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The Effect of Language Interventions Aiming to Improve Students' Mathematics: A Meta-Analysis

NORSMA 2023
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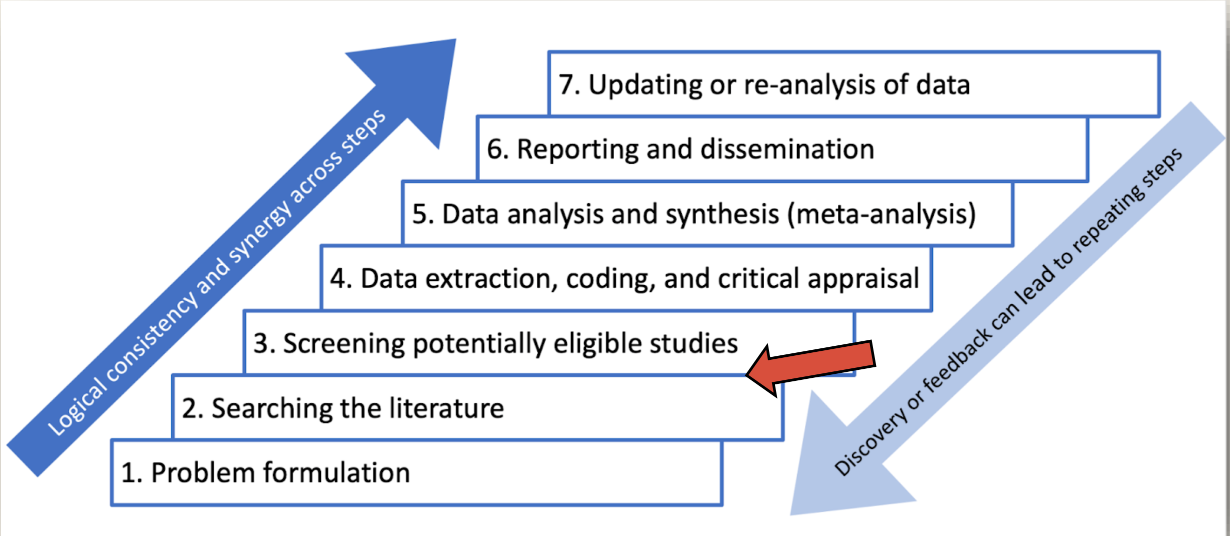
Overview

1. Background information
2. Definition: Language
3. Correlations between mathematics and language
4. Theories about the relationship
5. Language interventions implemented to improve mathematics
6. Research gap and research questions
7. The current study
8. Questions/feedback

Background information

- First article in my Ph.D.-project
- Authors: Nordbø, E., Lopez-Pedersen, A., Rønneberg, V., Melby-Lervåg, M., Solheim, O.J.
- Current stage: Searching
- Planned submission: Summer/Autumn 2025



Language

- Language comprehension skills
  - Receptive and expressive vocabulary (Lervåg et al., 2018)
  - Mathematics vocabulary
- Phonological processing skills
  - Phonological awareness
  - Phonological memory
  - Rapid automatized naming (RAN)
- Both are related to mathematics

Why language?

- Associations between domain-general abilities and mathematics*.

- We know less about the relationship between language and mathematics.
  - Increased attention the recent years.
  - Language is fundamental for school success.
  - Language difficulties are related to math difficulties.
  - Language supports students in connecting various mathematical representations.

** I.e., Chu , vanMarle, & Geary, 2016; Geary, 2011; Friso-van den Bos, van der Ven, Kroesbergen, & van Luit, 2013; Bull, Espy, & Wiebe, 2008; Alloway & Passolunghi, 2011; Peng, Namkung, Barnes, & Sun, 2016).*

Correlations - Language comprehension skills

- Language correlates with mathematics*.
- Language comprehension skills correlates stronger with higher-order mathematics (i.e., word problems)

Language skill	Correlation (r) with math	95% CI
Language in general	.42	.40, .44
Vocabulary	.42	.41, .45
Oral comprehension	.43	.39, .47
Comprehensive language	.51	.44, .57
Mathematics vocabulary	.49	.47, .51

*Peng et al., 2020; Yang et al., 2021; Lin et al., 2020; Koponen et al., 2017.

