

# Tactile graphics and Nemeth code for math and science: Student performance, difficulties, and implications

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# Outline

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- Overview of the larger study and goals
- Analysis 1: Tactile graphics & math
- Analysis 2: Shape familiarity
- Analysis 3: Nemeth & math performance

# Overview of Larger Study

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- Data from ~19 high-school students
  - Academically achieving: expect diploma by age 21
  - No additional learning disabilities
  - Used braille as main literacy medium
  - Located in CA or BC
  - 9 female
  - Average age 15.6 years (min 13, max 21)
  - Average onset 1.6 years  
(15 congenital, others: 1, 2, 5, 12 years)

# Overview of Larger Study

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Participants	Condition
5	Retinopathy of prematurity (ROP)
3	Anophthalmia or microphthalmia
2	Glaucoma
2	Retinal detachment
2	Unknown
2	Leber congenital amaurosis (LCA)
1	Norrie disease
1	Optic nerve hypoplasia (ONH)
1	Familial exudative vitreoretinopathy (FEVR)

# Overview of Larger Study

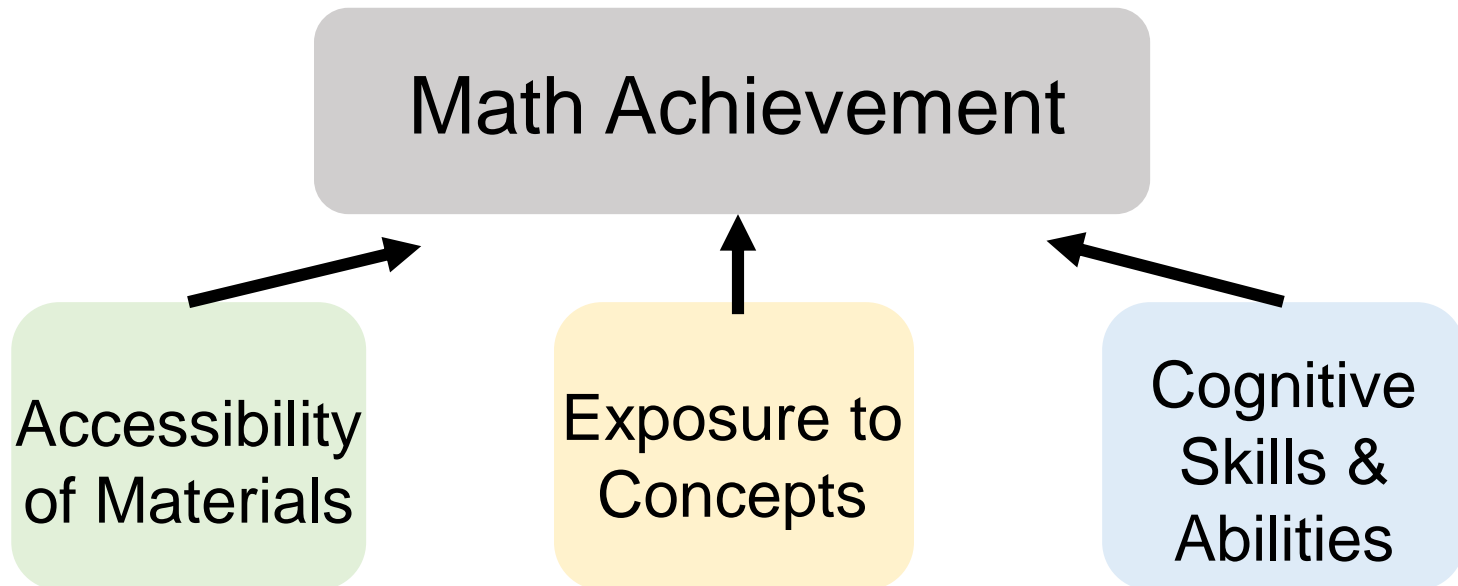
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- Tested on 26 measures
  - 11 math achievement (KeyMath braille)
  - 15 accessibility, exposure, and cognitive measures

# Overview of Larger Study

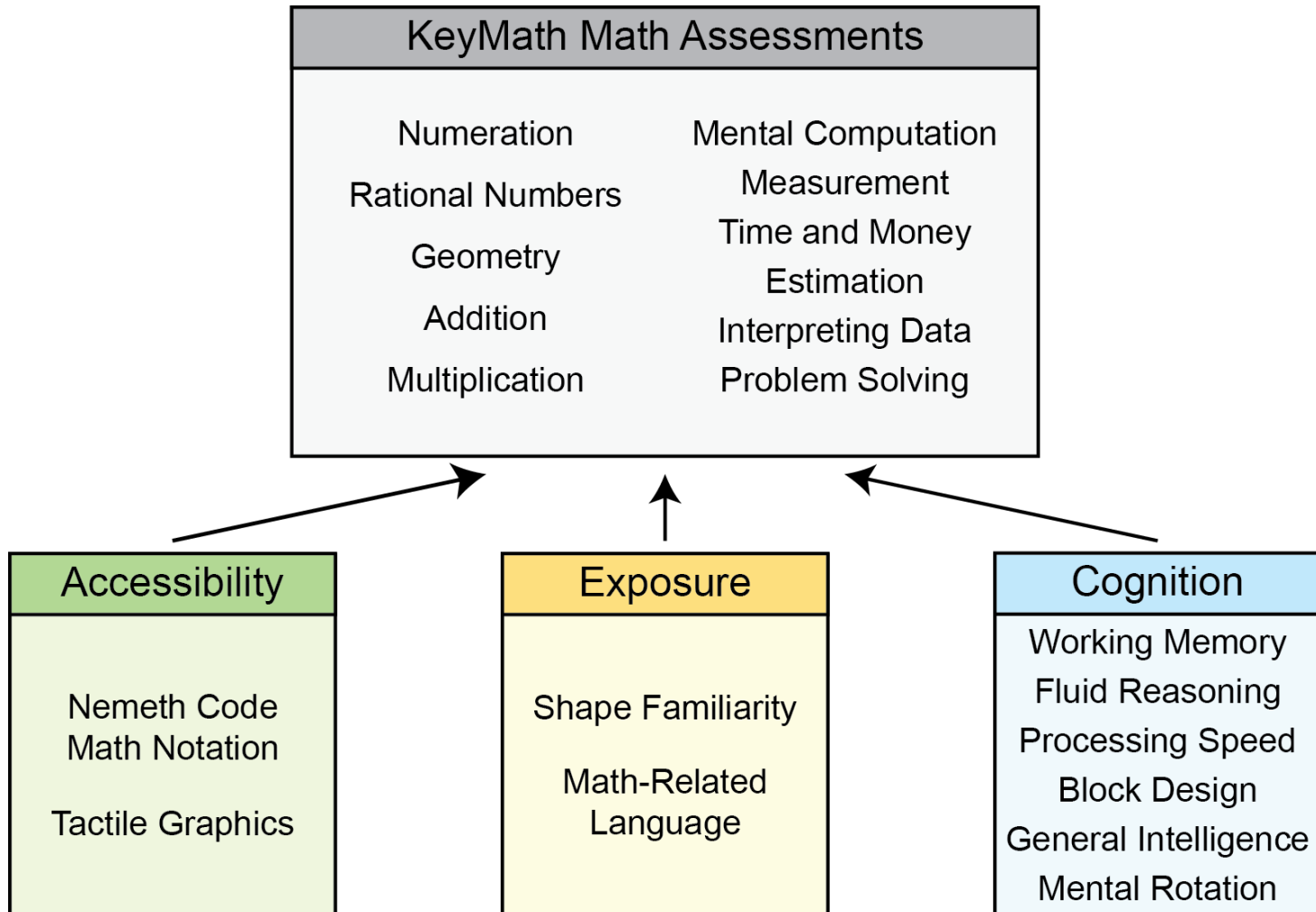
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- Tested on 26 measures
  - 11 math achievement (KeyMath braille)
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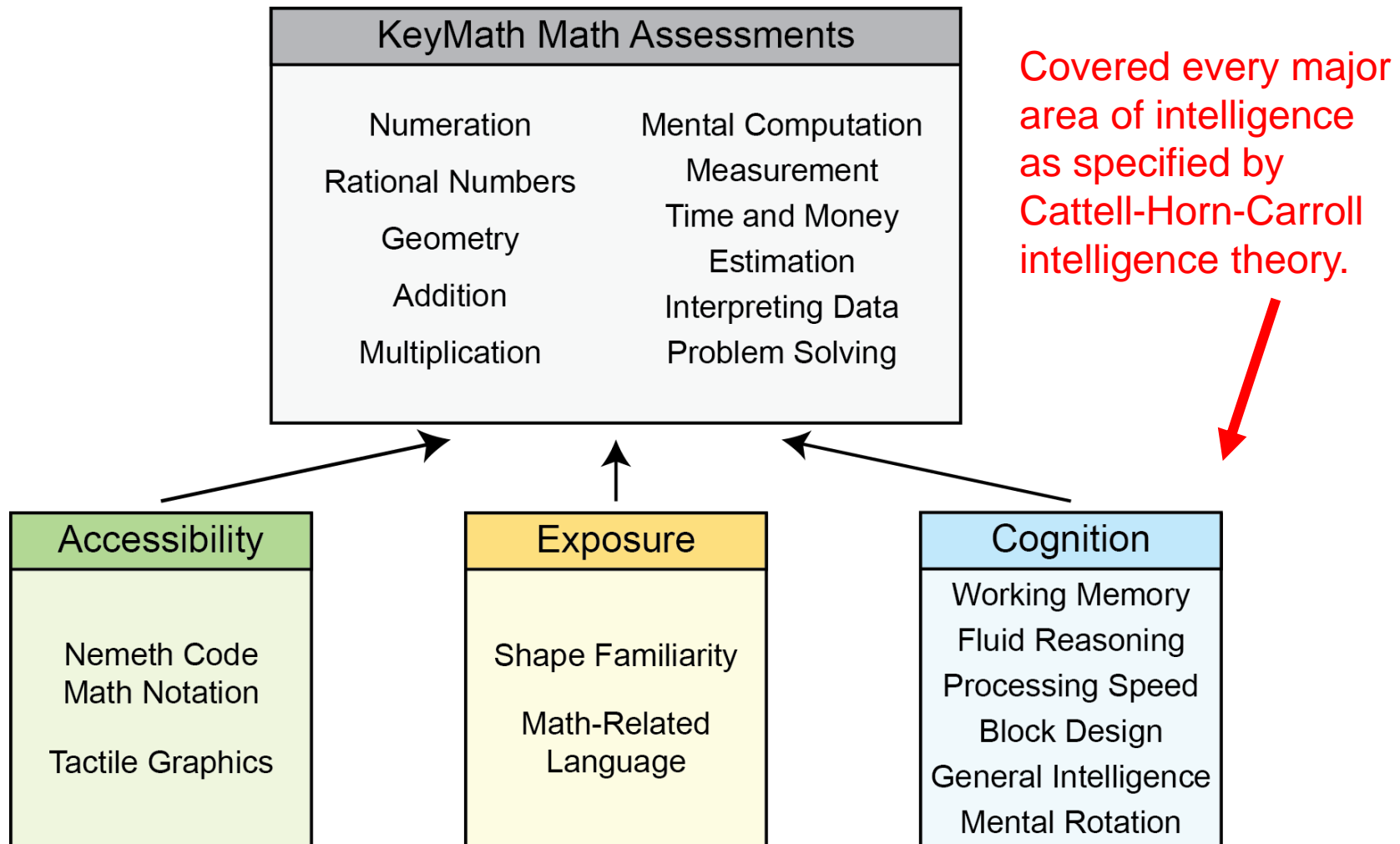


