Dual Mechanisms of Cognitive Control Over Interference

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INTRODUCTION

- Cognitive control protects goal-directed behavior from interference (Kane & Engle, 2002).
- How does cognitive control protect from interference?
- Cohen et al. models: proactive control mechanisms can prevent interference (e.g., Braver, Cohen & Barch, 2000)
- Active maintenance of goal / context representations in PFC
- Top-down bias to task-relevant pathways; better inhibition of task-irrelevant pathways
- However, recent studies of interference on working memory have shown:
  - Single PFC region (BA 45) more active for interference trials (Jordés et al., 1998)
  - Activation is greater for interference trials only at time of probe (O’Donóstio et al. 1999)
  - Suggests existence of reactive control mechanisms that resolve interference

PREDICTIONS

- Reactive Control: Low Expectancy
  - Neural activation:
    - Recent Negatives > Novel Negatives
    - After presentation of the probe
  - Behavioral effects:
    - Sizeable interference
    - Significant facilitation effects
  - High gF subjects will show proactive control, low gF subjects will not
  - Proactive control prevents interference, reducing later need for reactive control
- Proactive Control: High Expectancy
  - Neural activation:
    - High Expectancy > Low Expectancy
    - Sustained during the retention interval
  - Behavioral effects:
    - Reduced interference
    - No facilitation effects
  - High gF subjects will show reduced reactive control activity in high expectancy condition

BEHAVIORAL RESULTS (pilot study)

- Interference and Facilitation Effects
- Interference and Facilitation Effects (median split)
- High gF group
  - p = .05
  - Low gF group
  - p = .10

fMRI RESULTS

- Reactive Control Activity:
  - Activity greater for recent negatives than novel negatives at the time of the probe
  - 9 ROIs identified
- Proactive Control Activity:
  - Activity greater during retention interval for high expectancy compared to low expectancy
  - 5 ROIs identified

CONCLUSIONS

- Reactive control is utilized when interference is unexpected
- Proactive control is utilized when interference is predicted, but apparently only by high gF individuals
- These control mechanisms are associated with different temporal characteristics and different brain regions
- Individual differences in gF may be partially due to the ability to maintain information in lateral PFC, not the ability to use reactive control to resolve interference

DESIGN

Item Recognition Paradigm:

- 5-word memory set (2500 ms)
- Blank screen delay (5000 ms)
- Single-probe (2000 ms)
- Novel Positives
  - Recent Positives
  - Recent Negatives
  - Novel Negatives

Three within-participants factors:

- Target status: was probe in current memory set (positive) or not (negative)
- Recency: was probe in previous memory set (recent) or not (novel)
- Interference Expectancy (varied across blocks):
  - Low expectancy: Recency (familiarity) and target status were mostly congruent
    - 80% of negatives were recent, 80% of positives were novel
  - High expectancy: Recency (familiarity) and target status were mostly incongruent

Behaviors:

- No facilitation effects
- Reduced interference
  - High gF subjects will show reduced reactive control activity in high expectancy condition

fMRI METHODS

- event-related (fMRI) = whole brain, 1.5 T (Vision system)
- asymmetric spin-echo EPI sequence; 3.75 x 3.75 mm in-plane resolution for functional images
- 18 contiguous 8mm slices; reassembled into 3mm cubic voxels
- movement corrected; intensity normalized; artifact corrected
- warped to standard atlas space (Talairach & Tourneaux 1988)

- participants = random effect for statistical analyses
- GLM-based analysis: dissociate sustained (STATE) from transient (ITEM) effects (Donakdson et al. 2001)

- Only item effects discussed here

Behavioral Measures:

- Interference and facilitation effects (median split)
- High gF group
  - p = .05
  - Low gF group
  - p = .10

CONCLUSIONS

- Data generally support the existence of dual mechanisms of cognitive control
- Reactive control is utilized when interference is unexpected
- Proactive control is utilized when interference is predicted, but apparently only by high gF individuals
- These control mechanisms are associated with different temporal characteristics and different brain regions
- Individual differences in gF may be partially due to the ability to maintain information in lateral PFC, not the ability to use reactive control to resolve interference