Dissociating fMRI activity related to familiarity strength vs. decision criteria during recognition memory

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Background

When individuals make a recognition memory judgment, they must *decide* whether an item was previously studied (old) or not (new) by determining whether the familiarity strength of an item exceeds the decision criterion (strength of familiarity required to respond 'old').

Responding 'old' will result in a hit or false alarm (FA), whereas responding 'new' results in either a correct rejection (CR) or miss.

Signal Detection Theory
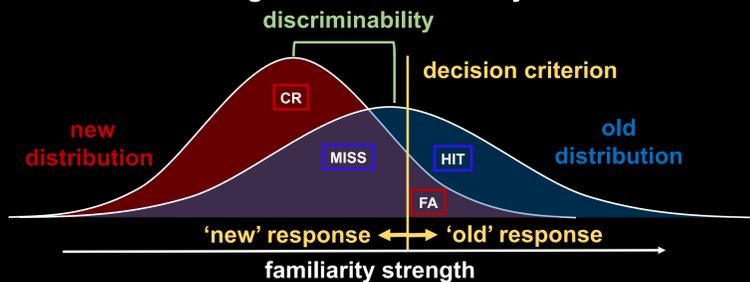
Aminoff et al. (2015) revealed widespread fronto-parietal fMRI activity in the hit > CR contrast when participants maintained a conservative criterion (requiring strong familiarity to respond 'old'), but not when maintaining a liberal criterion (requiring weak familiarity to respond 'old').

hit > CR contrasts (*N* = 95)

Conservative   Liberal

t = 3
t = 7
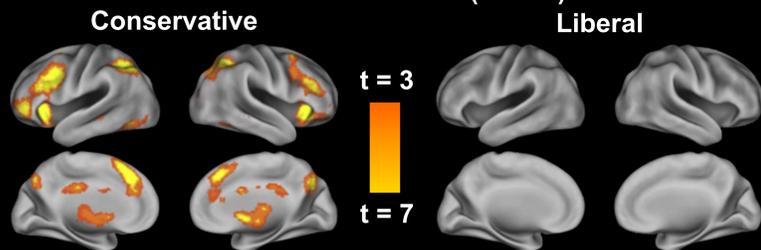
To better dissociate fMRI activity associated with familiarity strength versus criterion placement, we implemented a deep sampling approach by scanning a single subject across 16 sessions while they conducted a recognition memory task where familiarity strength and decision criteria were manipulated at four different levels each.

Recognition Memory Task

Each session included 4 cycles of a study phase followed by a test phase

study phase (240 face image presentations)

64 unique stimuli
16 shown 1x
16 shown 2x
16 shown 4x
16 shown 8x

200 ms   Jittered ISI: 520 ms – 2,680 ms

### test phase (4 mini-blocks: 16 old, 16 new images each)

Criterion shifts induced by payment manipulation: Correct response = +4 cents, Non-critical error = +0 cents, critical error = -8 (strong) or -1 (weak) cent(s)

Strong liberal   Weak liberal   Weak conservative   Strong conservative

2,500 ms

old   new   old   new   old   new   old   new
+4 or 0   +4 or -8   +4 or 0   +4 or -1   +4 or -1   +4 or 0   +4 or -8   +4 or 0

Each mini-block consisted of one criterion condition (strong liberal, weak liberal, weak conservative, or strong conservative) and one discriminability condition (studied images once, twice, four times, or eight times)
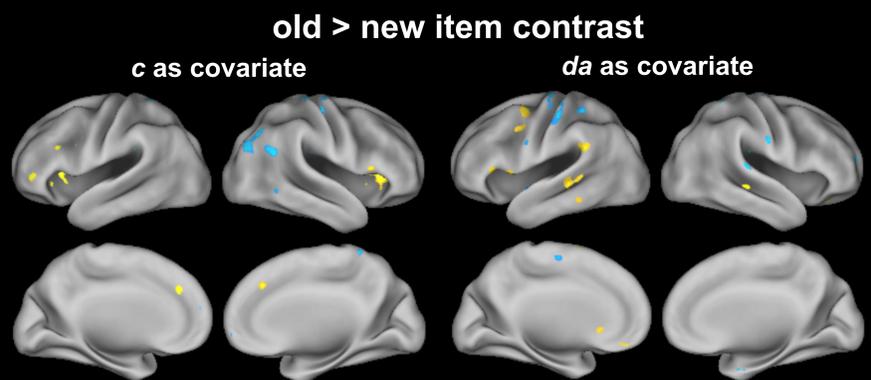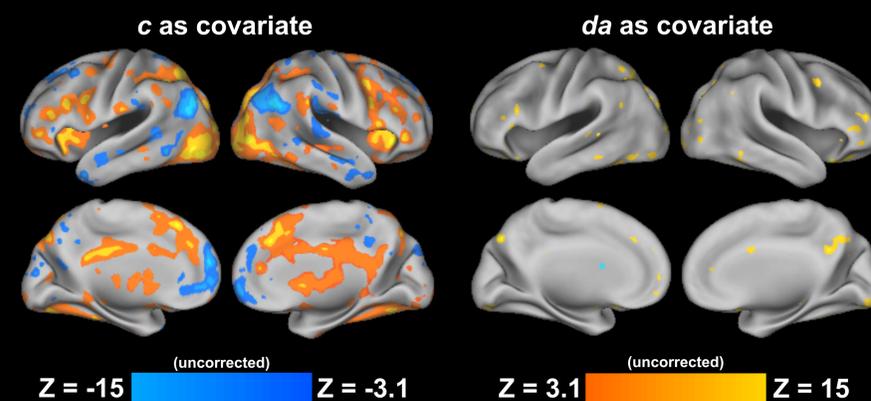
The participant completed each of the 16 sessions during fMRI scanning. Each session included all 16 test conditions in a random order with the exception that all 4 discriminability conditions appeared during each test phase to keep the length of the study phase consistent