# Overview of Larger Study

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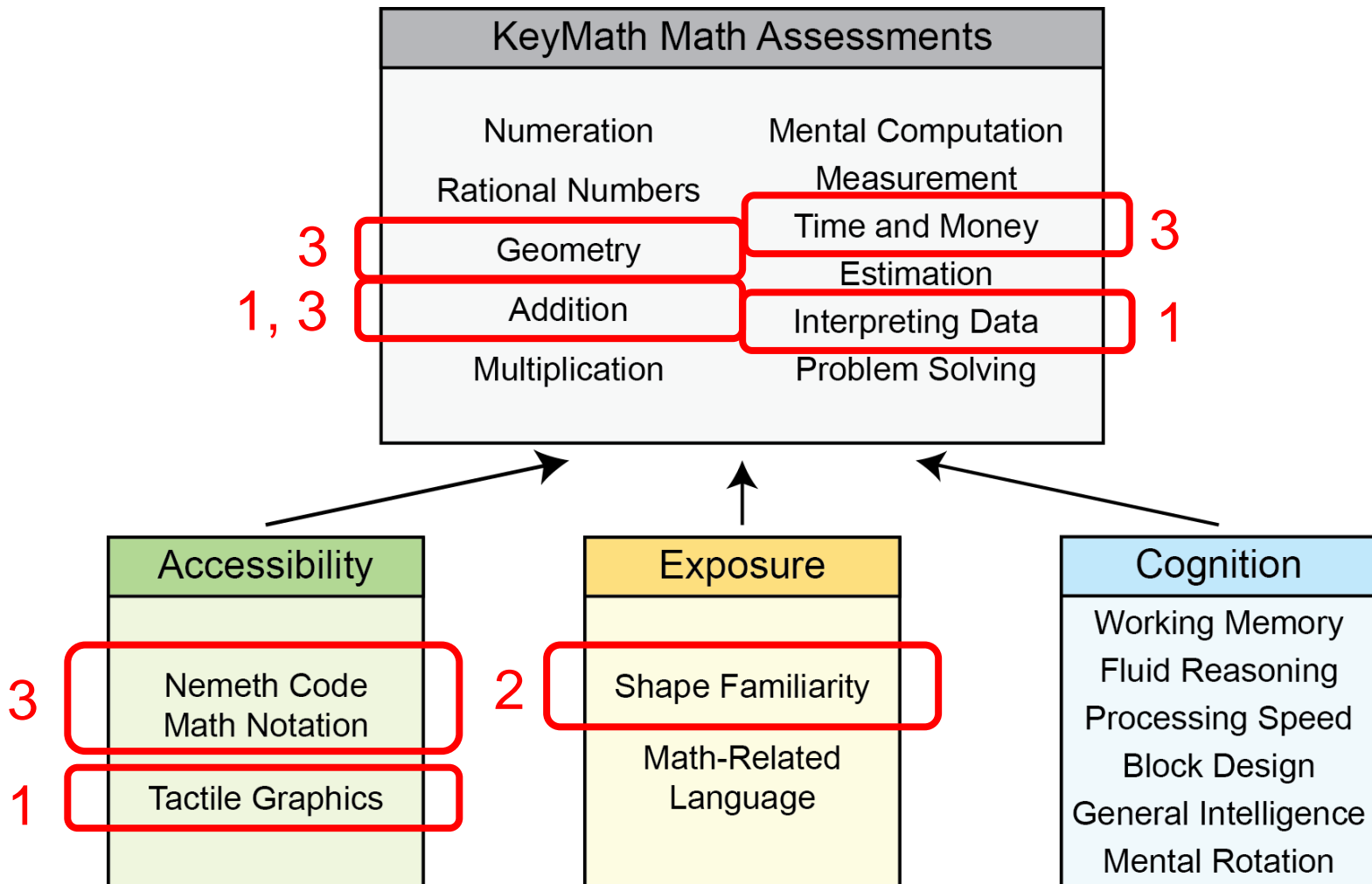


