Cognitive Correlates of First Graders' Fraction Knowledge

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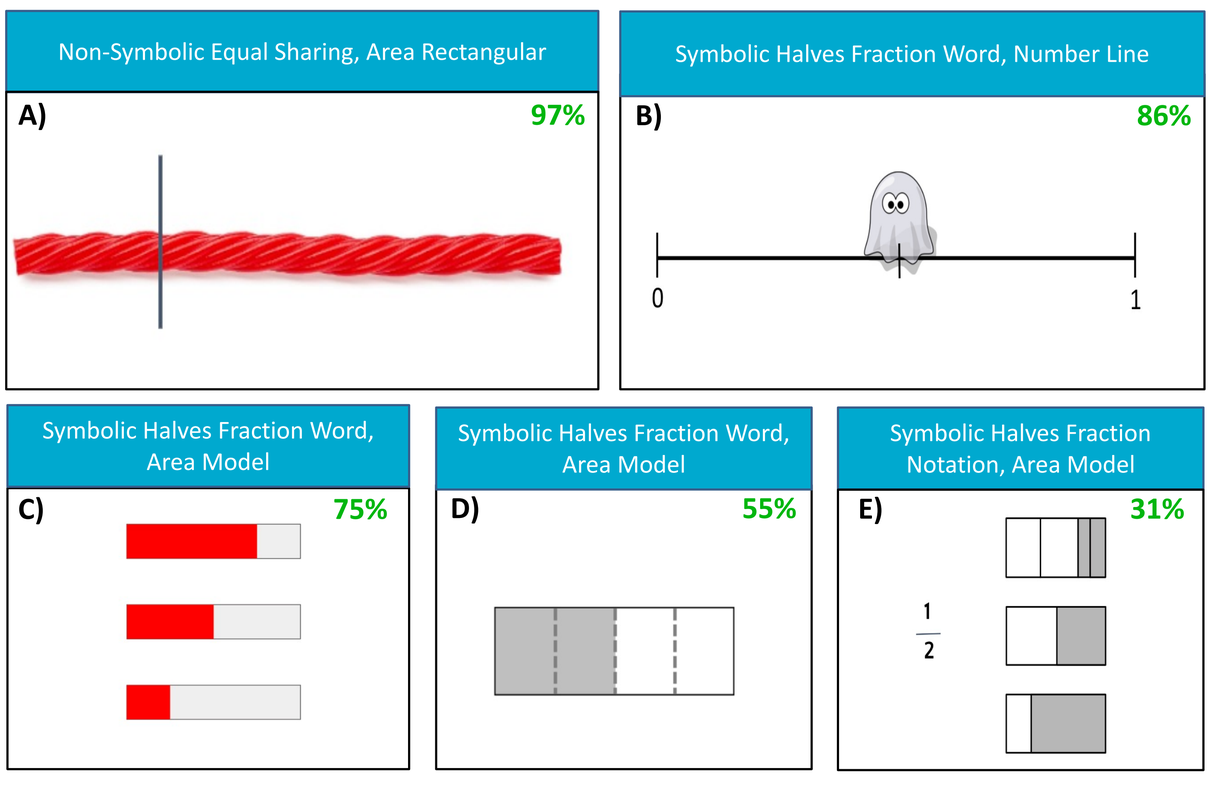
Background & Aim

- Many students struggle to understand fractions, which can lead to mathematics difficulties in later grades (Hansen et al., 2017).
- There are substantial individual differences in children's fraction knowledge when formal fraction instruction begins (Resnick et al., 2016).
- Recently, as part of a larger project, we found considerable variation in informal fraction understanding even earlier, as children begin first-grade (Miller-Cotto et al., 2022).
- Here, we examine how these early individual differences in informal-related fraction knowledge relate to whole number competencies, spatial skills, and other cognitive skills associated with math learning.

Method

- *Participants* were 106 first graders (46% female, 54% male; 58% White, 18% Asian, 7% two or more identifiers, 1% Hispanic, 10% unknown) from three schools (one independent and two parochial).
- *Measures:*
  - Researcher-Developed Fractions Assessment (α = .82)
    - *See Figure 1 for examples of different categories of items*
  - Whole Number Knowledge (*Screener for Early Number Sense, SENS,* α= .85)
  - Whole Number Line Estimation (α = .88)
  - Inhibitory Control (Hearts & Flowers, α = .82)
  - Spatial Scaling (α = .88)
  - Working Memory (Forward Span & Backward Span, α =.87)
  - Proportional Reasoning (α = .94)
  - Vocabulary (NIH Picture Vocabulary, α = .94)
- The fractions assessment and whole number knowledge tasks were administered using paper booklets. All other measures were administered using an iPad.
- All tasks were administered in the same order (as listed above), one-on-one with a trained member of the research team at school.
- Measures were administered at two time points during the school year (start and middle) to reduce student fatigue.

Figure 1. Categorized examples from the fractions assessment – involving halves



Note. **A)** Children were asked if two friends would get the same size piece. **B)** Children were asked whether or not the ghost was half of the length from 0 to 1. **C)** Children were asked to recognize one-half (spoken). **D)** Children were asked how much of the shape was shaded. **E)** Children were asked to match the notation to the picture. *Percentage of correct responses is reported in green.*

Results

- All correlations with the fractions assessment were significant, r = -.19 to r = .63, except for inhibitory control.
- Red shading represents the strength of the correlation.

Measures	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1. Fractions Assessment							
2. Whole Number Knowledge	**0.63***						
3. Whole Number Line Estimation PAE	**-0.51***	**-0.65***					
4. Spatial Scaling	**0.26***	**0.23***	-0.17				
5. Working Memory	**0.43***	**0.43***	**-0.39***	**0.29***			
6. Proportional Reasoning PAE	**-0.19***	**-0.21***	**0.24***	-0.01	-0.08		
7. Vocabulary	**0.30***	**0.27***	**-0.20***	**0.26***	**0.26***	0.13	
8. Inhibitory Control	-0.18	**-0.27***	**0.26***	**-0.31***	**-0.22***	0.11	-0.15

Note. Significant correlations are bolded and *p < .05.

- A linear regression analysis revealed that whole number knowledge was the **only** significant predictor of early fraction skill when all the tasks were included in the model.

Model Coefficients – Fractions Assessment			
Predictor	**β**	**SE**	**p**
Whole Number Knowledge	0.42	0.17	< .001
Whole Number Line Estimation PAE	-0.13	0.09	0.193
Spatial Scaling	0.07	0.05	0.370
Working Memory	0.15	0.12	0.095
Proportional Reasoning PAE	-0.08	0.09	0.332
Vocabulary	0.12	0.02	0.143
R^2 = 0.450			

Significance

- We found that when accounting for all other variables, only whole number knowledge explained a significant amount of the variance in first graders' fraction knowledge. That is, whole number knowledge held more weight in accounting for differences in fraction knowledge.
- This is the first study to look at all these variables in combination.
- Whole number knowledge and early informal fraction knowledge may reflect an integrated early understanding of the full mathematical system.
- However, at later ages, knowledge about integers can interfere with using formal fractions, perhaps due to notational confusion (Ni & Zhou, 2005).

References

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