Relations between Children's Home Environment and the Neurocognitive Basis of Numerical Development

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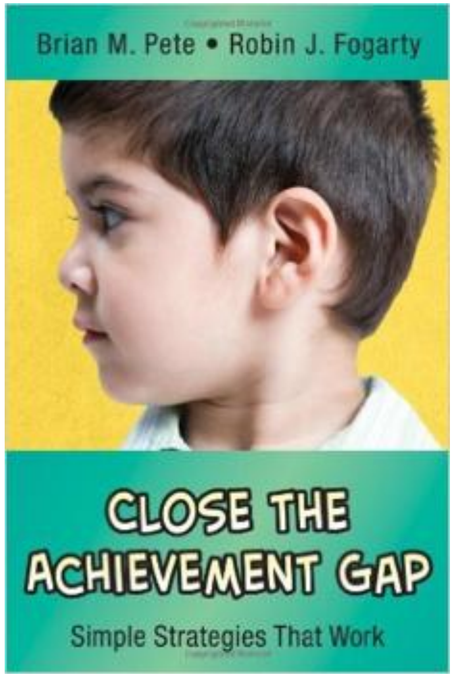
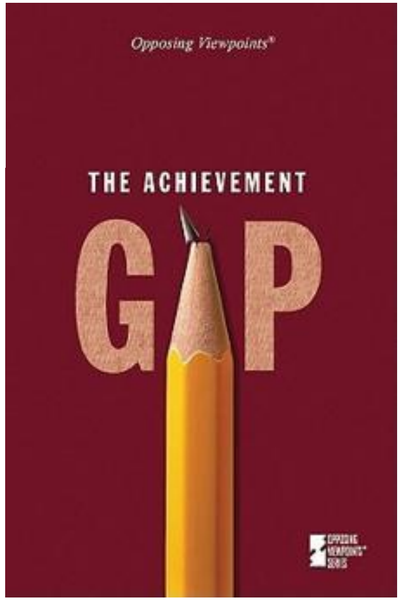
Department of Psychological and Brain Sciences / Stead Family of Pediatrics
University of Iowa

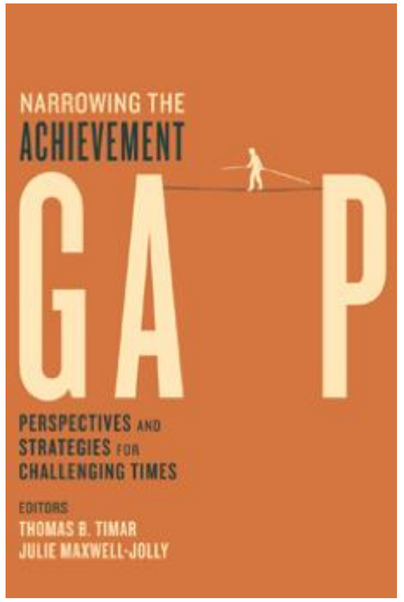
March 12, 2025 | BIG TEN EARLY LEARNING ALLIANCE
Early Math Learning in Big Ten States



New data highlights ‘achievement gap’ for students in the US

January 29, 2025 by Daily Dodge





The Atlantic

The Ignored Science That Could Help Close the Achievement Gap

There’s a body of research on cognitive reading processes, so why isn’t it being utilized?

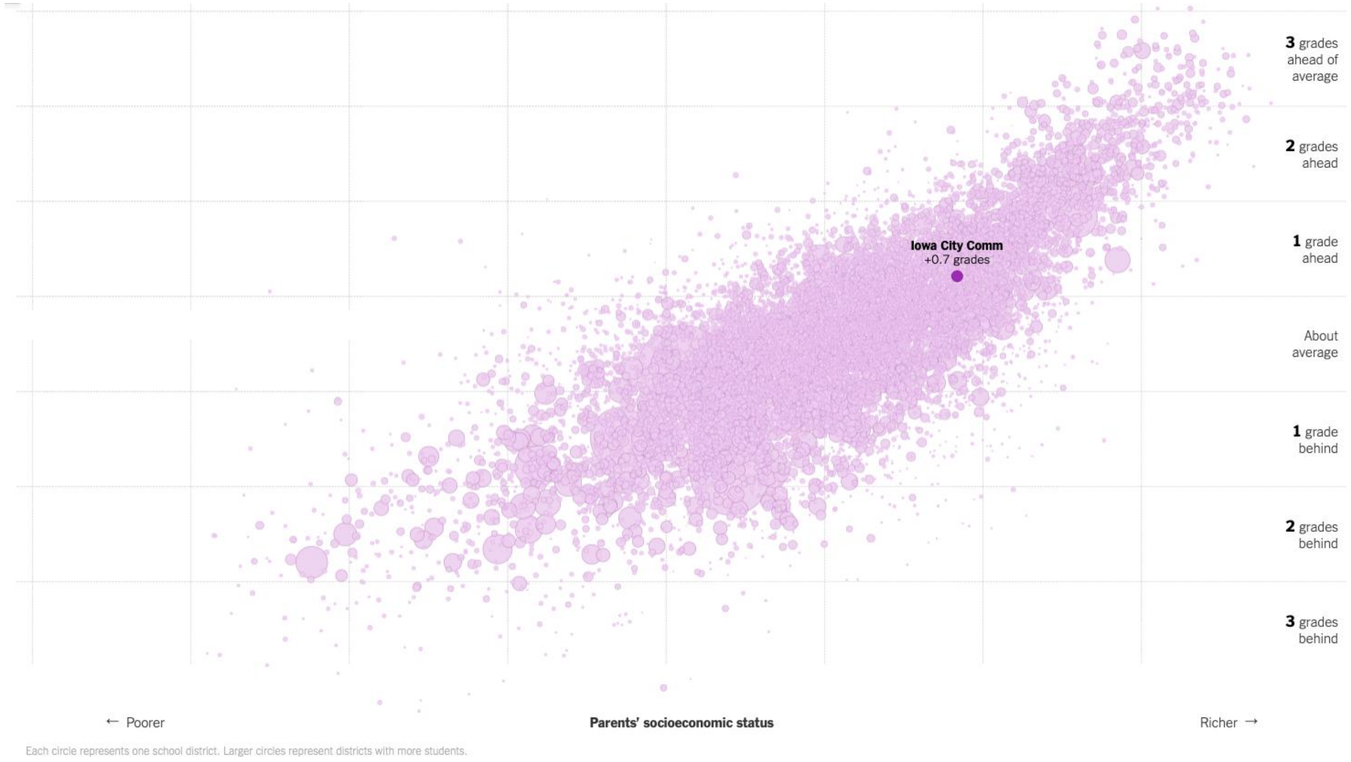
ECONOMY

Education Gap Between Rich and Poor Is Growing Wider

SEPT. 22, 2015

Children from disadvantaged parental backgrounds fall behind their peers from more advantaged backgrounds

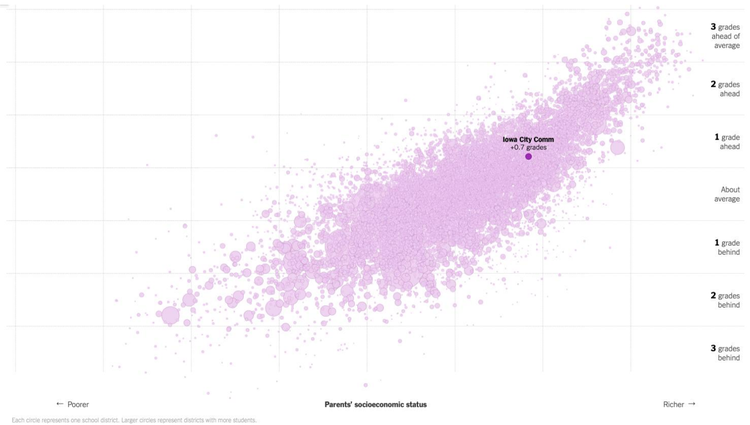
Sixth graders in the richest school districts are four grade levels ahead of children in the poorest districts



The Geography of Racial/Ethnic Test Score Gaps, by Sean F. Reardon, Demetra Kalogrides and Kenneth Shores of Stanford

Gap in mathematical performance

- Emerge early
- Persist over time
- Achievement gaps particularly pronounced in math, sometimes more than in literacy
- Predict important life outcomes in adulthood, sometimes more than literacy does

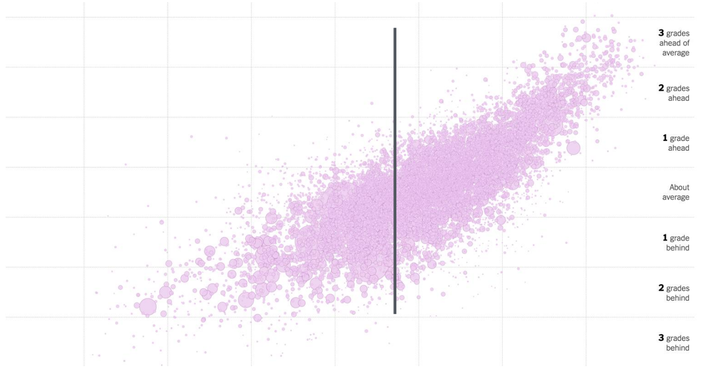


Classan & Engel, 2013; Duncan et al., 2007; Ritchie & Bates, 2013; Siegler et al., 2012; Watts et al., 2014