# Overview of Larger Study

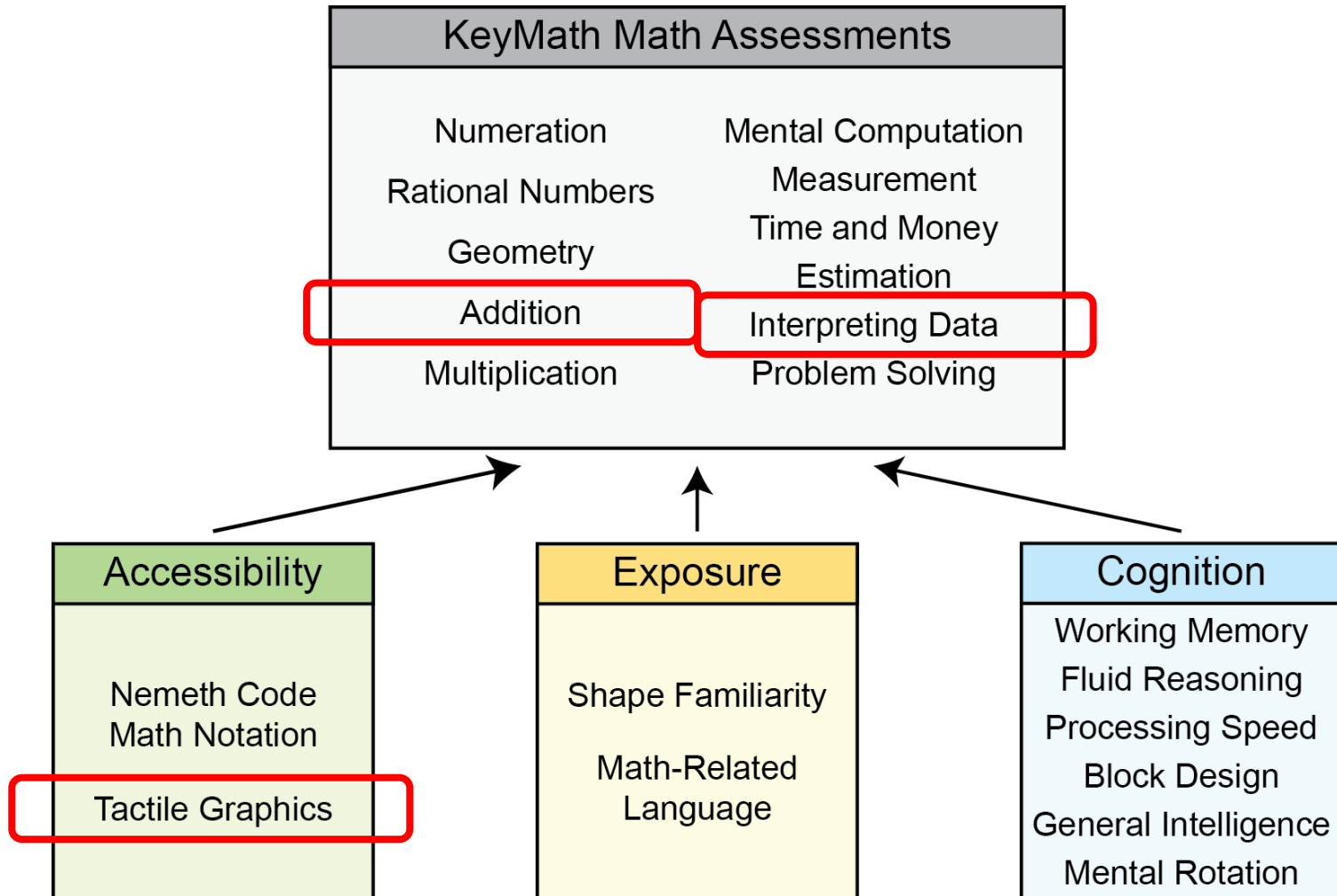




# Overview of Larger Study



# Analysis 1: Tactile Graphics & Math



# Analysis 1: Tactile Graphics & Math

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## Tactile Graphics Abilities

## Math Achievement

- With tactile graphics
- Without tactile graphics

## Questions:

- 1) Which tactile graphics are difficult?
- 2) Does tactile graphic performance predict math performance?

# Analysis 1: Tactile Graphics & Math

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## Measuring Tactile Graphics Abilities: Setting the Stage

### Items 1-6



1. Cup and zipper
2. Bracelet and puzzle-piece
3. Scissors and key
4. Ball and cube
5. Toothbrush and comb
6. Crayon and spoon

# Analysis 1: Tactile Graphics & Math

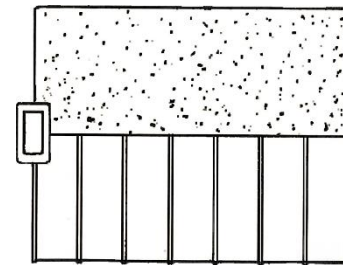
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## Measuring Tactile Graphics Abilities: Setting the Stage

Items 1-6



Items 7-11



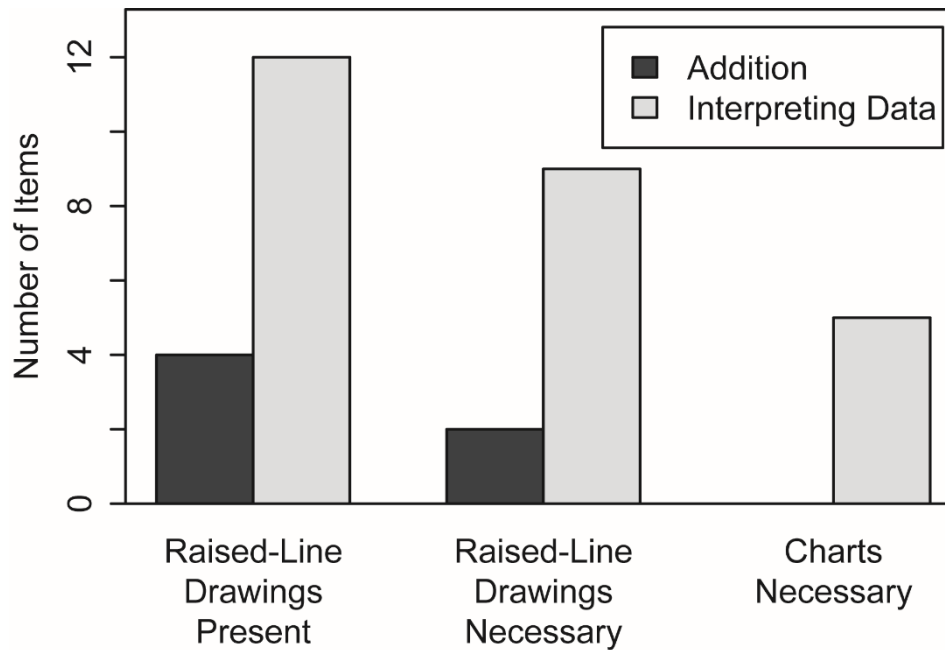
# Analysis 1: Tactile Graphics & Math

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## Measuring Math Achievement: KeyMath

A test with tactile graphics:  
Interpreting Data

A test without tactile graphics:  
Addition



# Analysis 1: Tactile Graphics & Math

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## Results: Tactile Graphics

- Overall Accuracy: 80%
- Distribution of errors not due to chance (Person  $X^2$ )  $p = 0.002$

# Analysis 1: Tactile Graphics & Math

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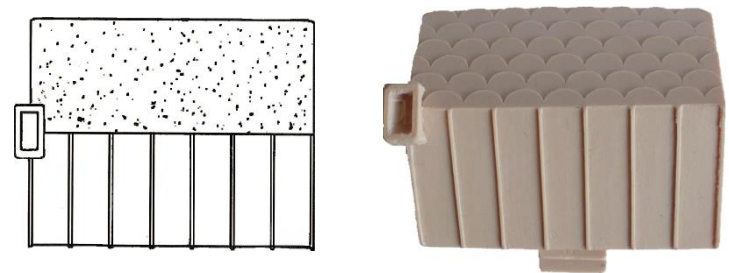
## Results: Tactile Graphics

- Overall Accuracy: 80%
- Distribution of errors not due to chance (Person  $X^2$ )  $p = 0.002$

Item 1: Accuracy 40%



Item 11: Accuracy 40%





# Analysis 1: Tactile Graphics & Math

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## Results: Math Achievement

- Overall Accuracy:

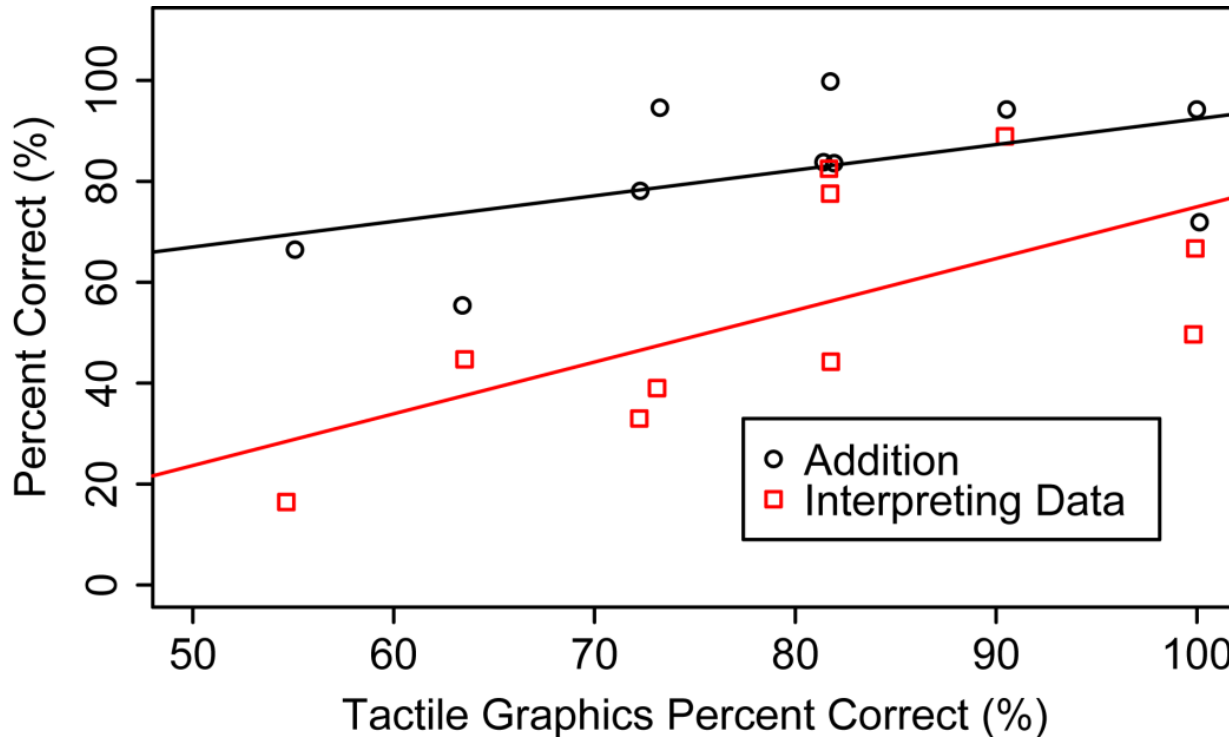
Addition (w/o TG): 82%      Data (w/ TG): 54%       $p=0.006$

- Age Equivalence:

Addition (w/o TG): 11.6 y      Data (w/ TG): 10.2 y       $p=0.034$

# Analysis 1: Tactile Graphics & Math

## Results: Tactile Graphics + Math



Addition:  
 $r = 0.39$ ,  $p = 0.26$

Interpreting Data:  
 $r = 0.64$ ,  $p = 0.047$

# Analysis 1: Tactile Graphics & Math

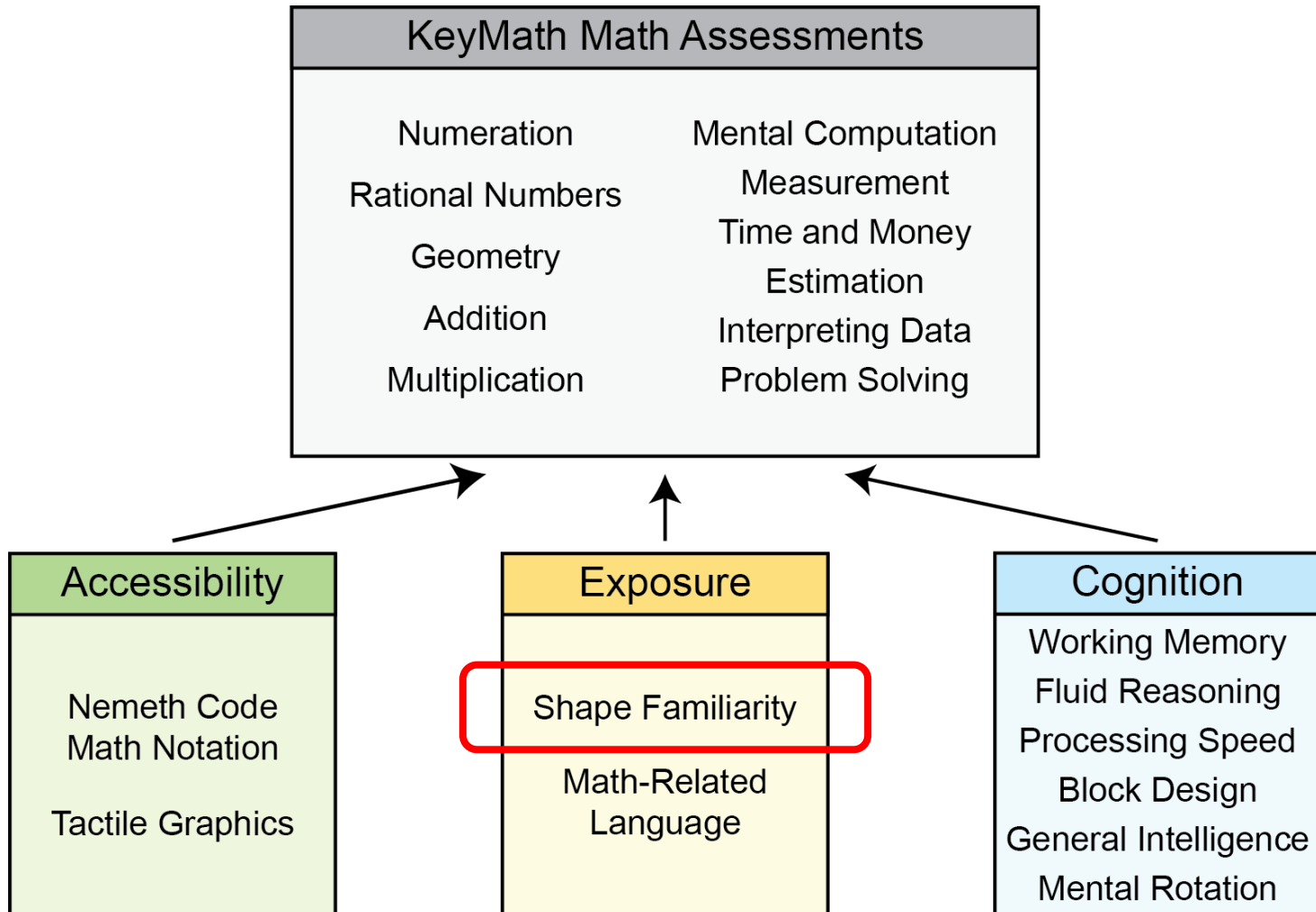
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## Summary

- Poorer performance on some TG items
  - May be associated with visual cues
- Poorer performance on math containing TG
  - Both in terms of accuracy & age equivalence
- TG performance predicts math performance
  - Only when math contains TGs

# Analysis 2: Shape Familiarity

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# Analysis 2: Shape Familiarity

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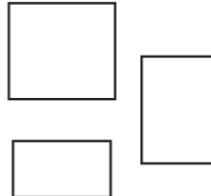
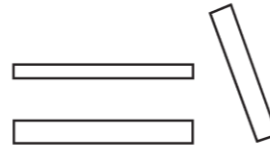
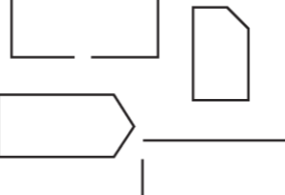