Correlations – Phonological processing

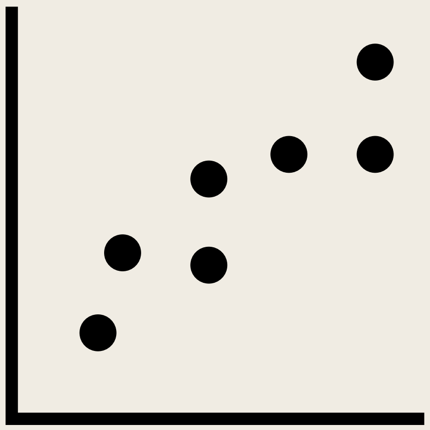
- Phonological processing correlates with mathematics.
- Longitudinal studies:
  - Contradictive findings*
  - PP does not seem to predict mathematics.

Language skill	Correlation (r) with math	95% CI
Phonological processing in general	.33	.30, .36
Phonological awareness	.38	.33, .42
Phonological memory	.28	.24, .31
Rapid Automized Naming	.35	.30, .39

*i.e., Amland et al., 2021; Durand et al., 2005; Fuchs et al., 2005; Purpura et al., 2011

Correlations – summary

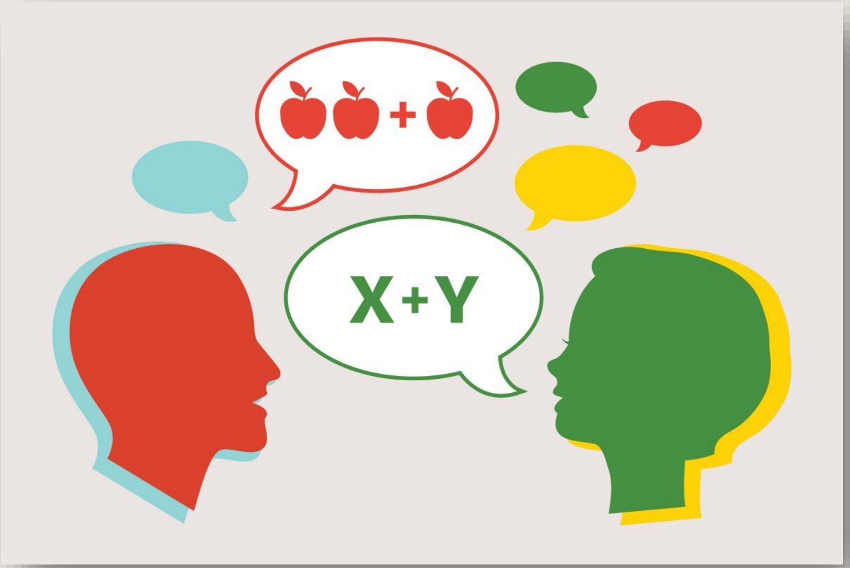
- Consensus about a correlation between language comprehension and mathematics.
- Various findings related to the correlation between phonological processing and mathematics.
- Mathematics is more related to comprehensive language skills.
- Language comprehension, PA, and PM: Higher-order mathematics and accuracy.
- RAN: lower-order mathematics and fluency.



Theories about the relationship (1)

Phonological processing*:

- PP: Provides available capacity for calculations.
- PA: Represent and manipulate basic math knowledge.
- PM: Facilitate WM and reasoning during math performance.
- RAN: Quick retrieval of math knowledge from LTM.

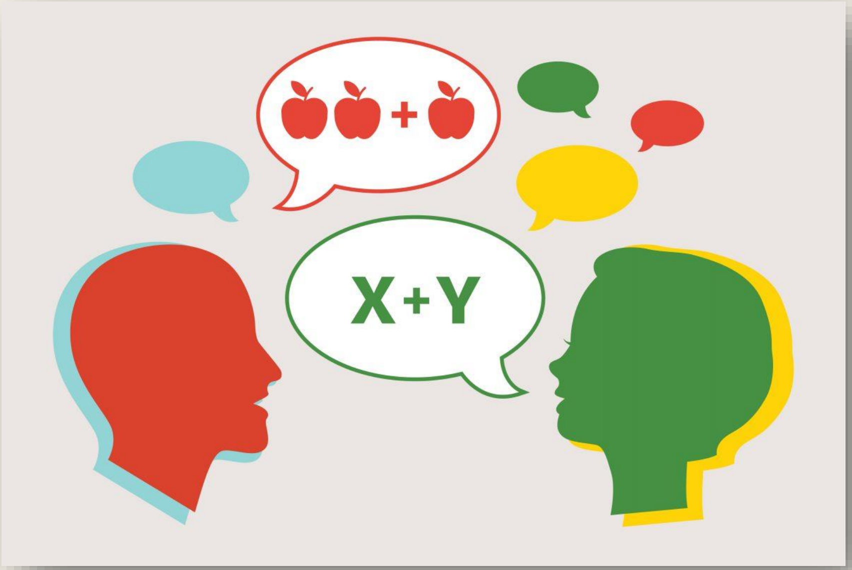


*Yang et al., 2021; Koponen et al., 2017

Theories about the relationship (2)

