Dense-sampling reveals flexible network architectures supporting adaptive decision strategies during recognition memory

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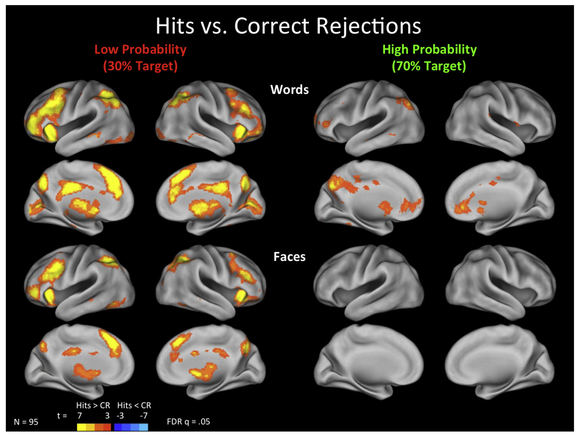
Introduction

When faced with uncertain memory evidence, one must weigh the available information against a *decision criterion*. **Signal detection theory** offers a framework for quantifying both: 1) the ability to discriminate between old and new information (*d'*), and 2) the extent to which one is monitoring the decision evidence (C).

Individuals differ greatly in their willingness/ability to strategically shift their decision criterion under situations of varying uncertainty (Aminoff et al., 2012). Recent work from our lab suggests that **the propensity to modulate one's decision strategy is a uniquely-individualized cognitive trait**, stable both over time and across decision domains (Layher et al., 2020).

While fMRI studies of recognition memory have consistently identified a robust frontoparietal network recruited during memory judgments, we have shown that this pattern of activity is driven by *conservative* criterion placement (Aminoff et al., 2015)—that is, when one is cautiously monitoring the evidence.



Here we present findings from three dense-sampling studies to further characterize the functional network substrates of memory decision processes, highlighting widespread sensitivity to the dynamic modulation of decision strategies—both over 'long' timescales and across conditions within individual scanning sessions.

Studies 1 + 2: Method

One healthy adult female (23 y/o), naïve to the recognition memory task prior to Study 1.

Encoding: 100 faces (Study 1) or 50 faces (Study 2).

Test: Old/new responses; *p*(old items) = *p*(new items) = 0.50

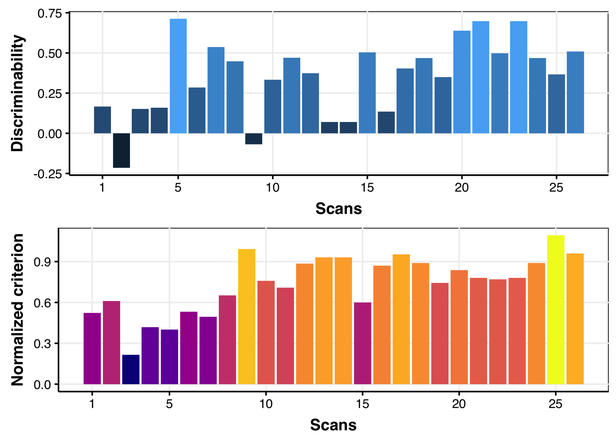
Conservative criterion induction: 5¢ reward for all correct responses; 10¢ penalty for all false alarms. No penalty for misses.

Scanned for 30 consecutive days in Study 1 (2 test runs every MWF—26 total scans).

Study 2 conducted one year later w/ same criterion manipulation (1 test run on each of 30 days).