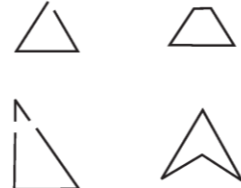
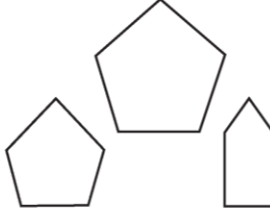
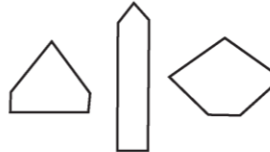
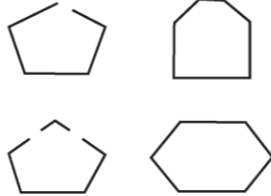
## Tactile-Graphic Shape Familiarity

(congenitally blind participants only)

Question:

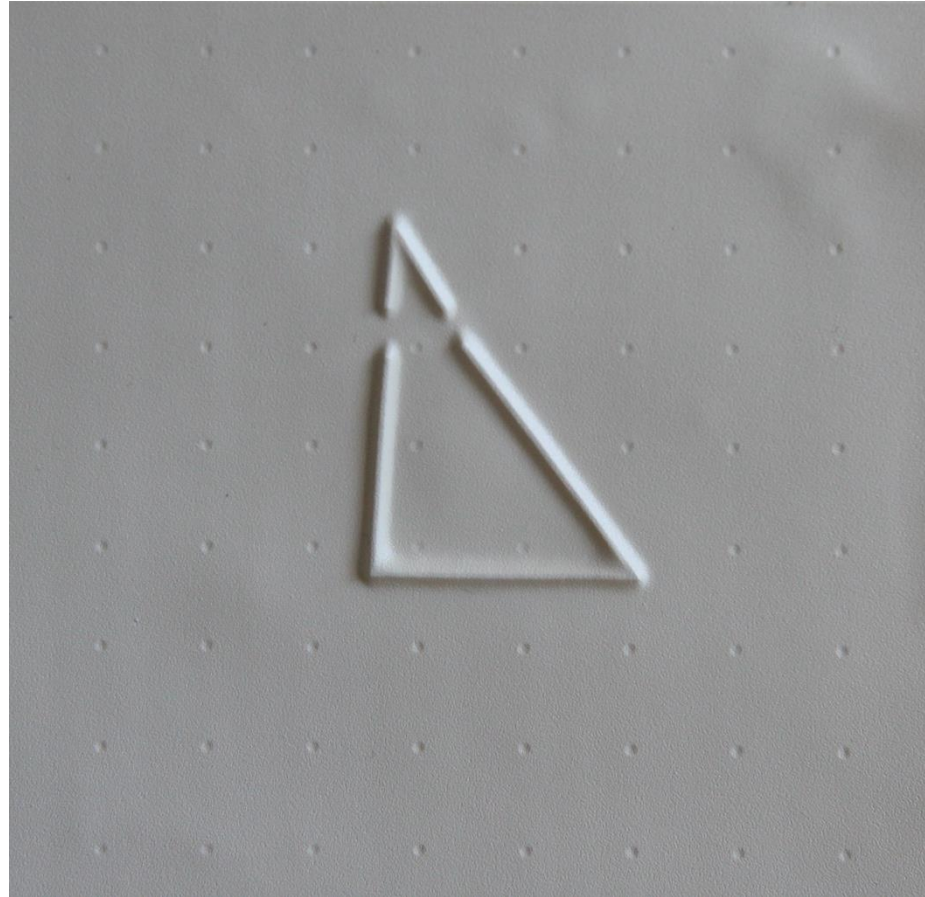
- 1) How well are students doing with TGs of simple shapes?

# Analysis 2: Shape Familiarity

	Typical	Atypical	Non-Valid
Circle			
Rectangle			
Triangle			
Pentagon			

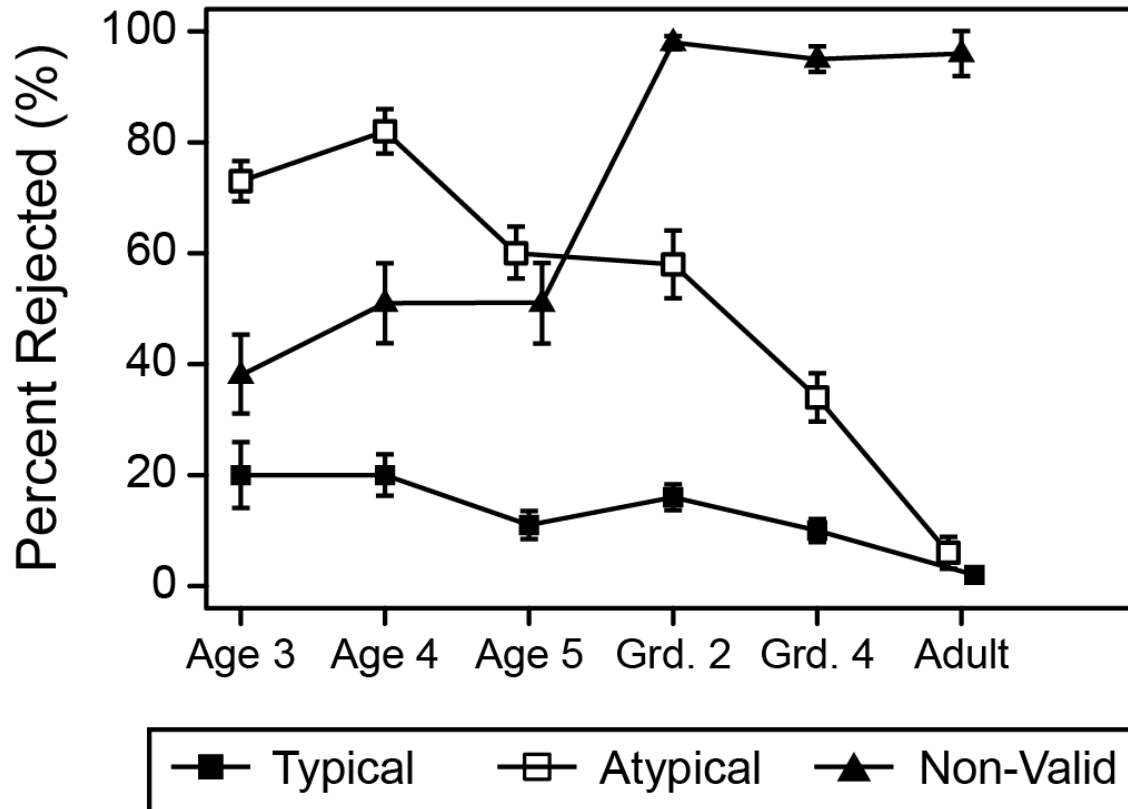
# Analysis 2: Shape Familiarity

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# Analysis 2: Shape Familiarity

