Neural Evidence of Control State Reinstatement: an fMRI Study

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Background

Research Question

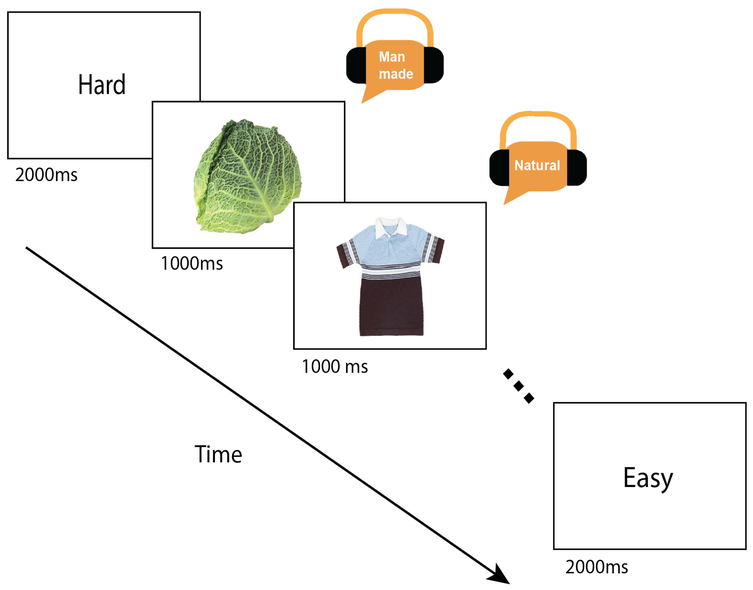
- When we experience an event, the different features associated with it (e.g., visual objects, sounds) are integrated into a memory file.
- If one feature is retrieved later, other features, even the ***mental state*** that was stored in the same file could be reinstated and could be used to help decision-making.
- The ***control state***, which is defined by a high attentional focus state, is an example.
- However, is there any biological evidence for attentional control state reinstatement? Using fMRI and visual-auditory Stroop task, the current study aims to answer this question.

Methods

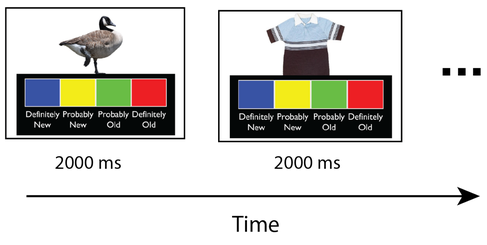
Design

- Visual-auditory Stroop task --> Classify objects as natural vs. man-made while ignoring spoken words
  - 160 trials x 4 runs
  - Hard block --> 80% incongruent trials
  - Easy block --> 20% incongruent trials
- Filler task
- Memory recognition task --> Indicate old vs. new
  - 120 trials x 2 runs

Phase 1: Auditory Visual Stroop Task



Phase 3: Memory Task

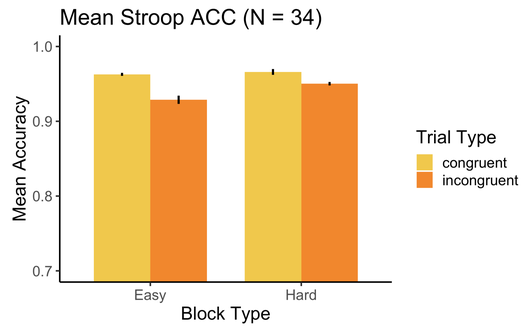


Hypotheses & Results

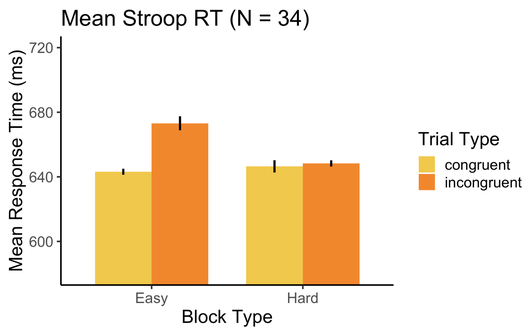
Behavioral Hypotheses

- Greater RT in incongruent vs. congruent trials
- Smaller stroop effect in hard vs. easy blocks
- Better at recalling images the were the trial image in hard blocks or in incongruent trials[1]