GAP

SES

MECHANISMS OF DISPARITIES

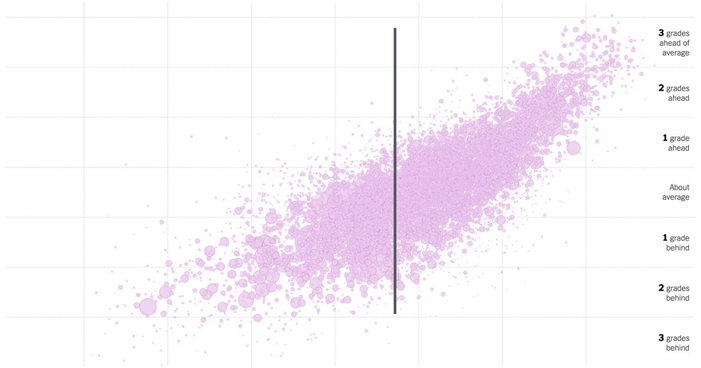


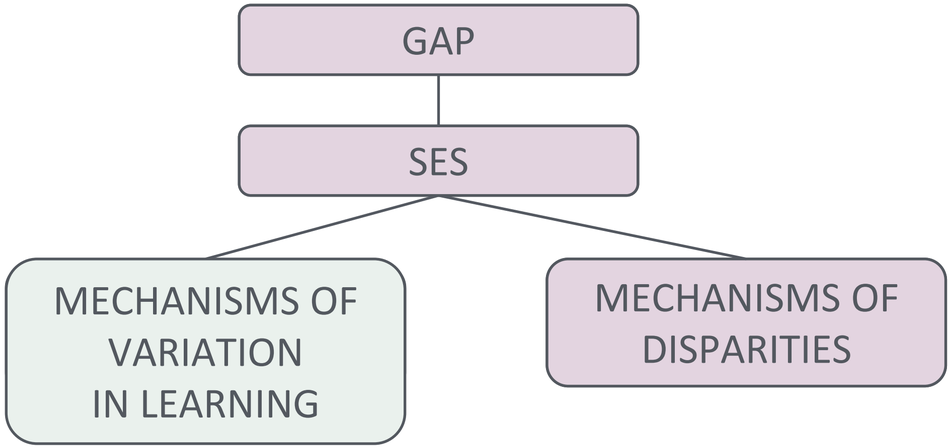
GAP

SES

MECHANISMS OF VARIATION IN LEARNING

MECHANISMS OF DISPARITIES

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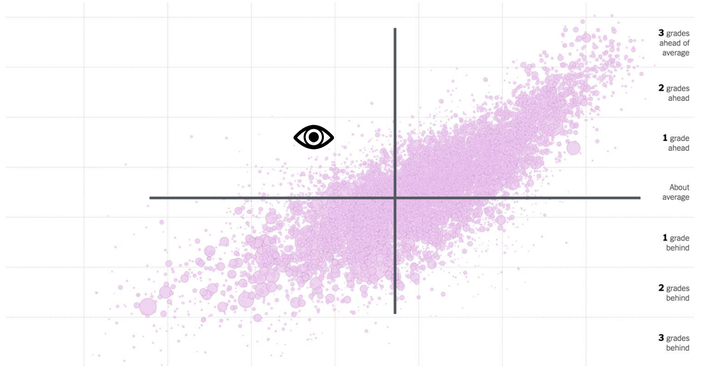
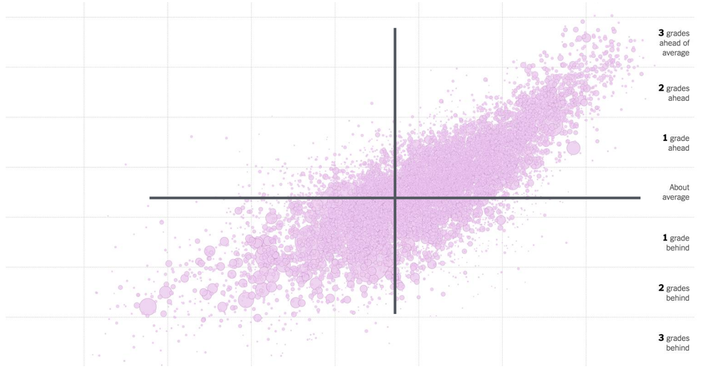

3 grades ahead of average
2 grades ahead
1 grade ahead
About average
1 grade behind
2 grades behind
3 grades behind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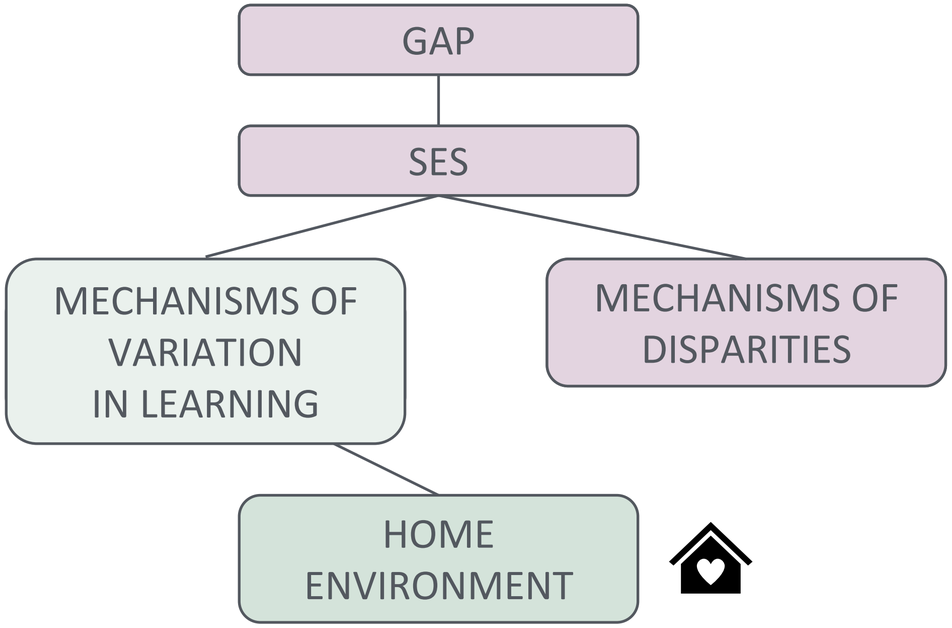
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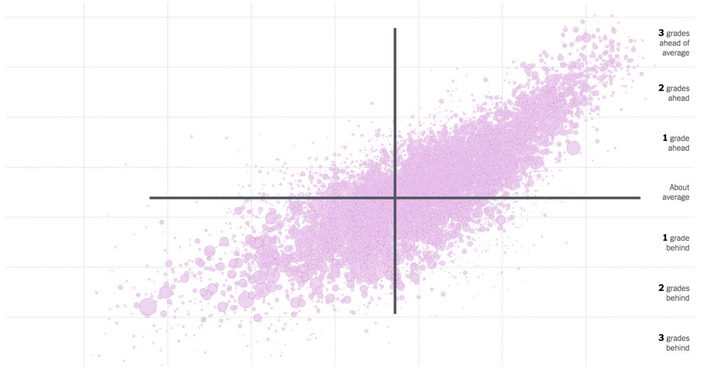
MECHANISMS OF VARIATION IN LEARNING
MECHANISMS OF DISPARITIES
HOME ENVIRONMENT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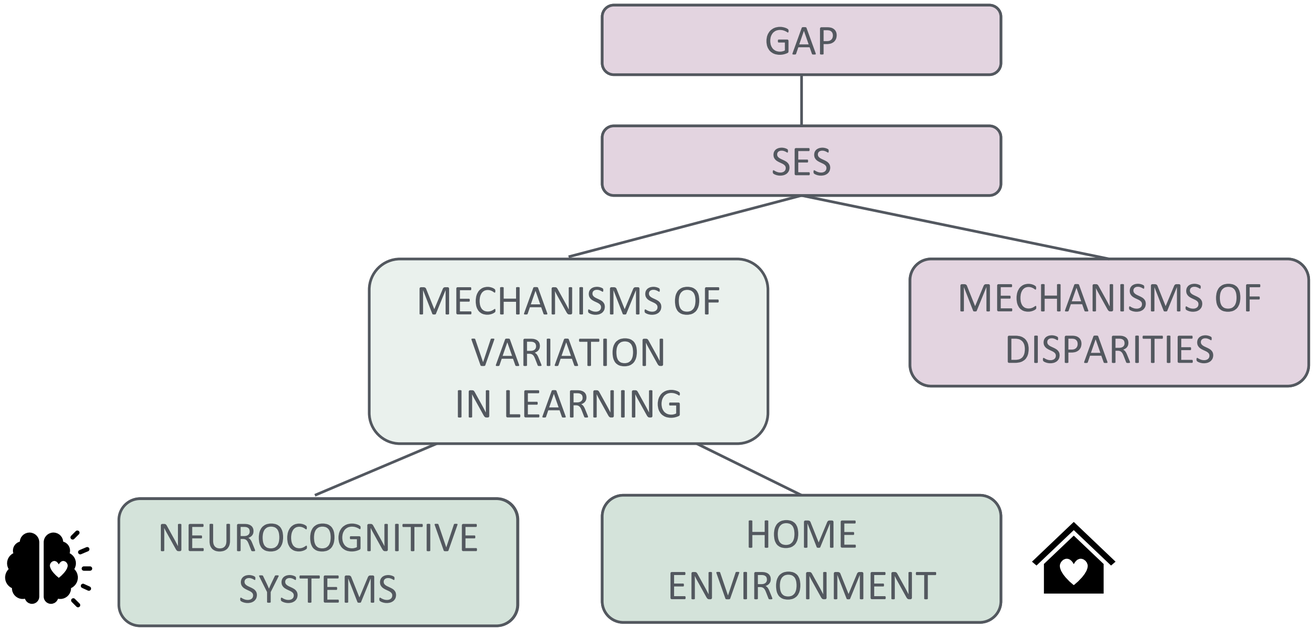
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NEUROCOGNITIVE SYSTEMS
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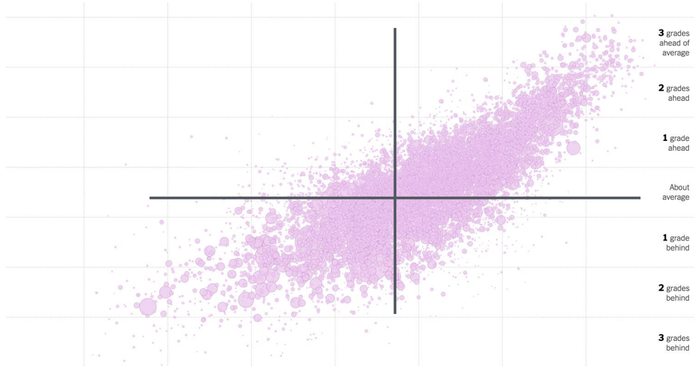