16 test conditions (ideal scenario)

criterion conditions
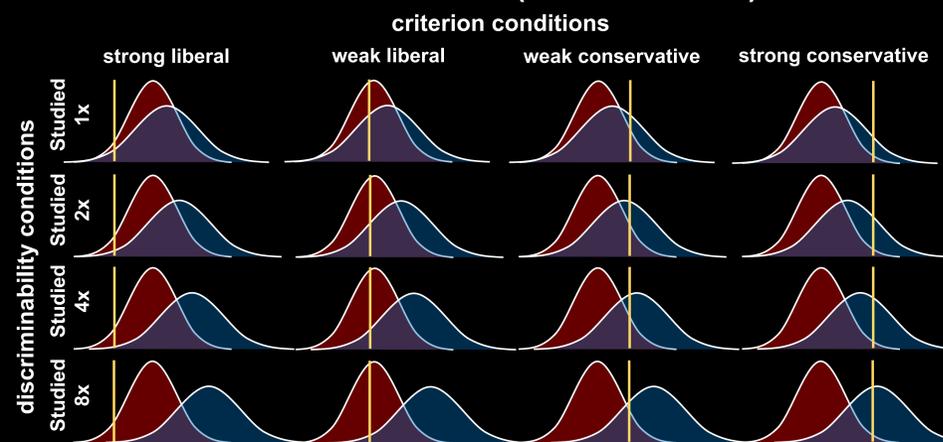
The 16 test conditions are performance based where the manipulations ideally would alter discriminability and criterion placement independently.

old > new response contrast

c as covariate   *da* as covariate

(uncorrected)
Z = -15   Z = -3.1   Z = 3.1   Z = 15

old > new item contrast

c as covariate   *da* as covariate

Results

Actual performance (16 session mean)

Criterion Placement
512 trials per condition

- strong conservative
- weak conservative
- weak liberal
- strong liberal

studied 1x   studied 2x   studied 4x   studied 8x

Discriminability
512 trials per condition

strong conservative   weak conservative   weak liberal   strong liberal

- studied 1x
- studied 2x
- studied 4x
- studied 8x

Using an unequal variance Signal Detection Theory model we implemented a least squares approach (from z-space) to compute individualized slopes for each discriminability condition.

We successfully manipulated criterion placement (*c*) and discriminability (*da*) across the 16 conditions.

Both *c* and *da* remained fairly consistent across conditions and we came close to achieving our "ideal scenario" for the conditions.

ROC curves

Hit Rate
False Alarm Rate

Criterion condition
▽ strong conservative
◇ weak conservative
□ weak liberal
△ strong liberal

Times images studied
1x
2x
4x
8x

Conclusions

For this individual, widespread fronto-parietal fMRI activity strongly associated with the conservativeness of the decision criterion in the old > new response contrast and revealed many similar regions that Aminoff et al. (2015) identified to be associated with a conservative criterion at a group level in the hit > CR contrast such as anterior insula, inferior frontal gyrus, dorsolateral prefrontal cortex, medial frontal gyrus, and superior parietal lobule.