Language comprehension*:

- Communicate, represent, explain, and retrieve mathematics.
- Comprehend math instructions.
- Relate number names to quantities and numerals.
- Word-problem solving



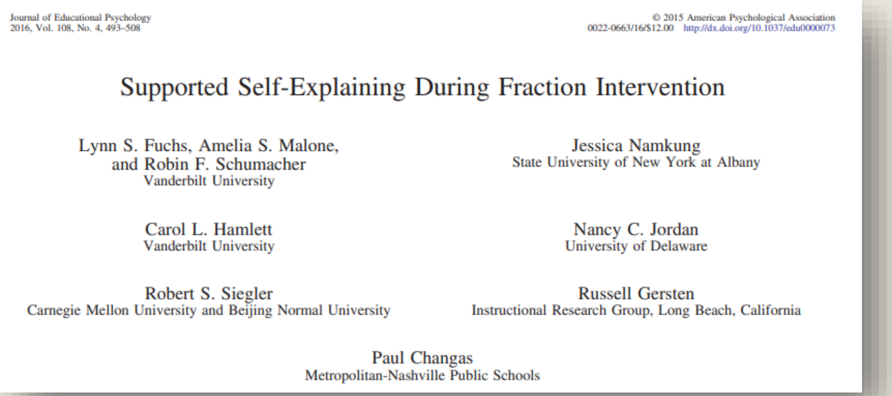
*Peng et al., 2020; Lin et al., 2020

Interventions

- Will intervening in language enhance students' mathematical achievement?
- Various findings:
  - Significant effects*
  - No effect**

* i.e., Ferraz et al., 2019; Fuchs et al., 2016, 2021; Purpura et al., 2017.
** i.e., Hassinger-Das et al., 2015; Jordan et al., 2012.

Fuchs et al., 2016: Supported Self-Explaining During Fraction Intervention


Journal of Educational Psychology
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Supported Self-Explaining During Fraction Intervention

Lynn S. Fuchs, Amelia S. Malone, and Robin F. Schumacher
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Vanderbilt University

Nancy C. Jordan
University of Delaware

Robert S. Siegler
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Russell Gersten
Instructional Research Group, Long Beach, California

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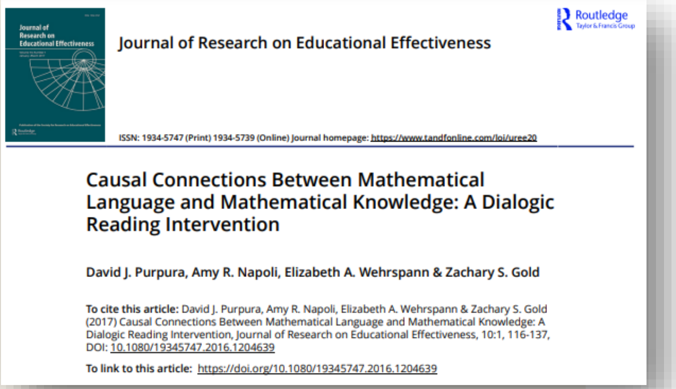
Metropolitan-Nashville Public Schools

- Aim: Test the effect of teaching students to provide high-quality explanations in a fraction intervention.
- Intervention
  - RCT, 212 at-risk students in 4th grade
  - 3 groups:
    - Control group (BAU)
    - Multicomponent fraction intervention with
      (A) an embedded practice of high-quality explanations when comparing fraction magnitudes, or
      (B) an embedded practice in solving fraction WP.
  - 36 lessons, 35 minutes each (7 min specific practice)
- Results:
  - Group A outperformed the other groups on accuracy of magnitude comparison and quality of explanations.
  - Group B outperformed the other groups on word problems.