GAP

SES

MECHANISMS OF VARIATION IN LEARNING

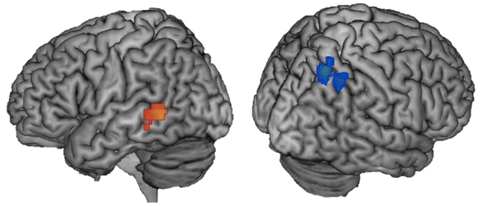
MECHANISMS OF DISPARITIES

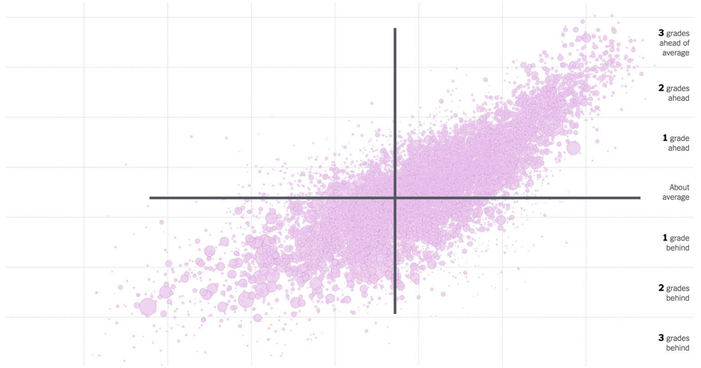
NEUROCOGNITIVE SYSTEMS

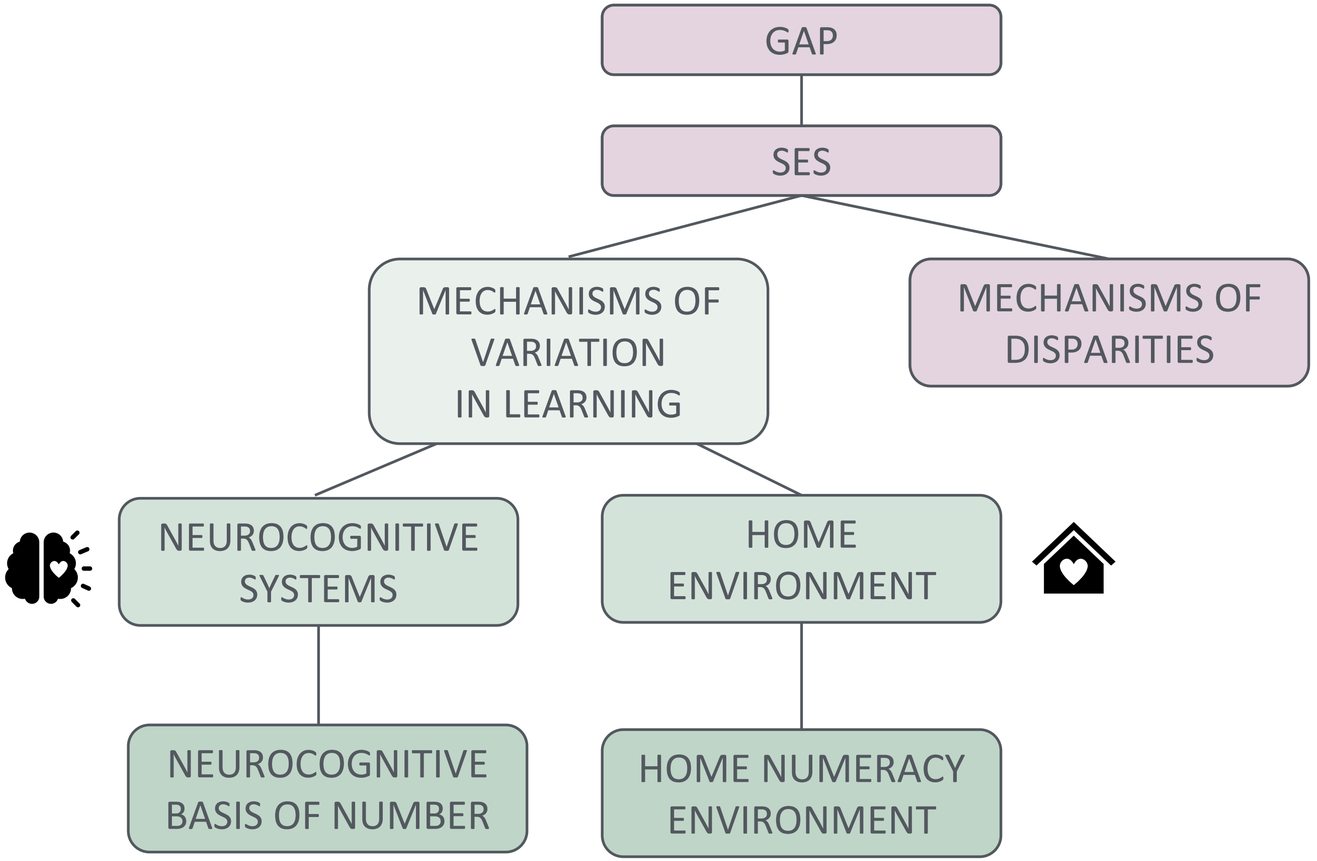
HOME ENVIRONMENT

NEUROCOGNITIVE BASIS OF NUMBER

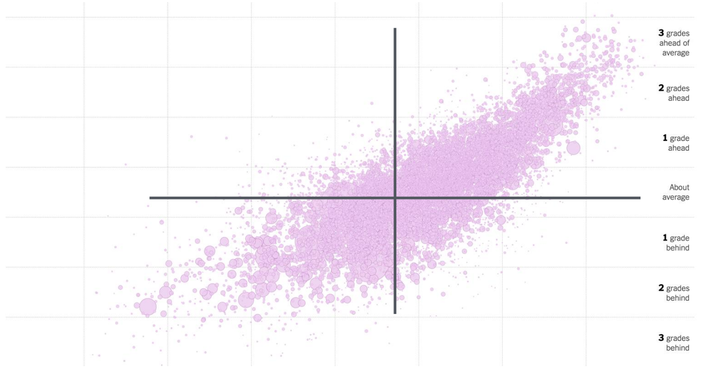
HOME NUMERACY ENVIRONMENT

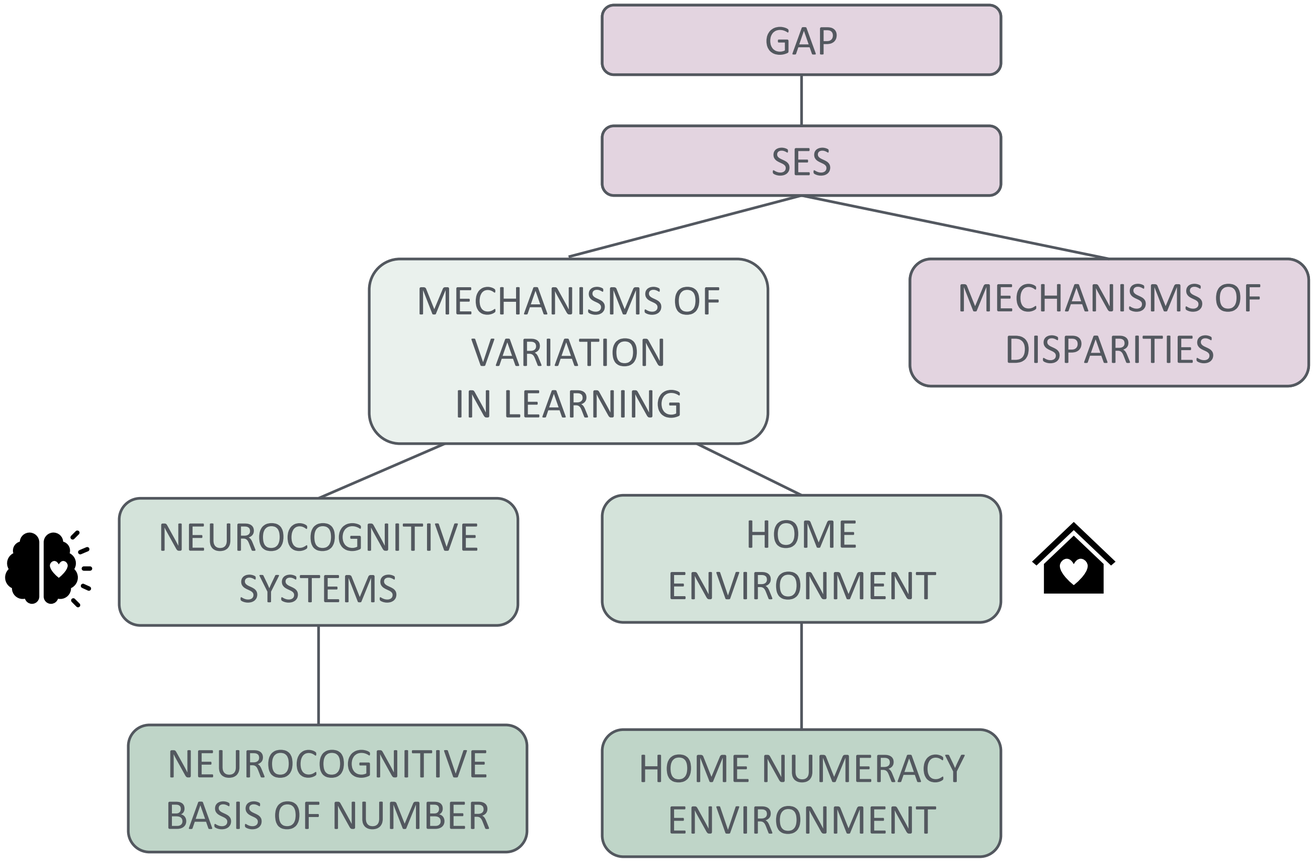






Children recruit *different* systems in the brain as a function of their home experiences





INTERVENTION

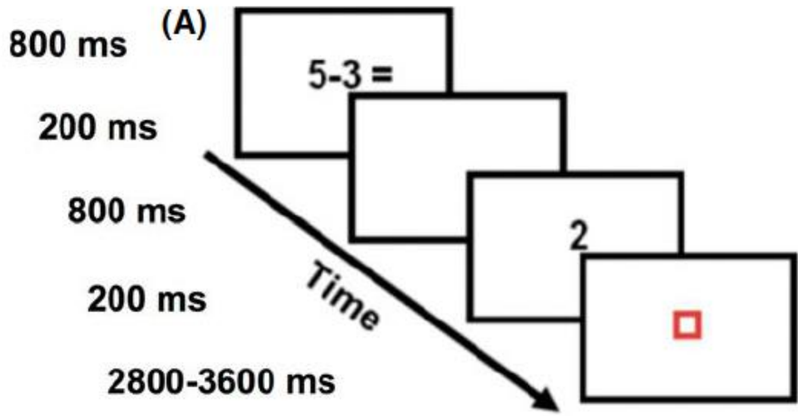
Children recruit *different* systems in the brain as a function of their home experiences

- SES and the neurocognitive basis of arithmetic processing in school aged children

- Home environment and the neurocognitive basis of numerical processing in preschoolers