This individual also showed fMRI activity in the old > new response contrast that tracked with the liberalness of the decision criterion (in blue) such as the angular gyrus and frontal pole that Aminoff et al. (2015) did NOT observe at a group level.
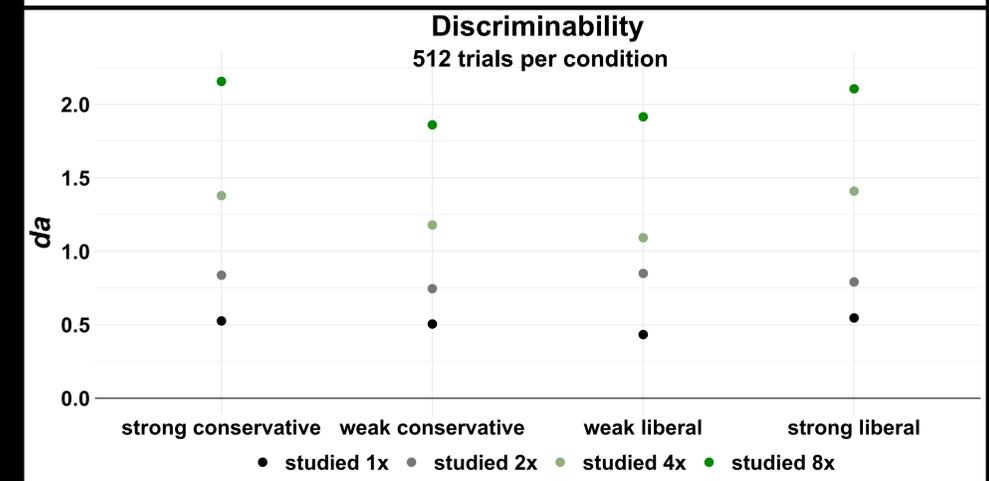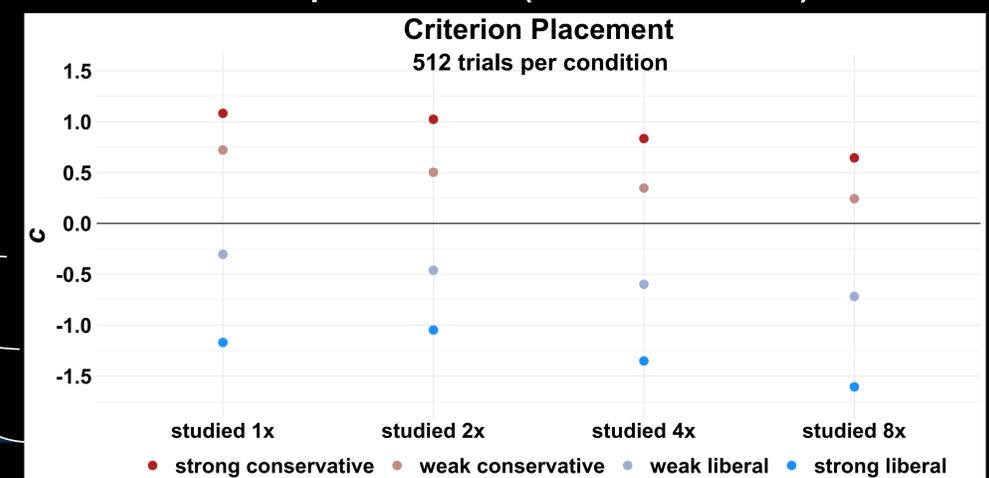
Surprisingly, the strength of discriminability (as measured by *da*) was not associated with widespread fronto-parietal activity (or hardly any fMRI activity at all) in either the old > new response contrast or old > new item contrast.

Identifying regions associated with familiarity strength regardless of the decision criterion with these contrasts are much more difficult then identifying networks associated with the decision criterion regardless of familiarity strength. Where is familiarity?

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Virtual conference: 05/04/2020

Reference: Aminoff, E., Freeman, S., Clewett, D., Tipper, C., Frithsen, A., Johnson, A., Grafton, S.G., & Miller, M. (2015). Maintaining a cautious state of mind during a recognition test: A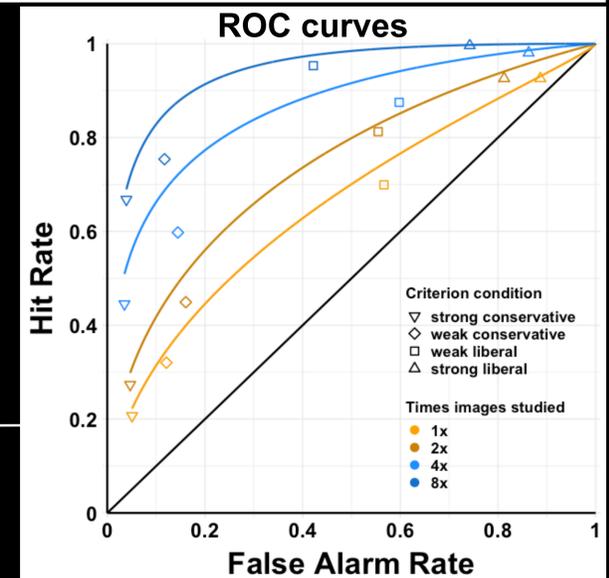 large-scale fMRI study. *Neuropsychologia, 67*, 132-147. https://doi.org/10.1016/j.neuropsychologia.2014.12.011