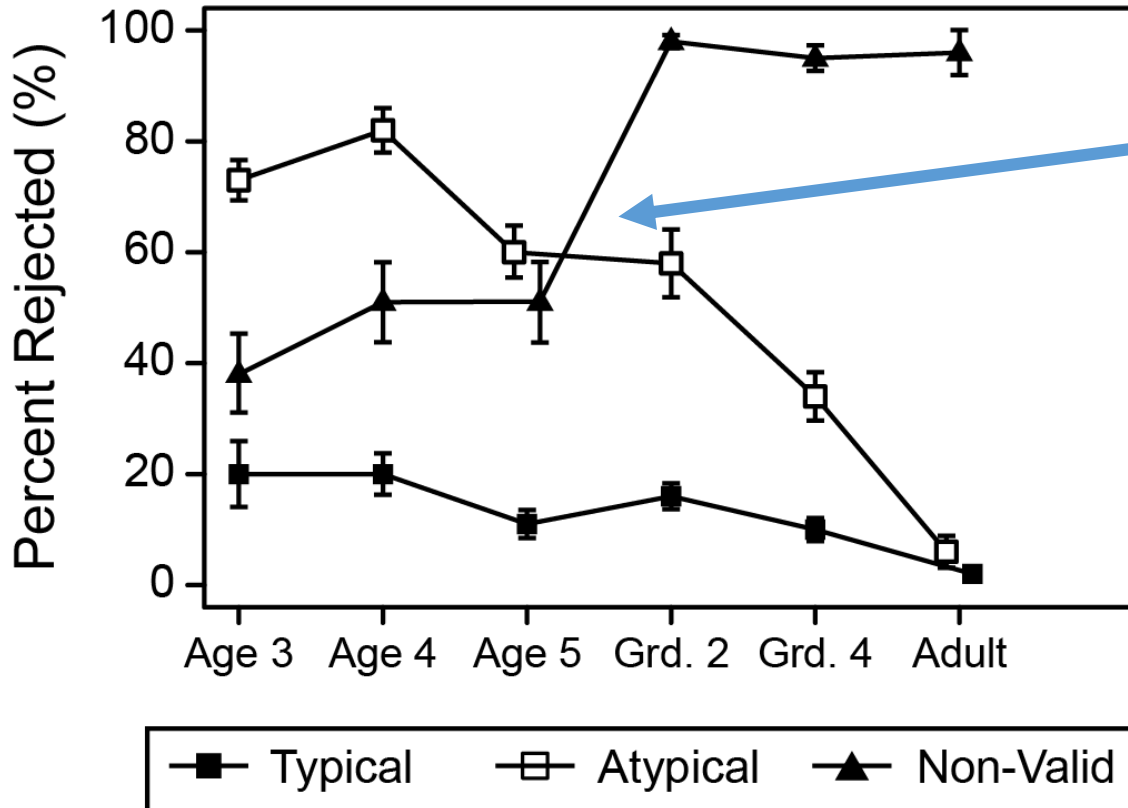
## Sighted Results





# Analysis 2: Shape Familiarity

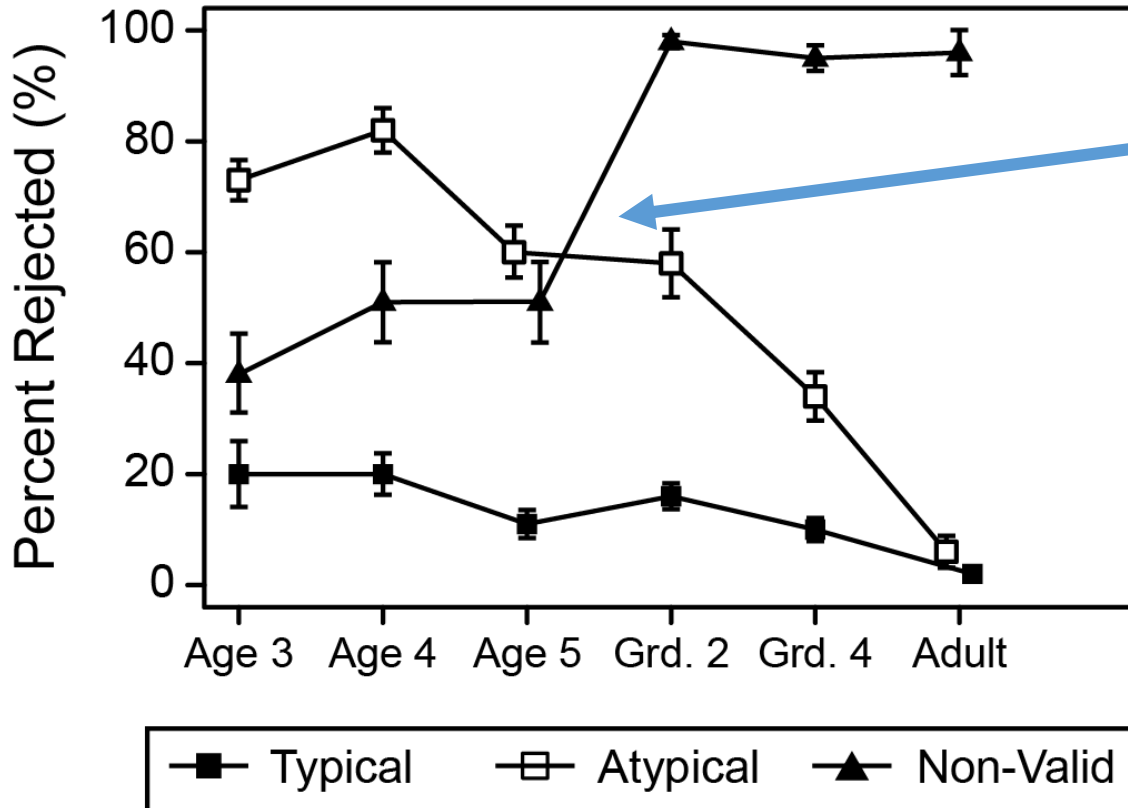
## Sighted Results



Explicit instruction necessary for concrete-to-abstract shift.

# Analysis 2: Shape Familiarity

## Sighted Results

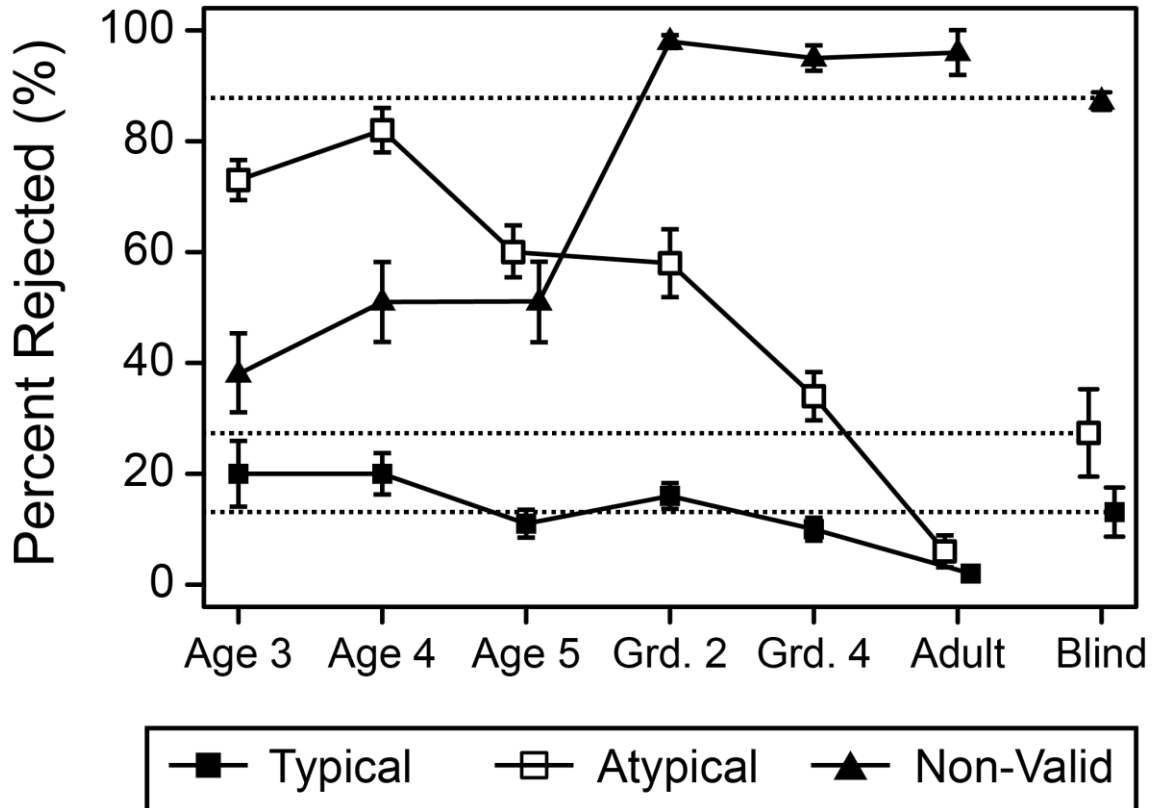


Explicit instruction necessary for concrete-to-abstract shift.