- Implications for learning environments/interventions*

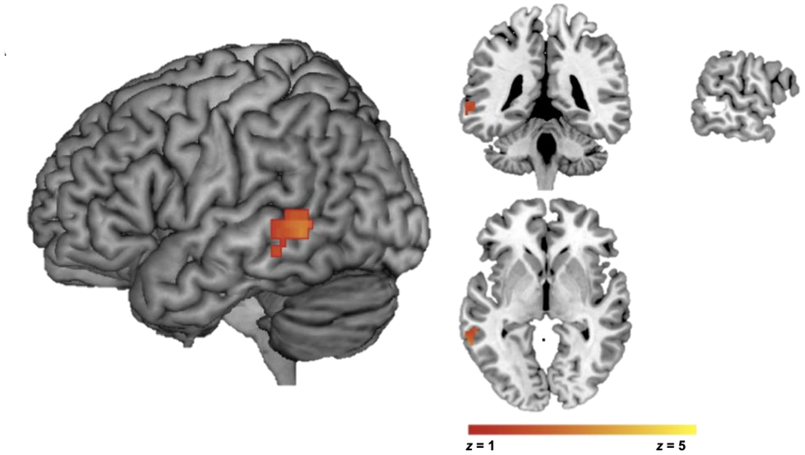
SES and the neurocognitive basis of **arithmetic processing** in **school aged children**



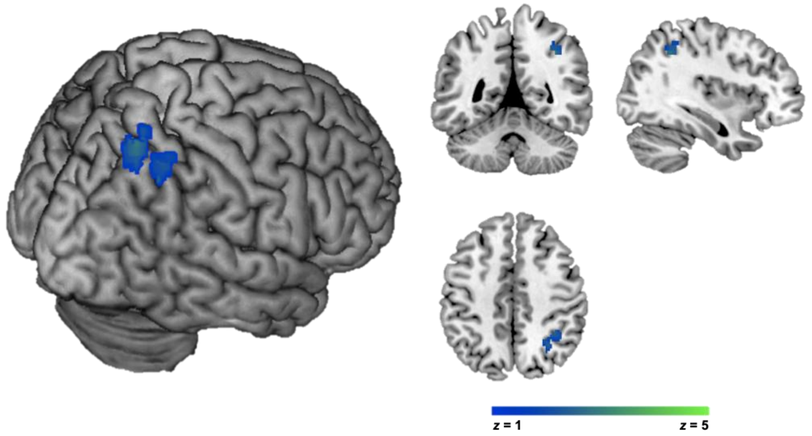
Demir, Prado, & Booth, 2015, *Developmental Science*

SES and the neurocognitive basis of **arithmetic processing** in **school aged children**

LANGUAGE AREAS
Left MTG
x = 62, y = 42, z = 2



SPATIAL AREAS
Right IPS
x = 38, y = 52, z = 45



Demir, Prado, & Booth, 2015, *Developmental Science*

- Children recruit different systems in the brain as a function of their experiences, sometimes to perform on par with their peers

- What are the home experiences that give rise to these differences?

