Neural evidence for the flexible use of working memory & episodic memory in prospective remembering

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Introduction: Prospective memory

How do we remember to execute a specific goal at the appropriate time despite busily pursuing other plans?

Theories of cognitive control (e.g., by Braver and colleagues) and of prospective memory (e.g., by McDaniels and colleagues) suggest that we can either use proactive control (to actively maintain the goal information in working memory -- e.g., to mentally rehearse "stop at the karate studio"), or we could use reactive control (to rely on cue-based retrieval of goal information from episodic memory -- e.g., seeing the karate studio when driving home from work).

Questions: Can we use fMRI brain activations to track the flexible deployment of working memory and episodic memory to achieve a delayed goal?

Task design and behavioral results

We developed a prospective memory paradigm for fMRI consisting of a picture-target detection task (four novel scenes) embedded in an ongoing n-back task (lexical judgments).

The flexible choice of strategy is a particular goal (home or work) or a task that can be flexibly, and successfully, used in the environment to achieve a delayed goal.

Hypothesis and experimental approach

Both working memory and episodic memory strategies predict that target activation at the point of target appearance will predict prospective memory accuracy.

If participants are using a working memory strategy, then:

(a) Target activation before the point of target appearance will also predict prospective memory accuracy.

(b) Suppression of lexical decision processing before the point of target appearance should also predict prospective memory accuracy.

Analysis strategy

Use fMRI pattern classifiers to read out the activation of the target on a moment-to-moment basis. Use these neural measures to predict whether people will identify the target when it reappears at the end of each trial.

Relating target activations to prospective remembering

Identify "target-sensitive" regions

Contrast: Target hits vs. Misses at time of target reappearance

When a participant's performance deviates from the model's predictions regarding optimal strategy choice, there are two possible explanations:

1. The participant may be using the wrong strategy due to limited working memory resources in order to optimize performance.

2. The participant may be using the wrong strategy due to a bias towards a particular strategy. These explanations can be used to fine-grained predictions about how people should deploy working memory and episodic memory resources in order to optimize performance.

Future directions: Modeling & training

We are developing normative computational models that formally specify the costs associated with different memory strategies. These models will generate fine-grained predictions about people's deployment of working memory and episodic memory resources in order to optimize performance.

When a participant’s performance deviates from the model's predictions regarding optimal strategy choice, there are two possible explanations:

1. Our model of optimal performance is wrong and needs to be updated

2. The person is behaving suboptimally (i.e., they could do better by adjusting strategy)

To admit these possibilities, we will use real-time fMRI neurofeedback to train people to use the strategy that the model predicts is optimal.

Using methods that were recently developed at Princeton, we will apply fMRI decoding of real-time fMRI neurofeedback to train people to use the strategy that the model predicts is optimal.

The results of this study will provide evidence for the flexible use of working memory & episodic memory in prospective remembering.