Dual Mechanisms of Cognitive Control Over Interference

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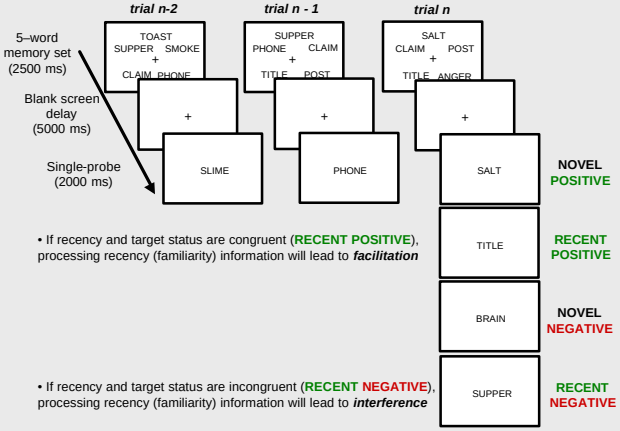
INTRODUCTION

- 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, 2002)
  - 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 (Jonides et al., 1998)
  - Activation is greater for interference trials only at time of probe (D'Esposito et al, 1999)
  - Suggests existence of **reactive control** mechanisms that ***resolve*** interference
- **Perhaps both types of cognitive control exist!!!!**
- Which mechanism is utilized may depend on various factors:
  - **Interference Expectancy**
    - If interference is unexpected (driving on sunny day), reactive control mechanisms used
    - If interference is expected (driving on rainy day), proactive control mechanisms preferred
  - **Fluid Intelligence (gF)**
    - Fluid intelligence possibly related to active maintenance abilities
    - **High gF** individuals may be more successful with **proactive control** mechanisms
    - **Low gF** individuals may prefer (or fall back on) **reactive control** mechanisms

DESIGN

Item Recognition Paradigm:



- If recency and target status are congruent (**RECENT POSITIVE**), processing recency (familiarity) information will lead to ***facilitation***
- If recency and target status are incongruent (**RECENT NEGATIVE**), processing recency (familiarity) information will lead to ***interference***

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 novel, 80% of positives were recent
  - ***High expectancy***: Recency (familiarity) and target status were mostly *incongruent*
    - 80% of negatives were recent, 80% of positives were novel

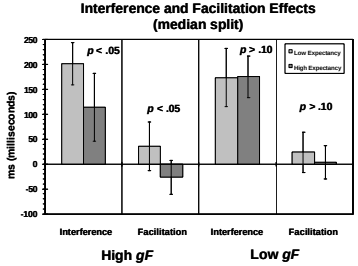
PREDICTIONS

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

fMRI METHODS

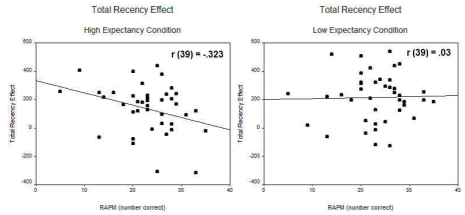
- **event-related fMRI** = whole brain, 1.5 T (Vision system)
- asymmetric spin-echo EPI sequence; 3.75 x 3.75 mm in-plane resolution for functional images
- 16 contiguous 8mm slices; resampled into 3mm cubic voxels
- movement corrected, intensity normalized, artifact corrected;
- warped to standard atlas space (Tailarach & Tourneaux 1988)
- participants = random effect for statistical analyses
- GLM-based analysis: dissociate sustained (STATE) from transient (ITEM) effects (Donaldson et al. 2001)
- (Only item effects discussed here)

BEHAVIORAL RESULTS (pilot study)



HIGH gF GROUP (n = 20; mean RAPM = 28.05, SD = 2.929)
- Expectancy x recency x target interaction, F (1,19) = 8.015, p = .011
- Interference reduced for high vs. low expectancy, F (1,19) = 4.586, p = .045
- Facilitation reduced for high vs. low expectancy, F (1,19) = 5.941, p =.025

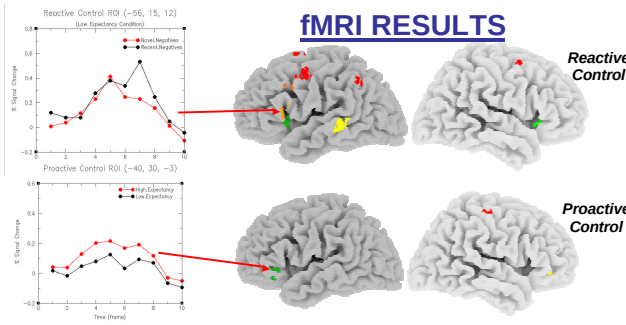
LOW gF GROUP (n = 21; mean RAPM = 18.52, SD = 5.046)
- No expectancy x recency x target interaction, F (1,20) = 0.181, p = .675
- No interference reduction in high vs. low expectancy, F (1,20) = 0.000, p = .997
- No facilitation reduction for high vs. low expectancy, F (1,20) = 0.537, p =.472



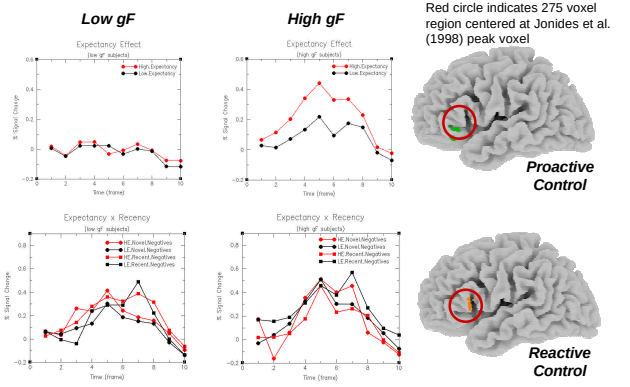
HIGH EXPECTANCY CONDITION
- **Total Recency Effect correlated with gF**
- ***r* (39) = –0.323, *p* = .04**
- **High gF subjects experience smaller recency effects than low gF subjects**

LOW EXPECTANCY CONDITION
- **Total Recency Effect uncorrelated with gF**
- ***r* (39) = +0.03, *p* = .86**
- **High gF experience similar recency effects to low gF subjects**

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



gF effects:
- high gF subjects are more likely than low gF subjects to demonstrate proactive control related activity
- low gF subjects show similar reactive control related activity in high expectancy and low expectancy blocks
- Reactive control activity does not differ between high gF and low gF Ss in the low expectancy condition
- However, high gF subjects do not demonstrate reactive control activity in the high expectancy condition.
- Instead, high gF subjects show elevated activity during the retention interval in high expectancy blocks

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 to the ability to use reactive control to resolve interference