- SES and the neurocognitive basis of arithmetic processing in school aged children

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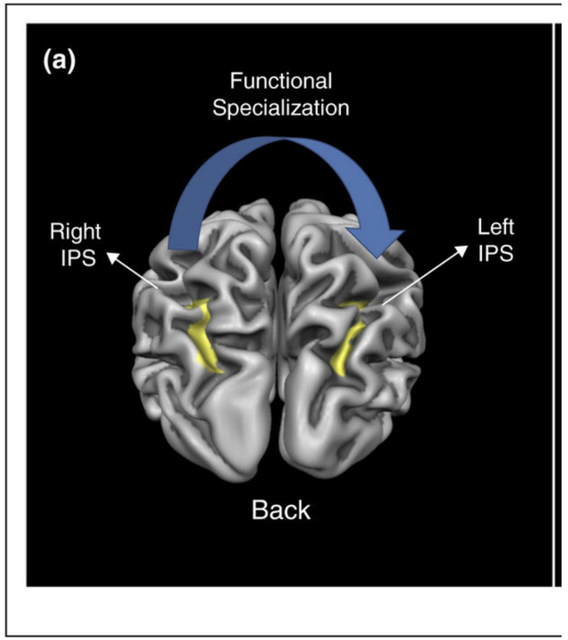
- Implications for learning environments/interventions*

Neurocognitive basis of symbolic numerical processing

- Developmental specialization of left parietal regions
- Fronto-parietal shift over the course of development



Bugden et al., 2016, COBS

Ansari et al., 2015; Bugden et al., 2012; Cantlon et al., 2006; DeSmedt et al., 2013; Edwards et al., 2015; Emerson & Cantlon, 2014; Holloway et al., 2010; Piazza et al., 2007; Sokolowski et al., 2017; Vogel et al., 2015

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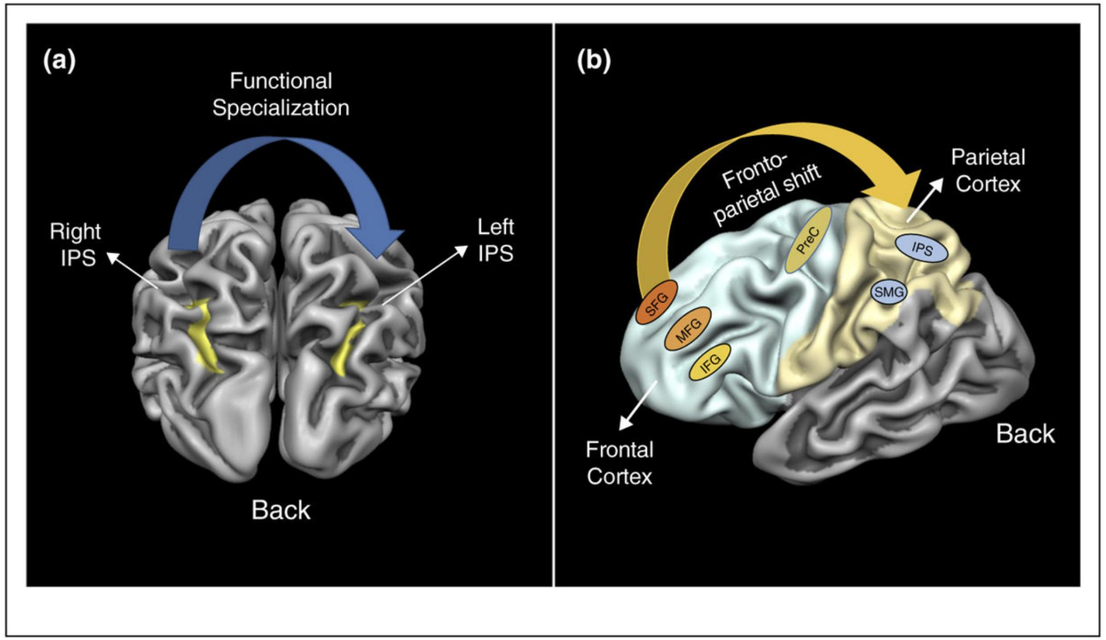

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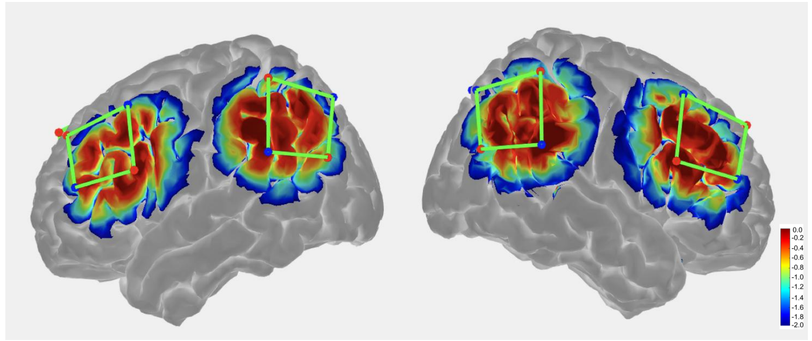
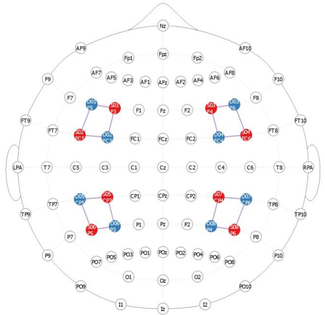
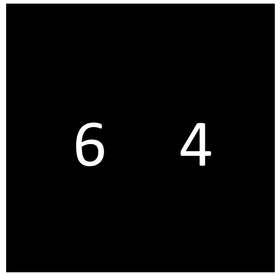
Home math environment and the neurocognitive basis of **numerical** processing in **preschoolers**

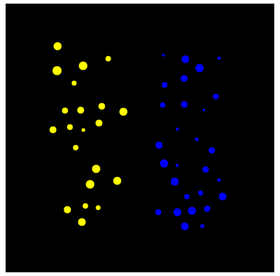




Symbolic comparison

Nonsymbolic comparison





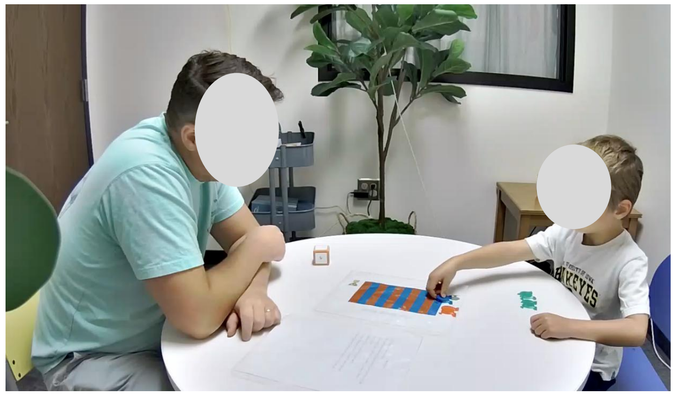
Home numeracy environment and the neurocognitive basis of **numerical** processing in **preschoolers**

Parent-child numeracy activities questionnaire

Formal: e.g. doing math in your head (asking your child 2+2), memorize math facts, counting

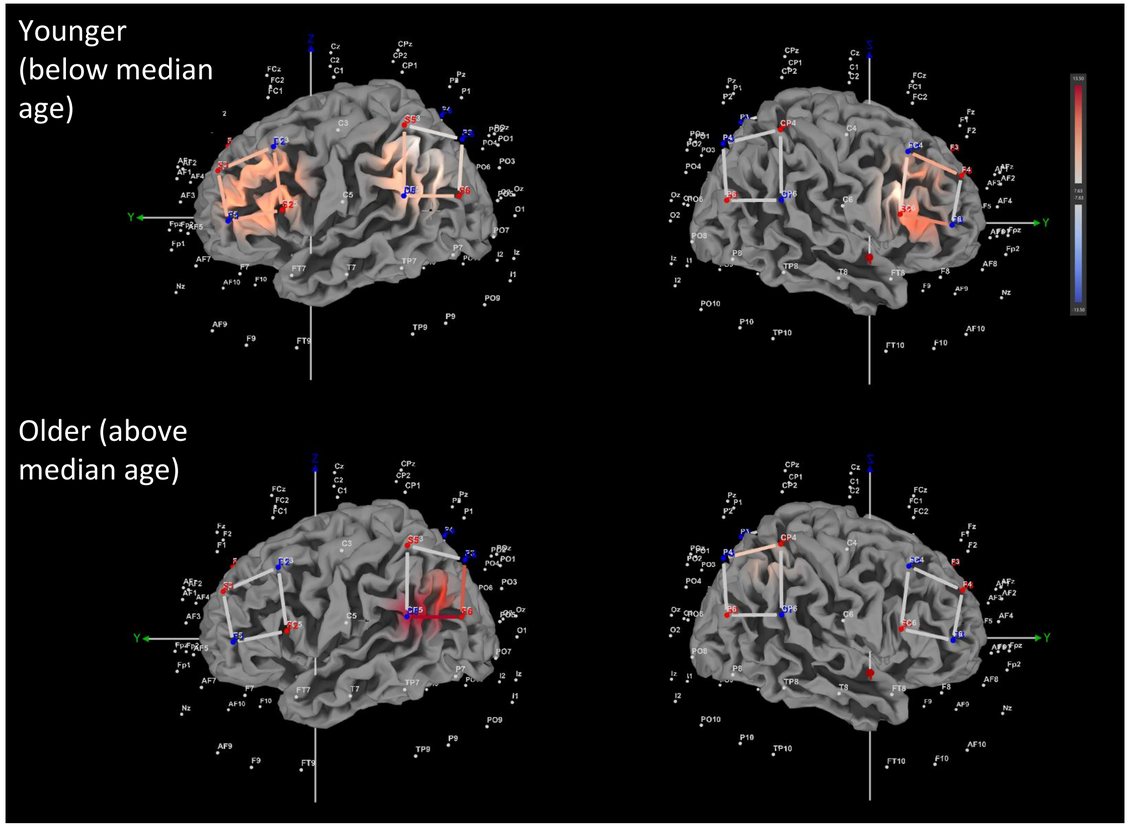
Informal: e.g. measuring while cooking, talking about time