Purpura et al., 2017: Causal Connections Between Mathematical Language and Mathematical Knowledge: A Dialogic Reading Intervention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Causal Connections Between Mathematical Language and Mathematical Knowledge: A Dialogic Reading Intervention

David J. Purpura, Amy R. Napoli, Elizabeth A. Wehrspann & Zachary S. Gold

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To link to this article: https://doi.org/10.1080/19345747.2016.1204639

- Aim: Investigate causal evidence on the association between mathematical language and mathematics.
- Intervention:
  - RCT, 47 preschool students (3-5 y/o)
  - Intervention group: 8 weeks (2-3 times a week, 15-20 minutes) with dialogic reading focused on quantitative and spatial math language.
  - Control group: BAU
- Results:
  - The intervention group outperformed BAU-group in math language and knowledge.
  - Increasing students’ exposure to mathematical language can affect mathematics.

Hassinger-Das et al., 2015: Reading stories to learn math

- Aim: Test whether a storybook intervention targeting mathematics vocabulary improves students' vocabulary and mathematics.

- Intervention:
  - RCT, 124 at-risk kindergarteners
  - 8 weeks (24 thirty-minute sessions)
  - Three groups:
    (1) Control group (BAU)
    (2) Storybook number competencies intervention (SNC)
    (3) Number sense interventions (NSI)
- Results:
  - SNC outperformed the other groups in mathematics vocabulary
  - SNC did not perform better on general mathematics measures.

HHS Public Access
Author manuscript
Elem Sch J. Author manuscript; available in PMC 2016 December 01.

Published in final edited form as:
Elem Sch J. 2015 December ; 116(2): 242–246. doi:10.1086/683986.

Reading Stories to Learn Math: Mathematics Vocabulary Instruction for Children with Early Numeracy Difficulties

Brenna Hassinger-Das[a], **Nancy C. Jordan**[a], and **Nancy Dyson**[a]
[a]School of Education, University of Delaware, Newark, Delaware, 19716, United States of America

Jordan et al., 2012: Building Kindergartners' Number Sense: A Randomized Controlled Study

- Aim: Test the effectiveness of a number sense intervention and a language intervention.

- Intervention:
  - RCT, 132 high-risk students
  - 8 weeks, 3 30-minute sessions per week.
  - Three conditions:
    - (1) Number sense intervention group
    - (2) Language intervention
    - (3) Control group (BAU)

Journal of Educational Psychology
2012, Vol. 104, No. 3, 647–660

0022-0663/12/$12.00 DOI: 10.1037/a0029018

Building Kindergartners' Number Sense: A Randomized Controlled Study

Nancy C. Jordan, Joseph Glutting, Nancy Dyson, Brenna Hassinger-Das, and Casey Irwin
University of Delaware

Math achievement in elementary school is mediated by performance and growth in number sense during kindergarten. The aim of the present study was to test the effectiveness of a targeted small-group number sense intervention for high-risk kindergartners from low-income communities. Children were randomly assigned to 1 of 3 groups ($n = 44$ in each group): a number sense intervention group, a language intervention group, or a business-as-usual control group. Accounting for initial skill level in mathematical knowledge, children who received the number sense intervention performed better than controls at immediate posttest, with meaningful effects on measures of number competencies and general math achievement. Many of the effects held 8 weeks after the intervention was completed, suggesting that children internalized what they had learned. There were no differences between the language and control groups on any math-related measures.

Keywords: at risk, mathematics, number sense, low income, intervention

- Results:
  - The number sense condition outperformed the other groups on all math measures.
  - No significant difference between language condition and control group.

Summary – intervention studies

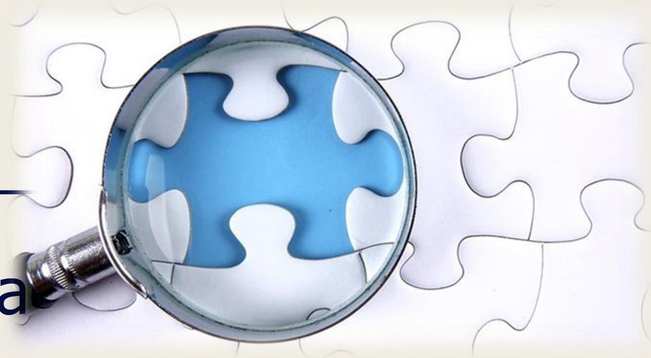
- Various findings: effect vs. no effect

- Variations in the interventions:
  - Age, duration, sample size
  - Targeted language skills
  - Mathematical domain
  - Instructional method

- A need for combining the interventions, investigate overall effects, and examine moderators.

