Strategy over operation
Neural activation in subtraction and multiplication during fact retrieval and procedural strategy use in children

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Background

- Arithmetic development characterized by strategy shifts
- Adult arithmetic brain network modulated by strategy use (Grabner et al., 2009, Neuropsychologia)
- In adults, no operation effects on activation when taking strategies into account (Tschentscher & Hauk, 2014, NeuroImage)

Why this study?

- First to investigate children's arithmetic activation as a function of strategy use
- Trial-by-trial approach

Methods

Participants

- 26 typically developing 4th graders (*M* = 9.56)
  - 17 ♂, 9 ♀
  - 23 right-handed, 3 left-handed
  - 20 participants remaining after motion correction

Procedure

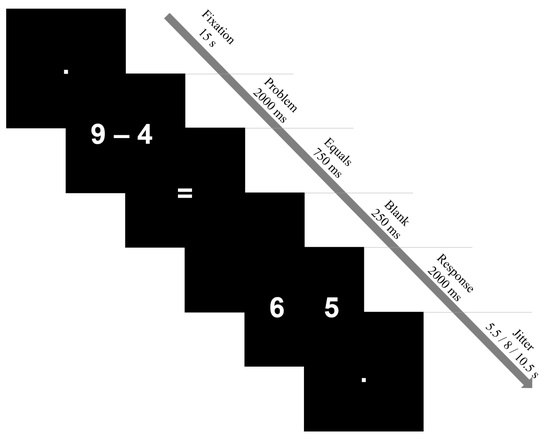
Standardized & strategy assessment → ± 3 week interval → MRI scanning session

Strategy assessment

- 100 arithmetic items
  - 50 multiplication
  - 50 subtraction
  - Items expected to elicit retrieval (e.g., 8 – 4 or 2 x 3) or procedure (e.g., 24 – 7 or 4 x 13)
- Trial-by-trial verbal self-reports
- Classified as *retrieval*, *procedure*, or *undefined*

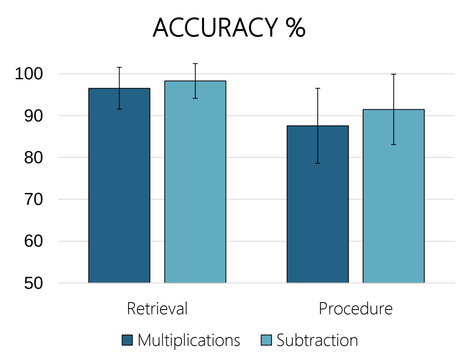
Scanning task

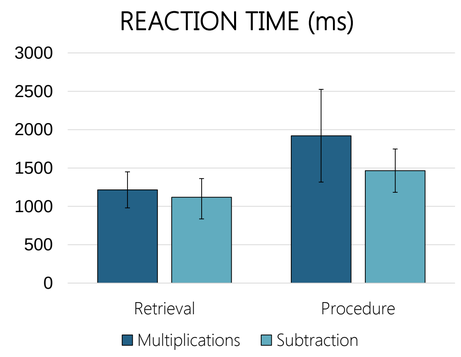
Event related fMRI: 4 runs



Results

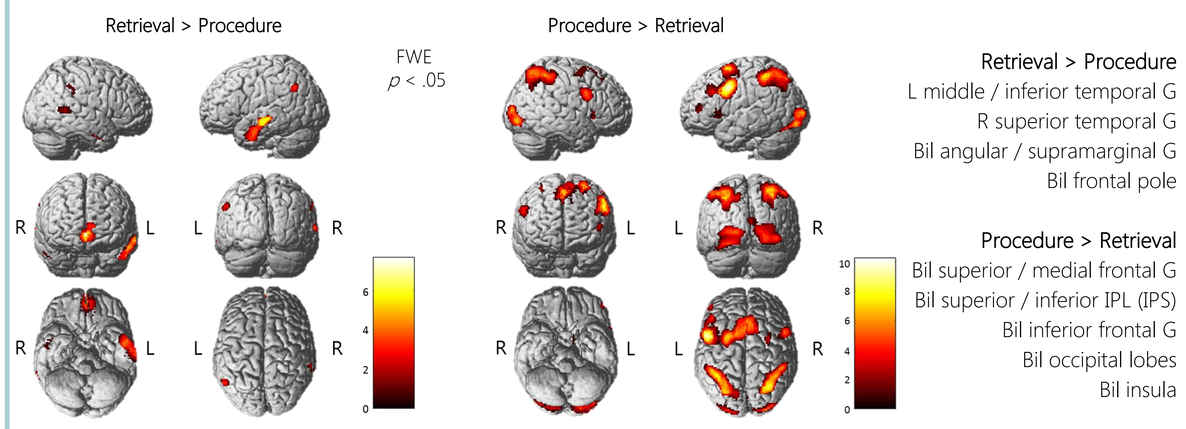
Behavioral data





Imaging

1. Strategy



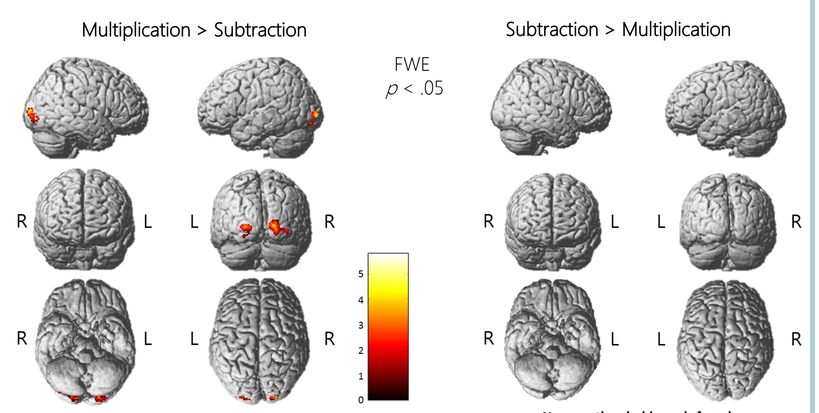
Retrieval > Procedure
L middle / inferior temporal G
R superior temporal G
Bil angular / supramarginal G
Bil frontal pole

Procedure > Retrieval
Bil superior / medial frontal G
Bil superior / inferior IPL (IPS)
Bil inferior frontal G
Bil occipital lobes
Bil insula

2. Operation

Multiplication > Subtraction
Bil occipital lobe
Primary visual cortex

Subtraction > Multiplication
No suprathreshold voxels found



3. Strategy × Operation

No strategy × operation interaction

4. Control Analysis

- Control analysis for task difficulty effects (TDE)
  - Hard retrieval vs. easy procedure contrasts
  - Significantly reduced TDE, but very similar imaging results

Conclusion

- Alternate brain networks found for different strategies
  - Procedural strategy = mainly decomposition of operands
- Less deactivation for retrieval vs. increased activation for procedure
- No differences in operation → entirely explained by strategies
- Future studies
  - Longitudinal / atypical populations / cross-educational / connectivity

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