Parent-child three bags task

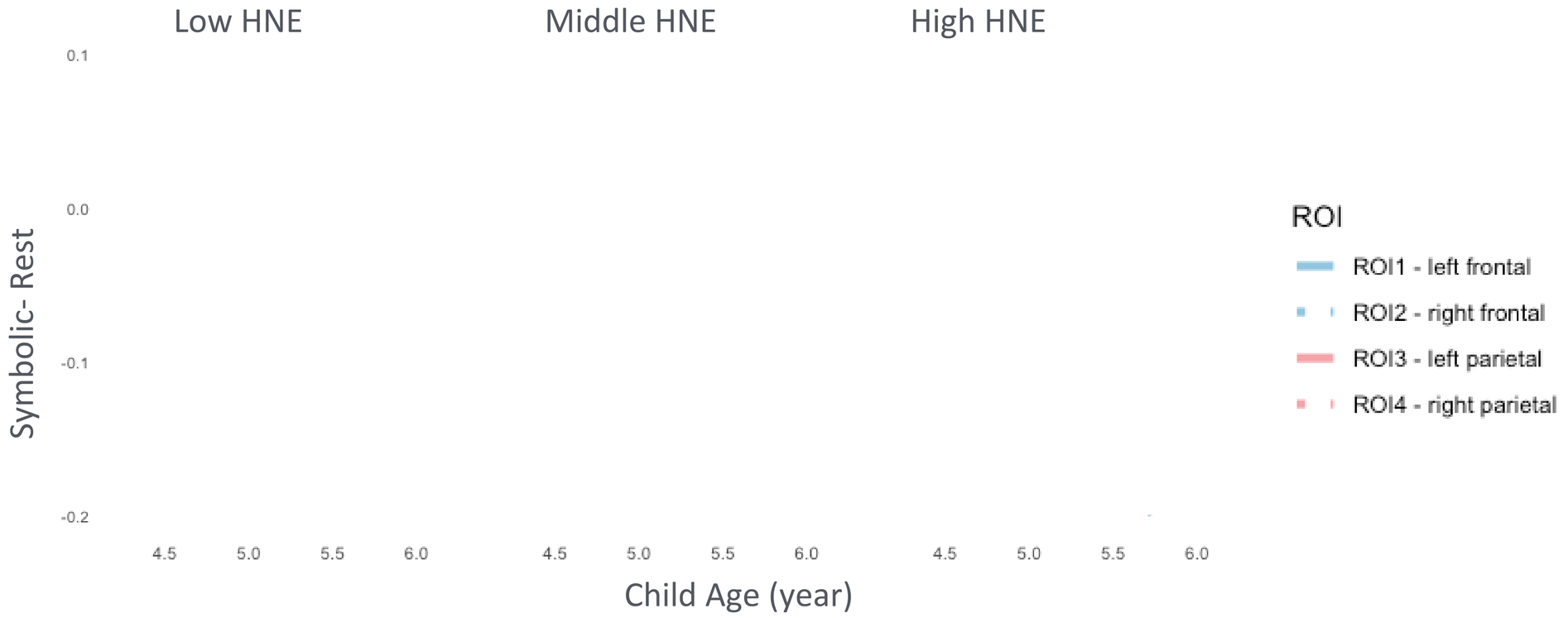


***Number talk**: Number of number words (one, two, three) or amount words parents say (a lot, many)*

Age differences underlying symbolic number comparison



Age differences underlying symbolic number comparison *differs* as a function of home numeracy environment (HNE)



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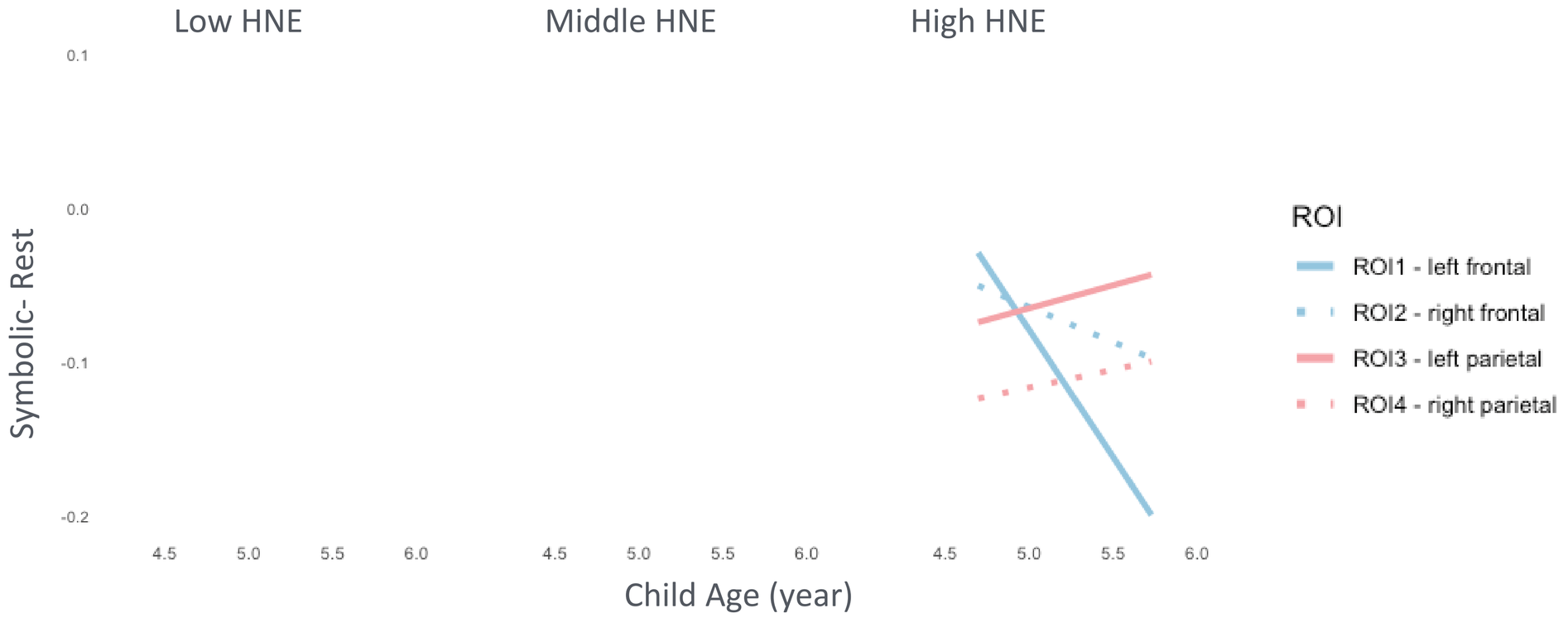

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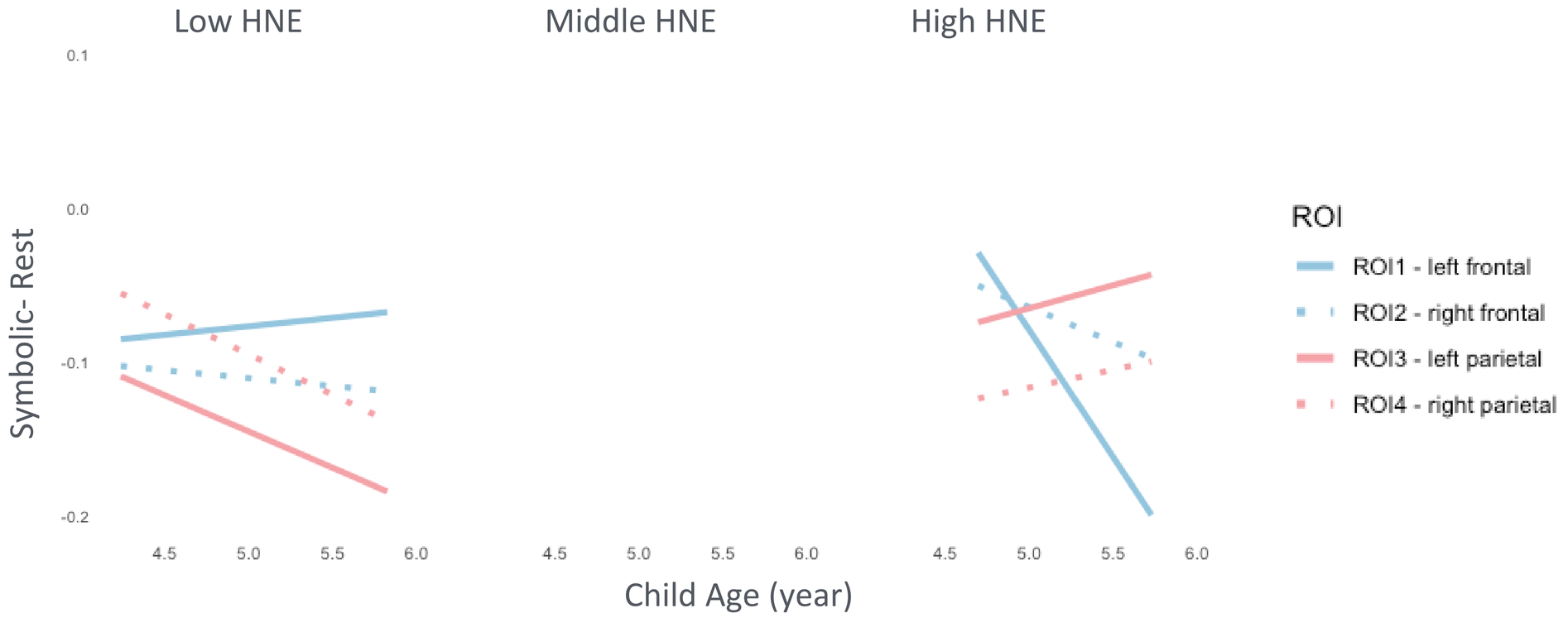

