** subtest **Morphological Awareness**	*Test of Word Knowledge*[9] *Test of Morphological Relatedness*[11]
Word **P**roblem	**Applied Problems** subtest	*Woodcock-Johnson*[8]
PARENTS	***N*** = 157 | ages (24.5–66.3) | 91% mothers	
Math **R**isk	[MR$_1$] "...difficulty learning new concepts in math..." [MR$_2$] "...needed extra help in math..." [MR$_3$] "...math skill compared to others..."; [MR$_4$] "...struggle with math in elementary school..."	*Adult Math History Questionnaire*[13*]
Math **A**bility	**Calculation** subtest **Math Fluency** subtest	*Woodcock-Johnson*[8]
Educational **A**ttainment	Highest Level of **Educational Attainment**	
Math **E**xposure	[ME$_1$] "...use math in everyday life..." [ME$_2$] "...I struggle with math tasks..." [ME$_3$] "...current work requires I use math..." [ME$_4$] "...completing math and logic puzzles..." [ME$_5$] "...helping child with math homework..."	*Adult Math History Questionnaire*[13*]
Literacy **E**xposure	[LE$_1$] "...reading for pleasure..." [LE$_2$] "...how many books..." [LE$_3$] "...how many magazines..." [LE$_4$] "...read daily newspapers..." [LE$_5$]"...read Sunday newspaper..."	*Adult Reading History Questionnaire*[11] *Title Recognition Test*[12]

RESEARCH QUESTION 1:

Note. All paths shown have $p < 0.05$.



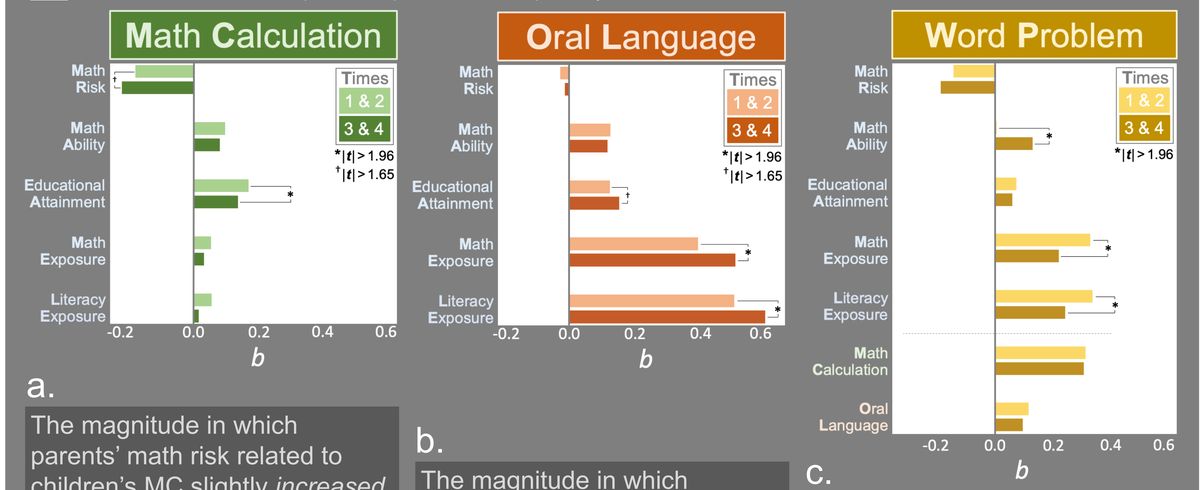
a. Parents' risk for math difficulties is negatively related to their math ability, educational attainment, and math exposure, but not literacy exposure.

b. Parents' math risk is negatively related to children's MC, but not OL. These relations are *indirectly* explained by other intermediate parental factors.

c. Parents' math risk is not directly related to children's WP, which could be explained by parents' educational attainment, math and literacy exposure, as well as children's MC and OL.

RESEARCH QUESTION 2:

Note. Two-tailed t = 1.65-1.96 is equivalent to p = 0.10-0.05, respectively.



a. The magnitude in which parents' math risk related to children's MC slightly *increased* as children reach later grades.

In contrast, the effect of parents' educational attainment *decreased* in children's MC.

b. The magnitude in which parents' educational attainment, as well as math and literacy exposure related to children's OL appeared to *increase* as children reach later grades.

c. Parents' math ability emerged as a significant predictor of children's WP in later grades, while the effects of math and literacy exposure *decreased*.

SUMMARY & CONCLUSION

Parents' math risk and related factors

Our findings confirmed that parents' early math difficulties could negatively impact their future math ability, educational attainment, and math-related activities (helping children with math homework; work-related math tasks)[4,6] [RQ1a].

There was no significant association between parents' math risk and their literacy-related exposure (reading for pleasure; familiarity with children's books) [RQ1a].

Parental effects on children's math calculation (MC)

Parents' early math difficulties were directly and negatively associated with children's MC [RQ1b]. This negative link could exacerbate as children reach later grades [RQ2a].

Accounting for the indirect impact of parents' math risk, their math ability and educational attainment, but not math or literacy exposure, were related to children's MC [RQ1b].

This suggests that children's MC may not be entirely explained by home environmental factors, but perhaps partly by other environmental factors, such as school instruction[7].

Cross-domain factors, children's oral language (OL)

While there was no direct impact of parent's math risk, their math ability, educational attainment, as well as math and literacy exposure all predicted children's OL [RQ1b]. Some of these associations appeared to increase overtime [RQ2b].

These results implicate cross-domain effects of math- and literacy-related environments in children's OL.

Intergenerational predictors of word problem (WP)

Parents' educational attainment, as well as math and literacy exposure predicted children's WP [RQ2c]. Parents' math ability was related to children's WP only in later grades, while the effects of math and literacy exposure decreased [RQ2c].

These could implicate shared biological and environmental effects of parents' math ability in children's WP outcome[1].

These relations between parental factors and WP in children could be mediated by children's MC and OL abilities[2] [RQ1c].

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