Smaller Stroop Effect in Hard Blocks

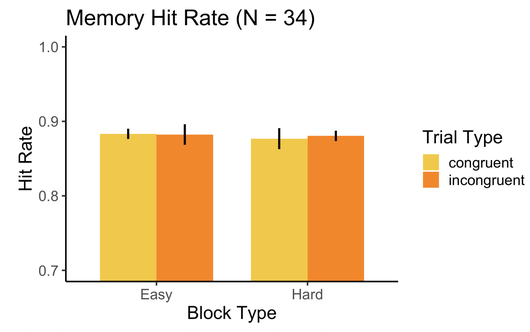


Block Type x Trial Type: $F(1,33) = 2.697$, $p = 0.11$, $\eta p^2 = 0.08$



Block Type x Trial Type: $F(1,33) = 20.95$, $p < 0.001$, $\eta p^2 = 0.39$

No Apparent Difference in Memory Performance



Block Type x Trial Type: $F(1,33) = 0.06$, $p = 0.808$, $\eta p^2 < 0.001$

Conclusions

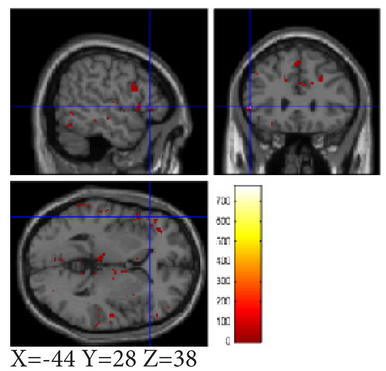
- Greater list-wide interference could induce a high control state and thus a smaller Stroop effect.
- The dlPFC, dACC, ACC and the inferior frontal cortex showed increased activation in hard blocks and similar activations were observed in memory task. This is one piece of evidence for the neural signiture of control reinstatment.

fMRI Hypotheses

- Neural signature of difficulty in the Stroop task, evidenced by increased activation in the dlPFC and dACC following incongruent trials and in hard blocks[2]
- In the memory phase, should see similar activation following incongruent trials and in hard blocks

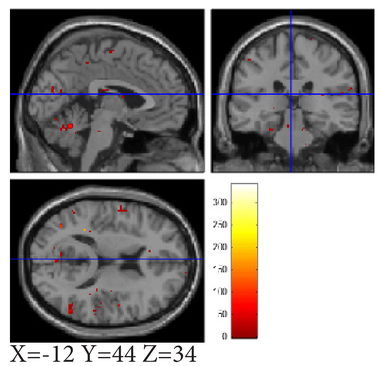
Significant Activation in the dlPFC, anterior cingulate cortex in Stroop Task

Hard>Easy (N=3)



X=-44 Y=28 Z=38

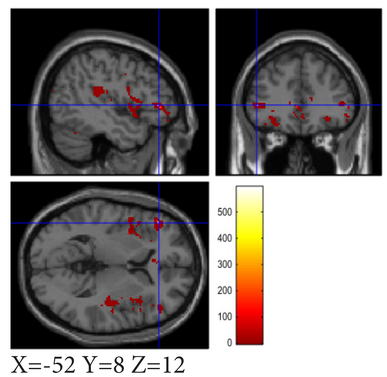
Hard(inc-con)>Easy(inc-con) (N=3)



X=-12 Y=44 Z=34

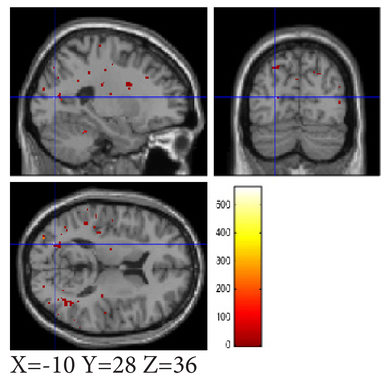
Significant Activation in the dACC, inferior frontal cortex in Memory Task

Hard>Easy (N=3)



X=-52 Y=8 Z=12

Hard(inc-con)>Easy(inc-con) (N=3)



X=-10 Y=28 Z=36

Future Steps

- Analyze all 34 subjects and look for more evidence for our hypotheses (e.g. reduced auditory processing)
- Organize data into a more reproducible, BIDS format and conduct the preprocessing steps using fMRIPrep
- Conduct higher level analysis to look for more direct evidence of control reinstatement

1 Brosowsky, N. P., & Crump, M. J. C. (2018), Journal of Experimental Psychology: General. 2 Chiu, Y.-C., & Egner, T. (2019), Neuroscience & Biobehavioral Reviews;