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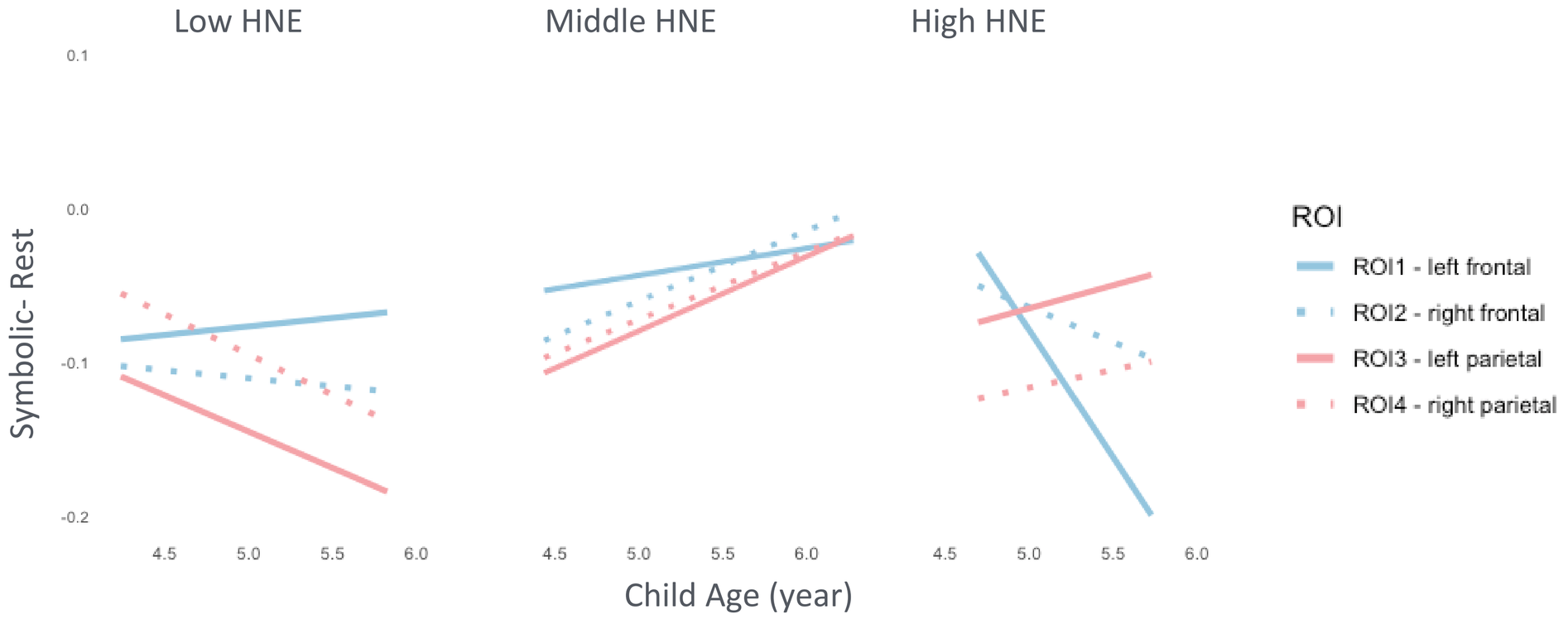

Intervention implications

If children recruit *different* systems in the brain as a function of their experiences to perform on par with their peers, then do they need *different* supports to succeed?

- **Visuospatial support?** Verbal support? Transitional support?

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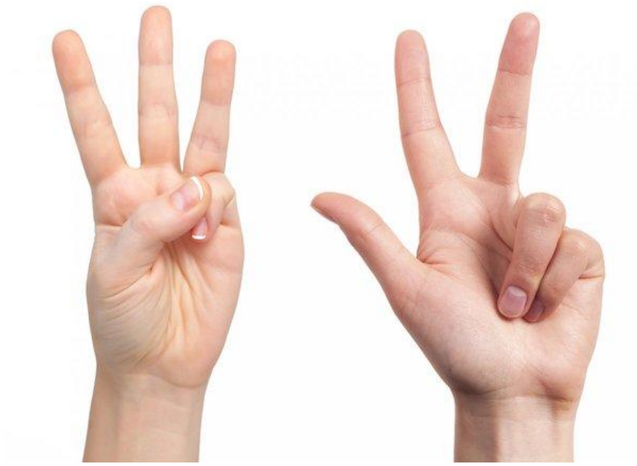
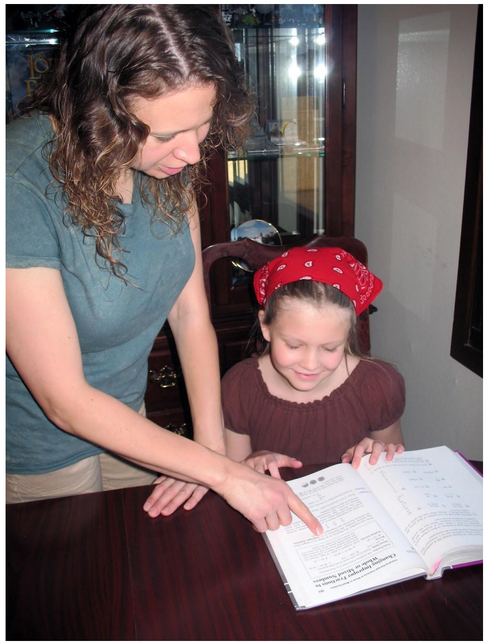
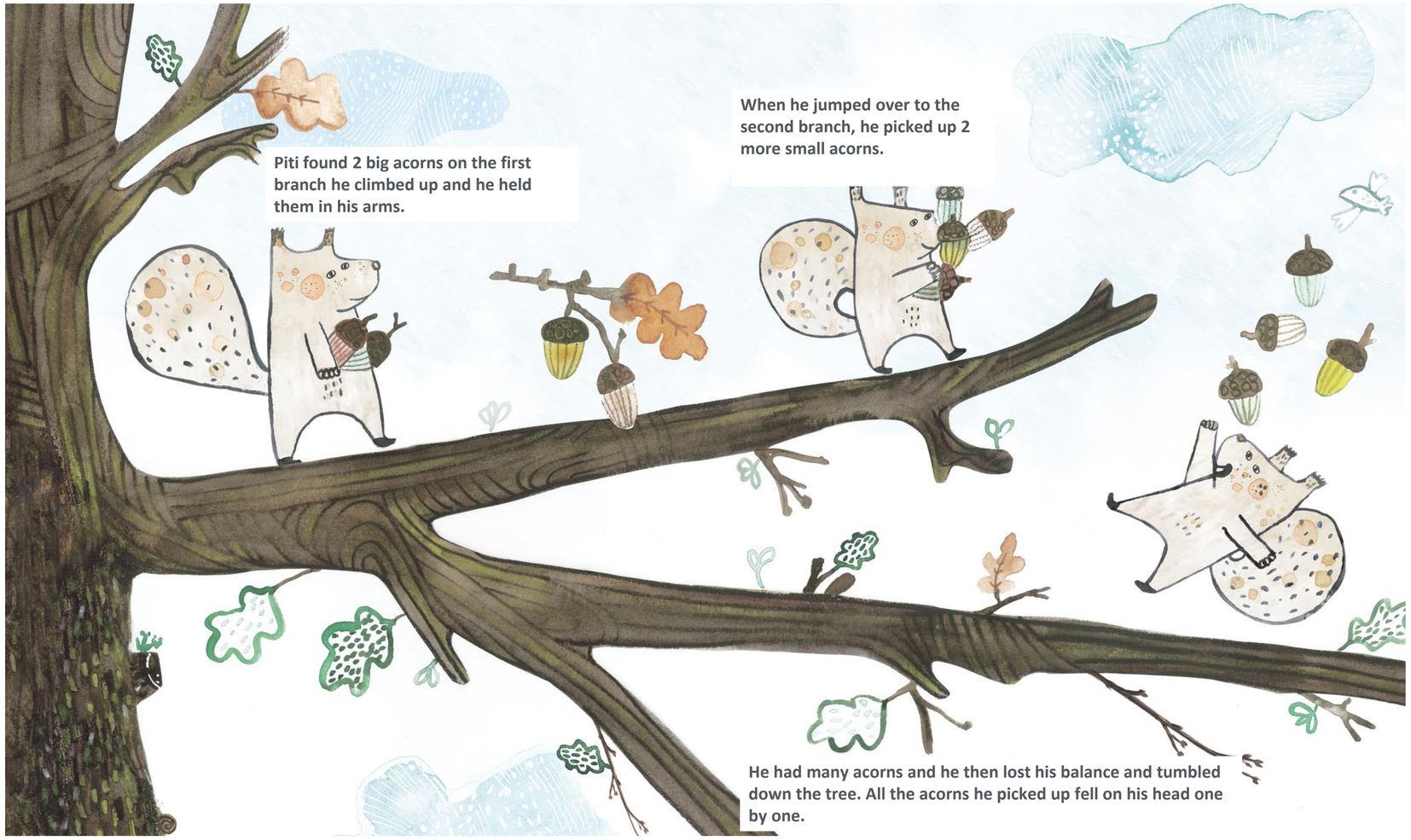




Cook et al., 2012; Goldin-Meadow et al., 2009

What is the role of a 6-week parent-administered home book-reading intervention?