Study 1: Behavioral Results

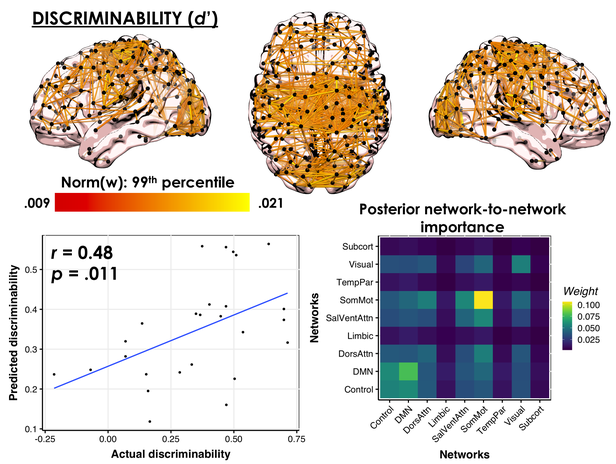
DISCRIMINABILITY & CONSERVATIVE CRITERION PLACEMENT SHOWED VARYING DEGREES OF LINEAR CHANGE OVER TIME



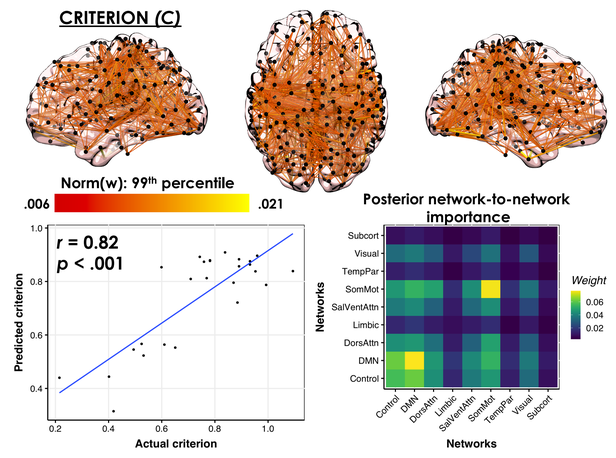
Study 1: Sparse Bayesian MVPA

WHOLE-BRAIN PATTERNS OF TASK-RELATED FUNCTIONAL CONNECTIVITY PREDICT BEHAVIORAL VARIABILITY OVER TIME

DISCRIMINABILITY (*d'*)

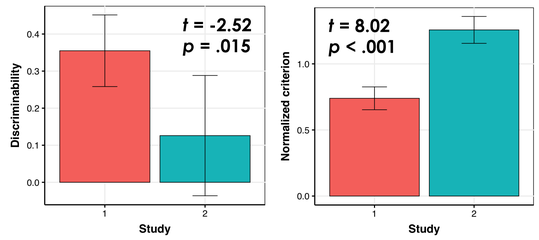


CRITERION (*C*)



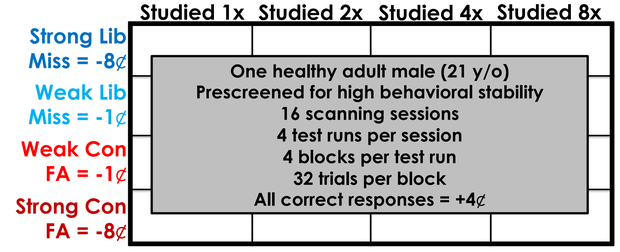
Study 2: Behavioral Results

BEHAVIORAL PERFORMANCE SIGNIFICANTLY DIFFERED ONE YEAR LATER: NETWORK-LEVEL EFFECTS IN STUDY 1 FAILED TO REPLICATE UNDER THESE BEHAVIORAL DIFFERENCES



