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Real-time fMRI-triggered experience sampling: A proof-of-concept study

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SCAN FOR MANUSCRIPT

INTRODUCTION

Background

The neural correlates of spontaneous thought have typically been studied by combining functional magnetic resonance imaging (fMRI) with random-onset experience sampling thought probes.[1]

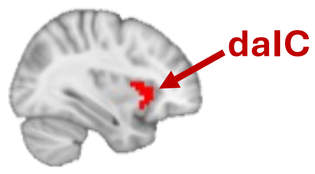
However, random-onset experience sampling:

- Is non-targeted in execution
- Only captures a fraction of thoughts a subject may have during an experimental session
- Can miss the occurrence of specific thought subtypes of interest

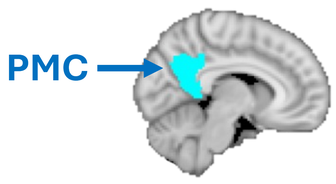
Current Study

To address these limitations, we developed a novel **real-time fMRI-triggered experience sampling (rt-fMRI-ES)** paradigm[2] in which thought probes are triggered based on increasing BOLD activity during resting state fixation periods in two regions of interest (ROIs):

1. **Dorsal anterior insular cortex (dalC)**
   - Implicated in task-evoked, physiological arousal[3]



2. **Posteromedial cortex (PMC)**
   - Implicated in stimulus-independent thought[1,4]



The current study builds off our initial peer-reviewed Stage 1 **Registered Report**.[5] Using the rt-fMRI-ES method, we aim to precisely and efficiently map unprompted mental experiences to spontaneous brain activity at rest.

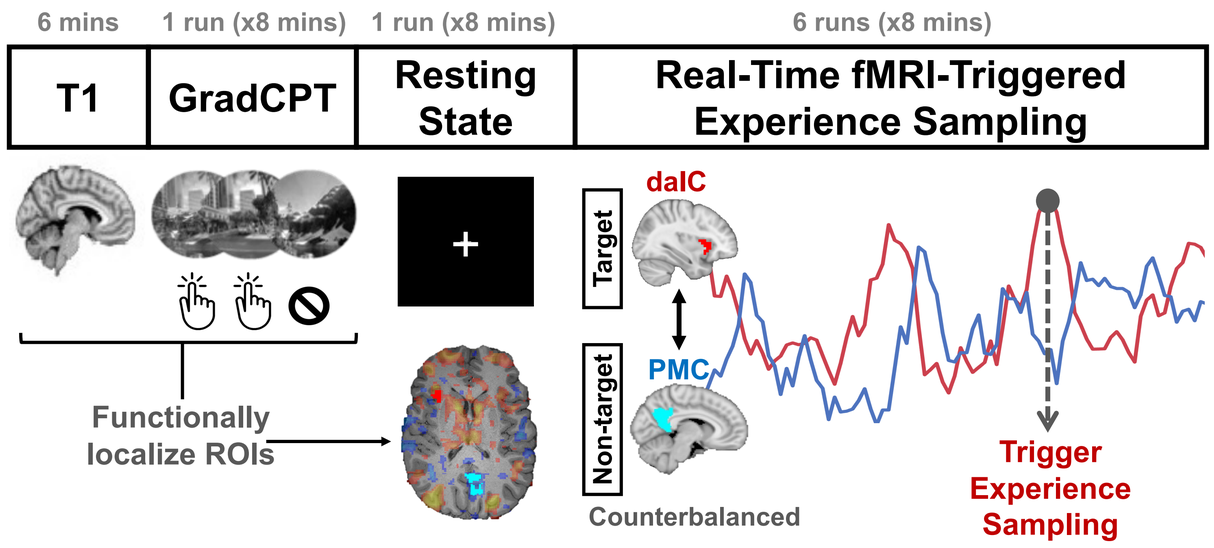
Pre-registered Hypotheses

H1: Increased spontaneous **dalC activation** will be time-locked to self-generated experiences with **higher ratings** of **arousal**.

H2: Increased spontaneous **PMC activation** will be time-locked to **lower ratings** of **external-attention**.

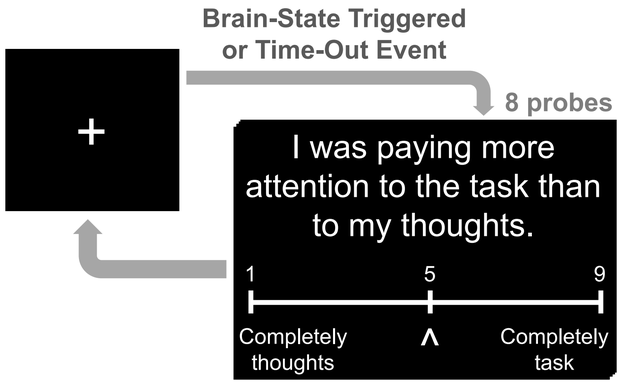
METHODS

Scan Procedures (N = 60 healthy adults)



Real-time fMRI-triggered Experience Sampling

rt-fMRI-ES Stimulus Presentation



Thought Probes of Interest

Arousal: I felt very activated / energized.