Know from other domains that informal experience w/ concepts prior to explicit instruction necessary for continued growth.

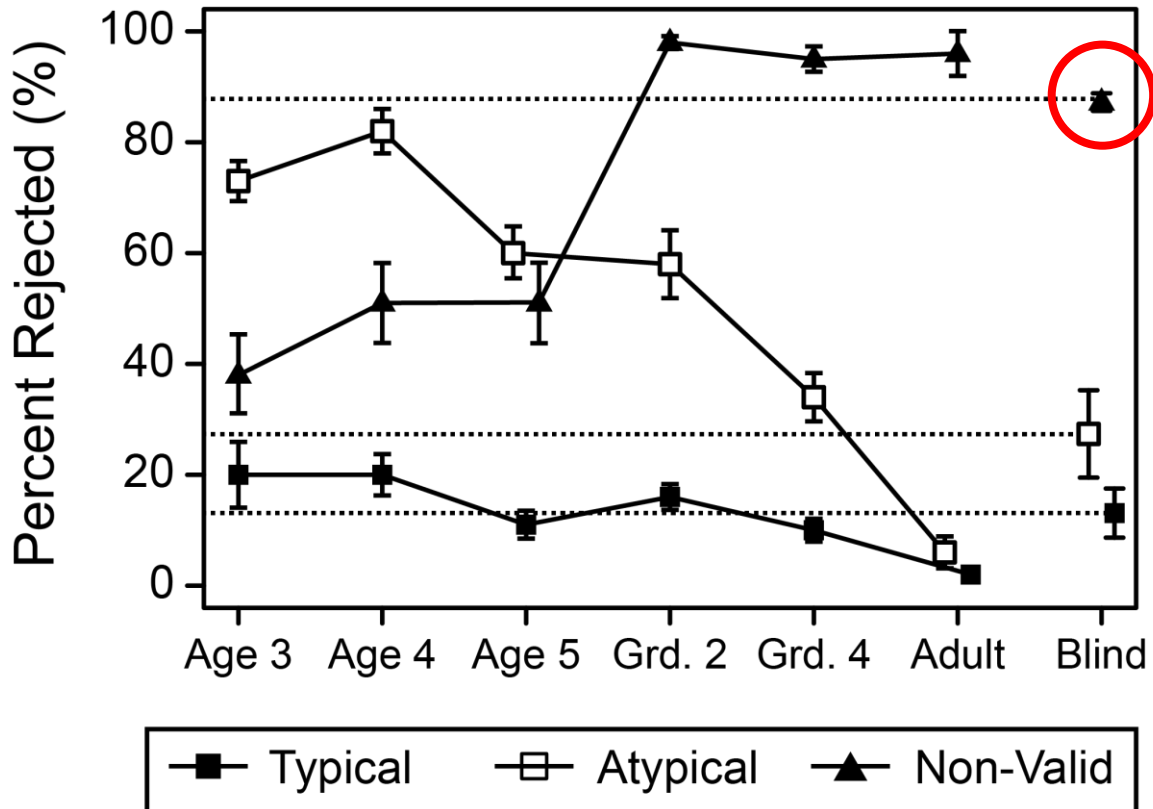
# Analysis 2: Shape Familiarity

## All Results



# Analysis 2: Shape Familiarity

## All Results



Lower than 2<sup>nd</sup> Grade Level

Typical & Atypical

$r = 0.69, p = 0.007$

Typical & Non-Valid

$r = 0.14, p = 0.64$

Atypical & Non-Valid

$r = -0.23, p = 0.42$

# Analysis 2: Shape Familiarity

## Participants' (who are Blind) Results

No effect of Age or Gender on Accuracy – Only shape and type affect accuracy.

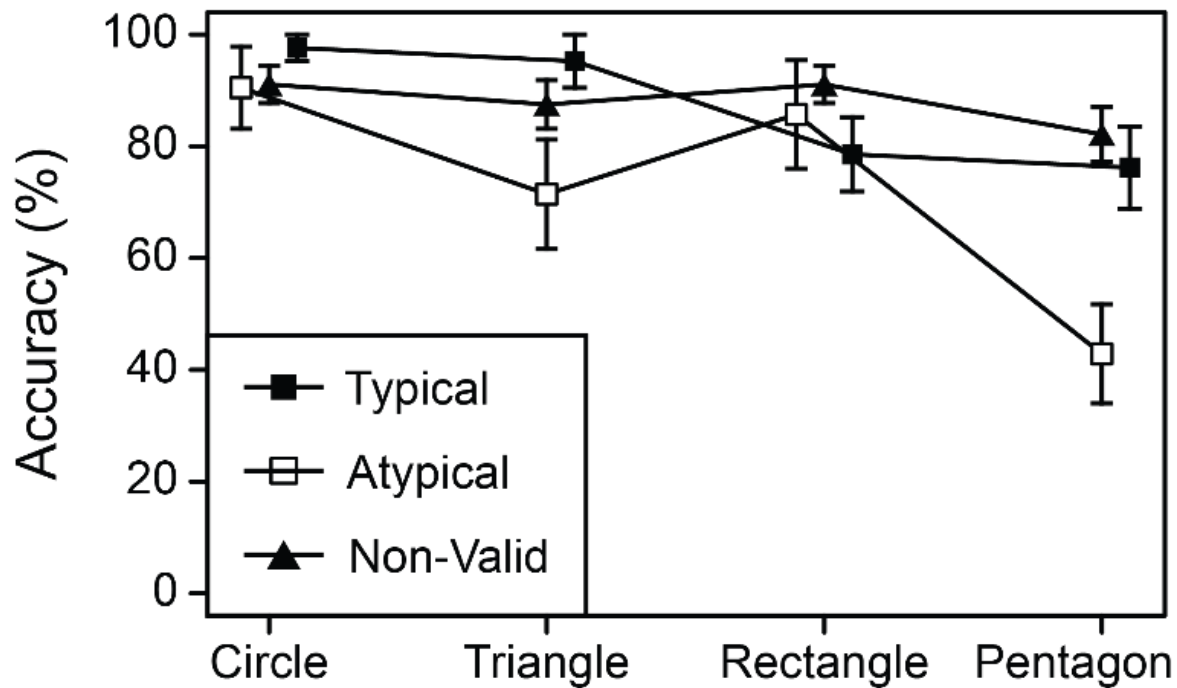
**Table 1. Shape classification accuracy model results.**

Main Effect	Marginal F Test	p Value
Age	F(1,11) = 1.01	0.337
Gender	F(1,11) = 0.45	0.515
Shape	F(3,132) = 12.66	< 0.001 ***
Type	F(2,132) = 7.11	0.001 **
Shape x Type	F(6,132) = 4.24	< 0.001 ***
Shape x Gender	F(3,132) = 1.04	0.376
Type x Gender	F(2,132) = 0.94	0.392
Shape x Type x Gender	F(6,132) = 1.18	0.319

\* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

# Analysis 2: Shape Familiarity

## All Results



Based on Tukey HSD test, worse ( $p < 0.05$ ) with:

- Atypical shapes
- Atypical pentagons

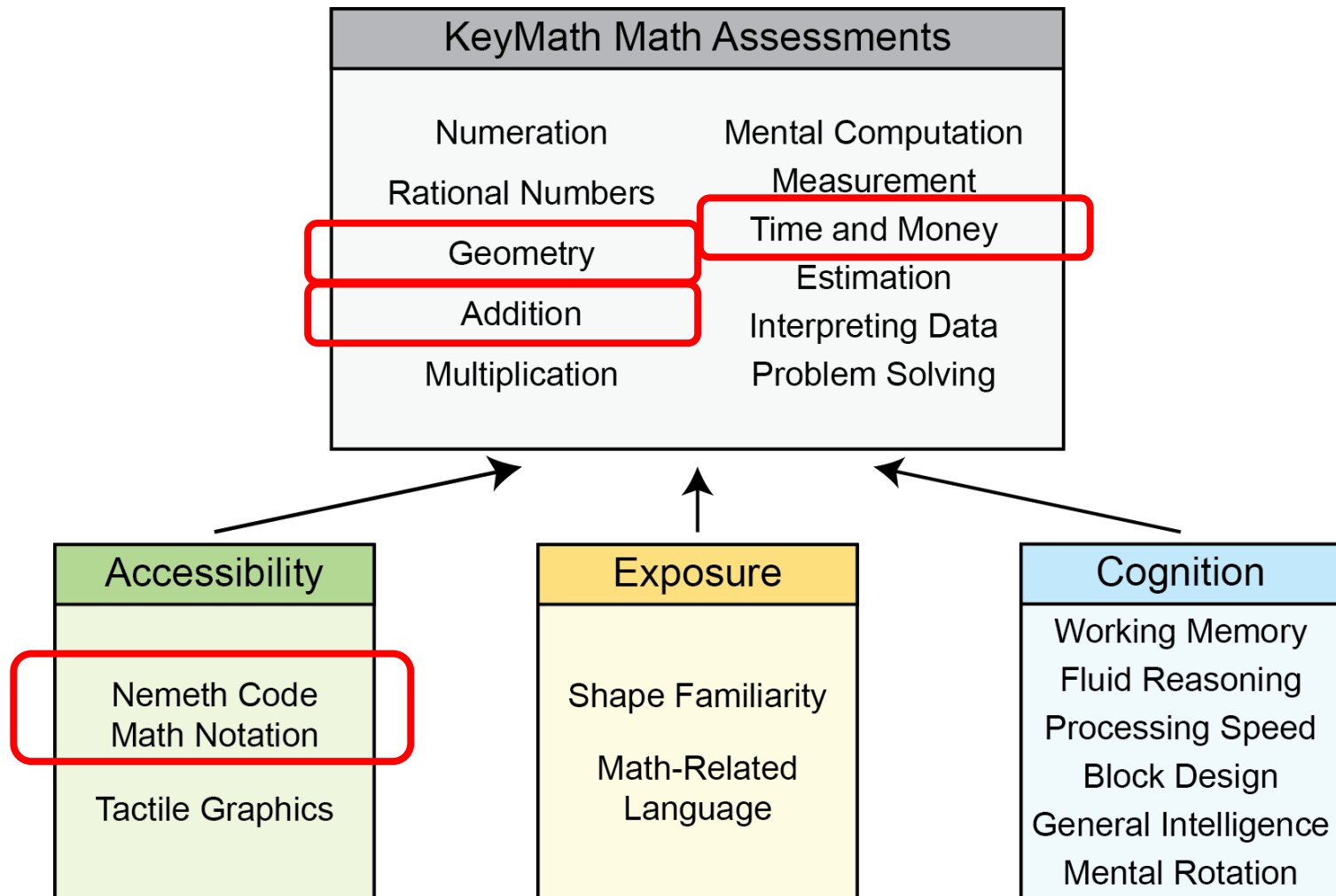
# Analysis 2: Shape Familiarity

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## Summary

- Participants were worse with:
  - Atypical shapes in terms of accuracy.
  - Non-valid shapes in terms of age-equivalence.
- Accuracy not predicted by age or gender.
- May reflect lower incidental exposure
  - Explicit instruction: concrete-to-abstract shift
  - Not sufficient for ongoing knowledge construction

# Analysis 3: Nemeth & Math Performance





# Analysis 3: Nemeth & Math Performance

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## Nemeth Abilities

## Math Achievement

- Academic Nemeth Topic
  - Addition
- Academic Non-Nemeth Topic
  - Geometry
- Non-Academic Application
  - Time and Money

Question:

- 1) Does Nemeth performance predict math performance?

# Analysis 3: Nemeth & Math Performance

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## Measuring Nemeth Abilities

### Items:

- 15 items reading Nemeth
- 15 items producing Nemeth (not discussed here)

### Difficulty range:

- Easy: write numbers & simple expressions
- Medium: degree symbol, square roots, ratios, exponents
- Difficult: involve summation, null set, infinity symbols

Average accuracy: 70% (SD = 10%)

# Analysis 3: Nemeth & Math Performance

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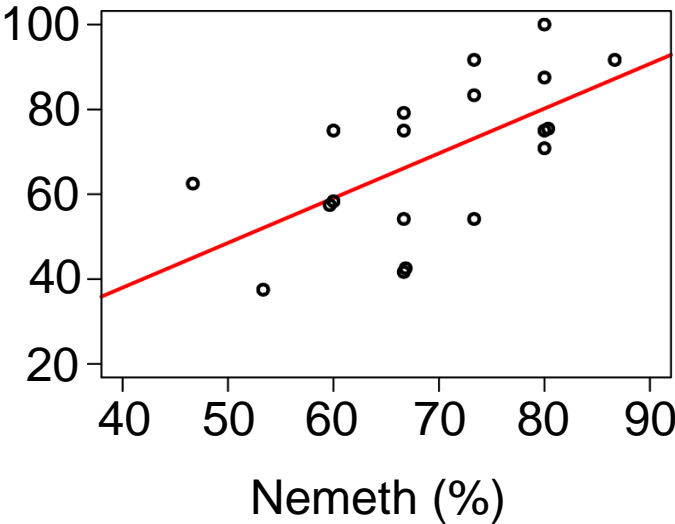
## Measuring Math Achievement: KeyMath

- 1) Academic Nemeth Topic: Addition
- 2) Academic Non-Nemeth Topic: Geometry
- 3) Non-Academic Application: Time and Money

# Analysis 3: Nemeth & Math Performance

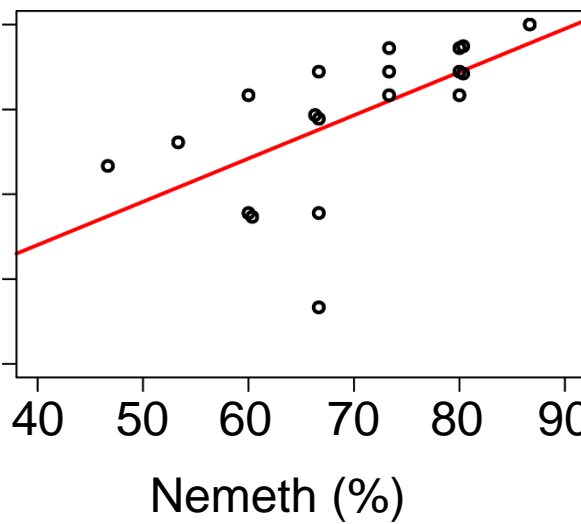
## Measuring Math Achievement: KeyMath

### Addition



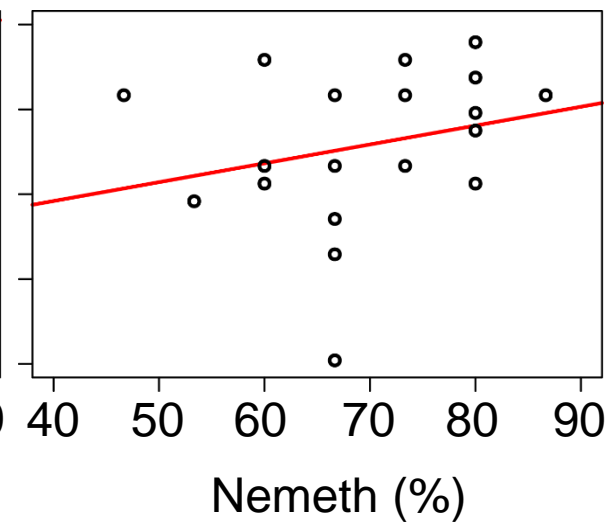
$r = 0.61, p = 0.005$

### Geometry



$r = 0.61, p = 0.006$

### Time & Money



$r = 0.25, p = 0.300$

# Overall Summary / Concluding Thoughts

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- Performance w/ simple TGs predicts performance with math TGs
- Poor performance w/ TGs may be due to lower incidental exposure – explicit instruction is not enough!
- Nemeth is related to math performance, including non-Nemeth academic math, but maybe not applications.

# Thank you!

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Results will be posted at:

[www.valeriemorash.com](http://www.valeriemorash.com)

As they become available.