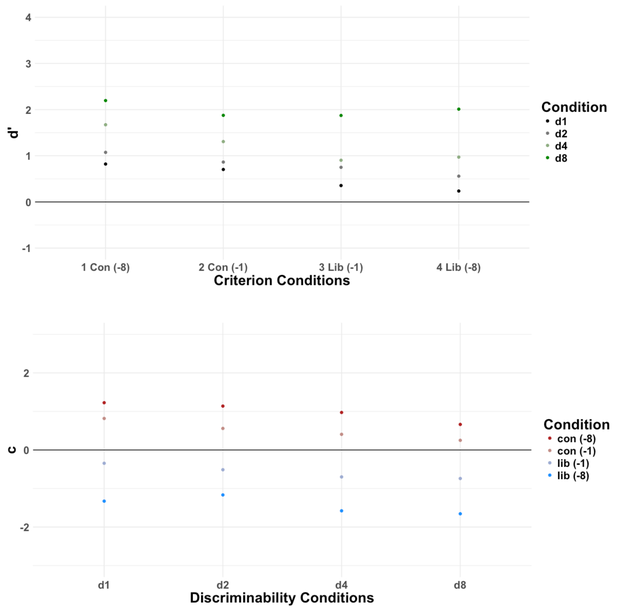
Study 3: 4x4 Memory Task

We designed a task to manipulate the strength of evidence/familiarity associated with memory items (via repeated presentations at encoding) across weak vs. strong levels of liberal and conservative decision criteria (via monetary penalties imposed on critical errors).



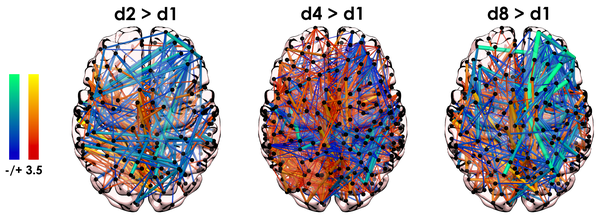
Study 3: Behavioral Results

ON AVERAGE, THE PARTICIPANT SUCCESSFULLY ADAPTED TO 4 LEVELS OF DECISION CRITERIA UNDER 4 LEVELS OF EVIDENCE STRENGTH (AND VICE-VERSA)

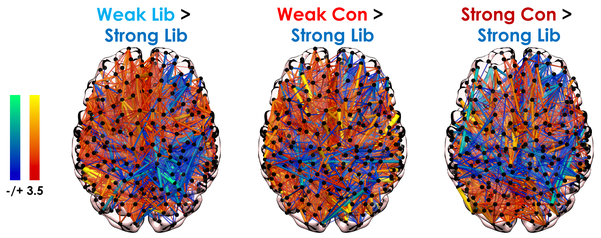


Study 3: Edge Timeseries GLM

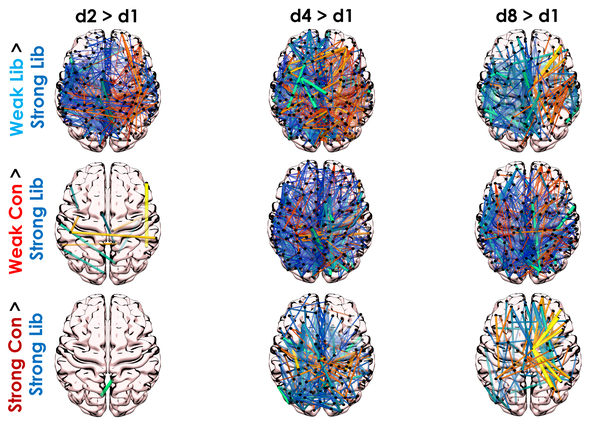
MAIN EFFECTS: STRONGER MEMORY EVIDENCE



MAIN EFFECTS: MORE CONSERVATIVE DECISION CRITERIA



INTERACTION: FAMILIARITY STRENGTH x CRITERION



Summary

In Study 1, whole-brain connectivity predicted accuracy (*d'*) and criterion placement in a naïve subject attempting to optimize performance over time—however, this did not replicate in Study 2 a year later. In Study 3, we observed robust, event-related changes in functional coupling as an individual dynamically adapted to different levels of criterion and item discriminability. The effects of familiarity strength were especially pronounced, which contrasts sharply with other voxelwise analyses and warrants further exploration. Together, these findings provide novel characterization of large-scale functional brain networks as they support strategic adaptation of decision criteria during recognition memory.

References

Aminoff, E.M. et al. (2012). Individual differences in shifting decision criterion: A recognition memory study. *Memory & Cognition*, *40*, 1016-1030.

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Layher, E., Dixit, A., & Miller, M.B. (2020). Who gives a criterion shift? A uniquely individualistic cognitive trait. *JEP: LMC*, *46*(11), 2075-2105.

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