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Introduction
- Retrieval and transformation are highly correlated in algebra problem solving:
  - Solve \( 2x + 1 = 5 \) Retrieve \( 5 - 1 = 4 \) Transform \( 2x = 4 \) Retrieve \( 4 / 2 = 2 \) Transform \( x = 2 \) Respond 2

- The current instantiation of the ACT-R theory (Anderson, 2005) associates retrieval and transformation with activity in prefrontal and posterior parietal cortex, respectively
- Activity in these regions are likewise correlated during naturalistic problem solving (Anderson et al., 2003)
- Can we isolate the processes of transformation and retrieval in algebra problem solving and manipulate them independently?
- If so, can we also isolate activity in their neural correlates?

Method
- 20 participants run in a BOLD fMRI study
- Algebra equations were created that needed to be solved in 2 phases:
  - Transformation phase: isolate x from a and b
  - Retrieval phase: calculate the value of x given the numerical values of a and b
- The transformation and retrieval could both be either high or low difficulty

Results and Modeling
- Manipulating retrieval load of algebra problems results in differential activity in both prefrontal and posterior parietal cortex
- Manipulating transformational requirements of algebra problems results in differential activity in both prefrontal and posterior parietal cortex

- Why did our manipulations fail to isolate the activity in these regions?
  - Explanation 1: These regions are not functionally distinct as characterized by ACT-R
  - Explanation 2: Our task manipulations failed to properly isolate retrieval and transformation

- We designed two ACT-R models to determine the plausibility of Explanation 2
  - Pure Model: Encompassed our initial assumptions about the design but failed to fit the RT data \((R^2 = .50)\)
  - Mixed Model: Assumed that both manipulations had retrieval and transformation components and fit the RT data well \((R^2 = .94)\)

Conclusions
- There is a lot of difficulty isolating the basic cognitive processes characterized by ACT-R
- The difference between the roles of prefrontal and posterior parietal cortices in algebra problem solving remains unclear
- Using cognitive modeling can help in the interpretation of behavioral and neuroimaging data

References