Visuospatial support? Verbal support?



Tilbe Göksun & Begüm Yılmaz
Koç University, Türkiye

6-week parent-administered home book reading intervention increases parental math talk

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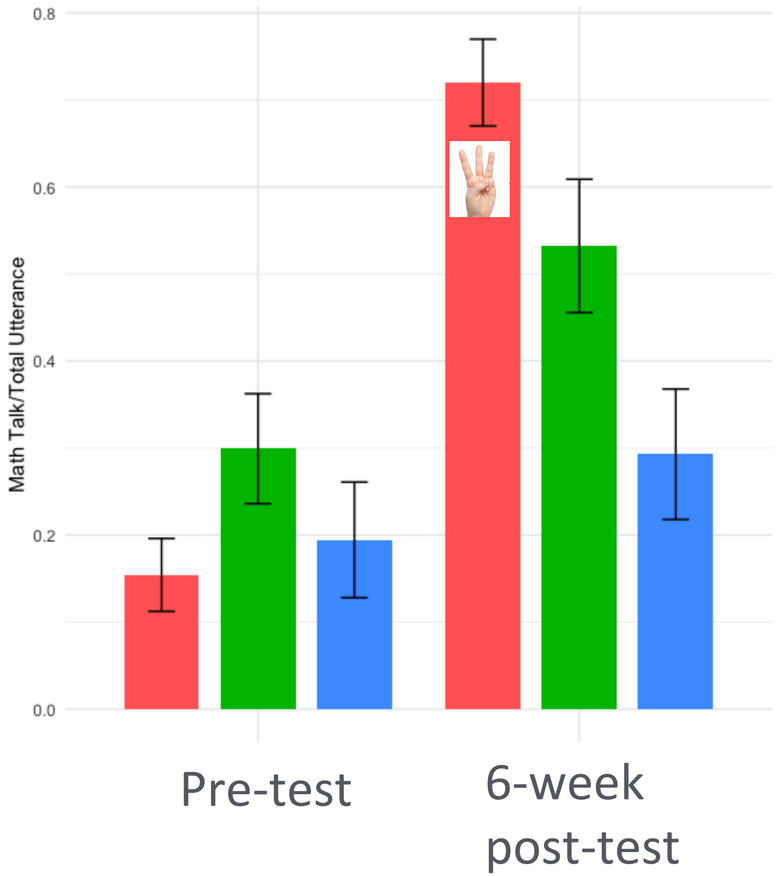
Parental math talk

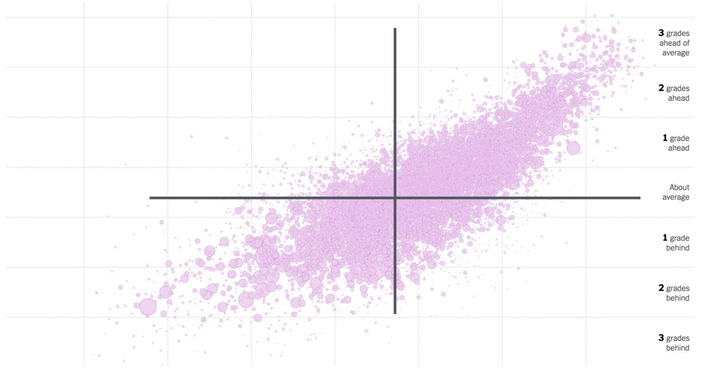


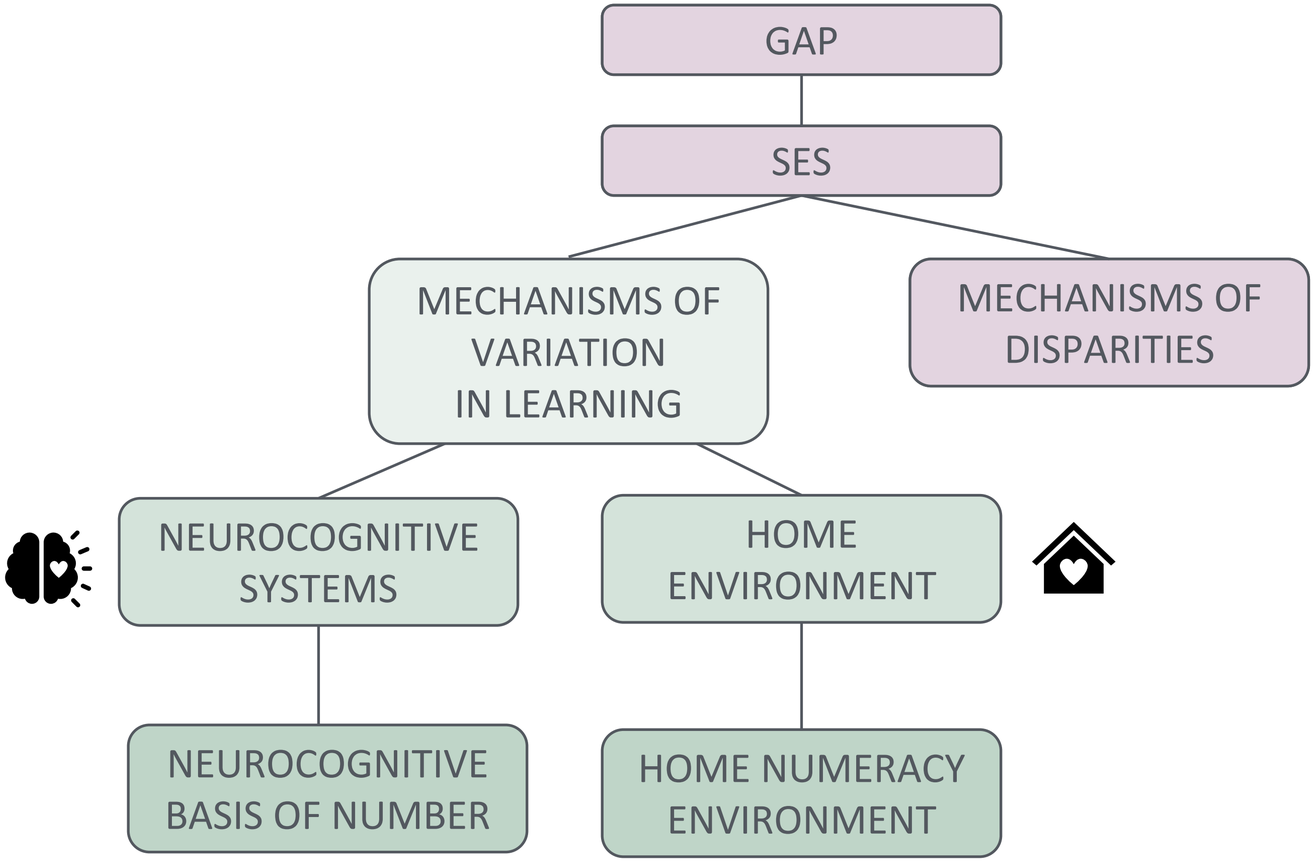
Condition

1 - Math Book Gestures Encouraged

2 - Math Book Gestures Restricted

3 - No Math Book





INTERVENTION

Children recruit *different* systems in the brain as a function of their home experiences

- Special thanks to the Development, Experience, and Neurocognition (DEN) Lab members
- Families and children who participated in our studies
- Funding agencies
- Collaborators
- Thank you!

James Booth

Jerome Prado

Tilbe Göksun

Begüm Yılmaz

Sinem Erdogan

Gulnaz Yukselen

Ying Li

Paige Nelson

Haley Laughlin

Eunice Kennedy Shriver National Institute of Child Health and Human Development

Children's Miracle Network Hospitals

University of Iowa Stead Family Children's Hospital