Age-Related Differences in Brain Responses in Mathematical Problem-Solving Among Children and Adolescents

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Introduction

- Math word problems bridge mathematical concepts with real-world applications, demanding both math skills and reading comprehension (Boonen et al., 2016).
- Adults exhibited an operation-specific lexical consistency effect at both the behavioral and neural levels during word problem solution (Ng et al., 2021).
- Here, we studied how problem descriptions impacted math word problem solutions in youth using fMRI.

Methods

- Participants: 21 children (9F/12M, aged 8.85-12.67 years) and 27 adolescents (15F/12M, aged 12.33-18.44 years).
- We adopted a 2×2×2 design to examine the effects of lexical consistency (consistent/inconsistent), arithmetic operations (addition/subtraction), and participant age (adolescents/children).

	Addition	Subtraction
Consistent	Tom has 6 books. Jerry has 10 books **more** than Tom. How many books does Jerry have?	Tom has 6 books. Jerry has 3 books **less** than Tom. How many books does Jerry have?
Inconsistent	Tom has 6 books. Tom has 4 books **less** than Jerry. How many books does Jerry have?	Tom has 6 books. Tom has 2 books **more** than Jerry. How many books does Jerry have?

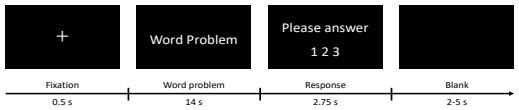

Figure 1. Procedure of math word problem task. Participants selected correct answer for each problem. After the scanning session, they completed a self-paced word problelm task for more accurate reaction times.

Results

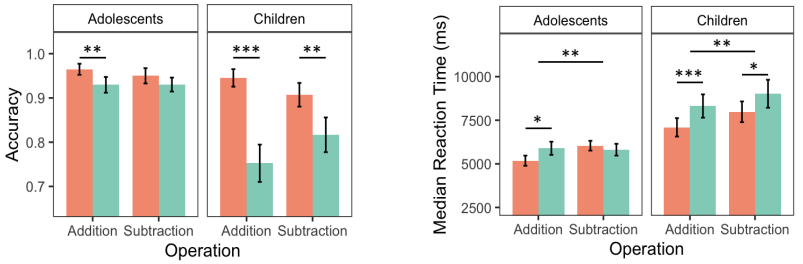

Figure 2. Behavioral results between children and adolescents. In accuracy, stronger consistency effects were observed in addition problems than in subtraction problems. In reaction time, adolescents exhibited a two-way interaction between consistency and operation, while children showed main effects for both consistency and operation.

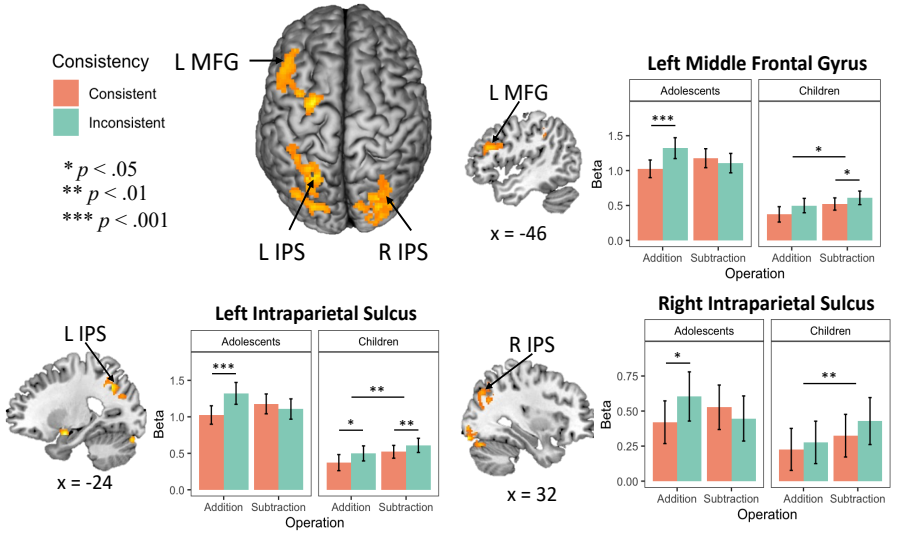

Figure 3. Three-way interactions among age group, lexical consistency, and arithmetic operation. Adolescents showed two-way interactions between consistency and operation; whereas children showed main effects of both consistency and operation.

Conclusion

- Mainly in the fronto-insular-parietal network, there is a three-way interaction between age, lexical consistency, and operation.
- Children are influenced by lexical consistency and arithmetic operations separately during word problem solving, whereas adolescents consider both relational terms and arithmetic operations.
- The maturation of cognitive mechanisms in mathematical problem-solving is fundamental for designing educational interventions.

References

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- Ng, C. T., Lung, T. C., & Chang, T. T. (2021). Operation-specific lexical consistency effect in fronto-insular-parietal network during word problem solving. *Frontiers in Human Neuroscience,* 15, 631438.

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