University of Stavanger

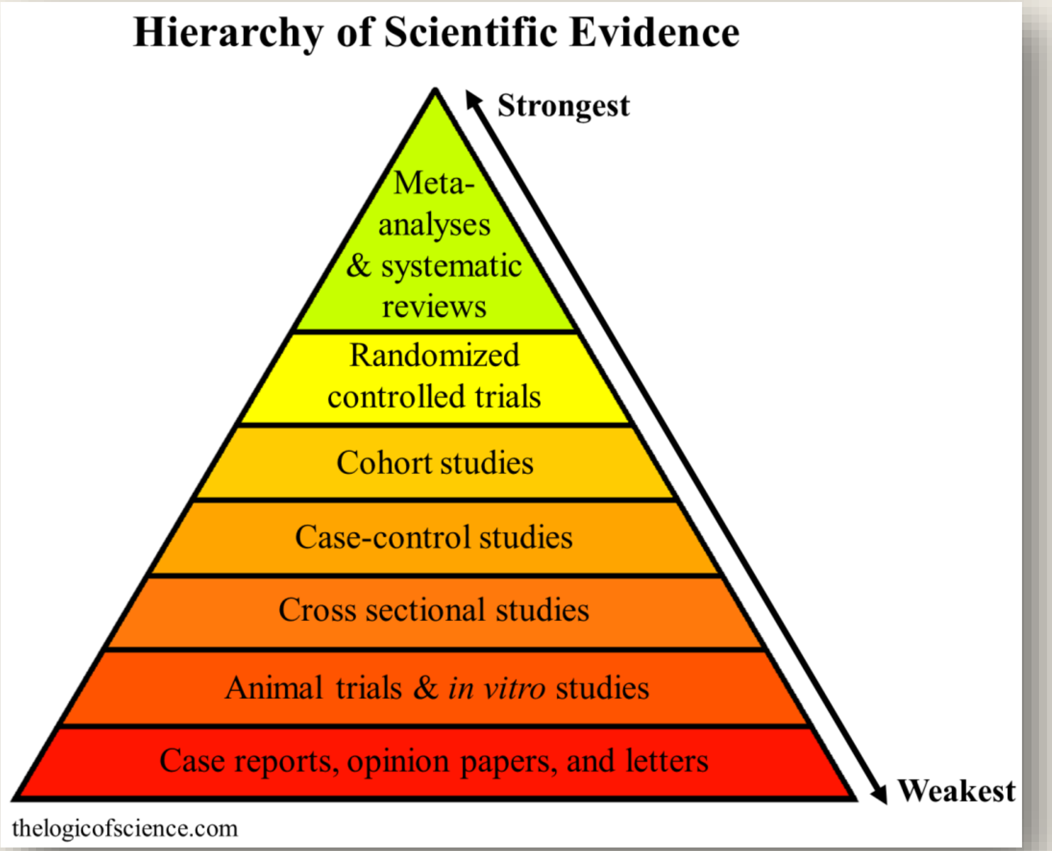
Research gap



- Early mathematics predicts later mathematical a (Duncan et al., 2007).
  - How to support the students falling behind?
  - Practice what we need to improve – embed language practice?
- Various findings from language interventions.
  - A need for examining the effects of these interventions, addressing moderators, and exploring heterogeneity.
- Current meta-analysis will contribute to filling this gap.

Meta-analysis

- Combine previous intervention results.
- Compute the overall effect.
- Comprehensive overview.
- Make sense of the inconsistent findings.



Implications for practice

- Crucial knowledge for researchers and teachers.
- Efficient to incorporate language practice?
- How should it be incorporated?
  - Age
  - Language skills
  - Mathematical domain

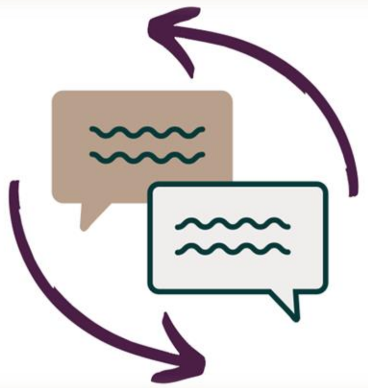
Research questions

1. What is the effect of language interventions targeting to improve students' (3-13 y/o) mathematical achievement?
2. How variable are the effect sizes?
3. What instructional, personal, and/or methodological characteristics moderate the effect?
4. Which language skills (i.e., vocabulary, phonological processing) are most investigated? Which produces the largest effect?

Feedback

- Do you know any language interventions implemented to improve students' mathematics?
- Tips for relevant prior research?
- Tips for the conduction of the current meta-analysis?

- Other comments or questions?



Thank you!

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