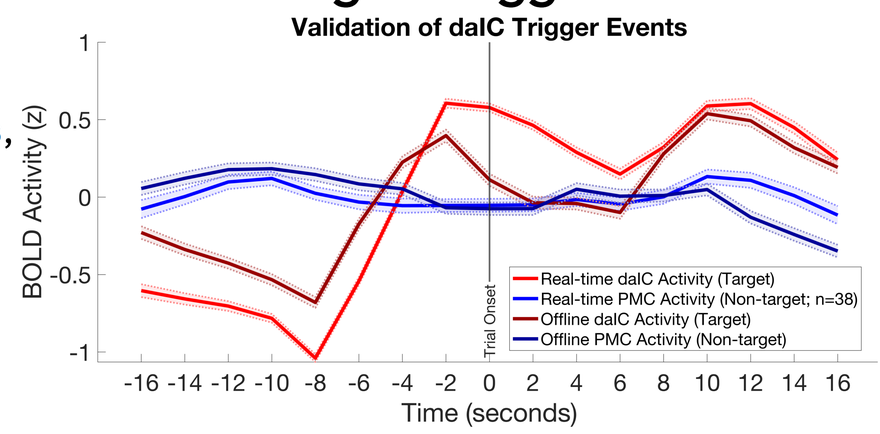
External-Attention: I was paying more attention to the task than to my thoughts.

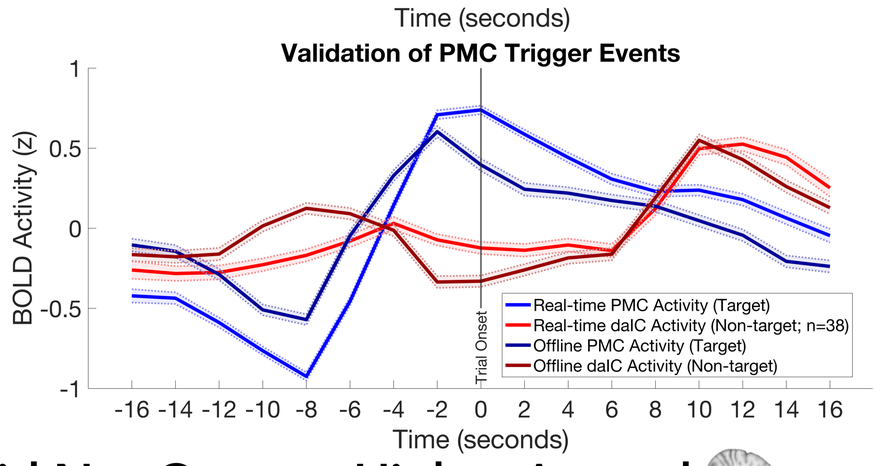
Presentation of a fixation cross is interrupted by trials of thought probes triggered by increases in BOLD activation in the run's target ROI (brain-triggered trials), or by lack of brain-triggered trials after 100 seconds ("time-out" trials). Across our sample, subjects completed an **average of 28.8 total thought probes trials**.

RESULTS

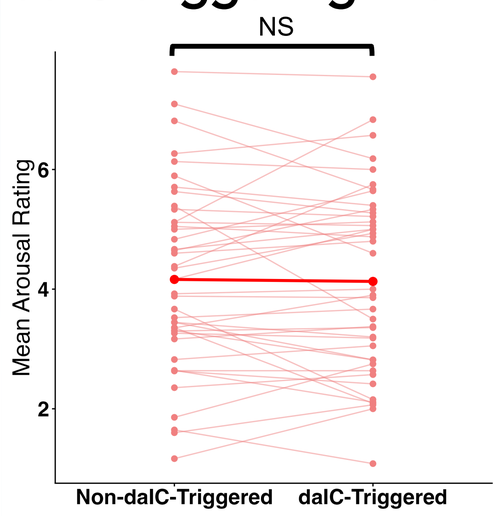
Validation of Real-time BOLD Signal Triggers

- For both **dalC trigger events** and **PMC trigger events**, we compared alignment between real-time BOLD estimates **("online")** and BOLD estimates obtained post-session **("offline")**.
- Online estimates of BOLD activation in either ROI were similar to their offline BOLD estimates.



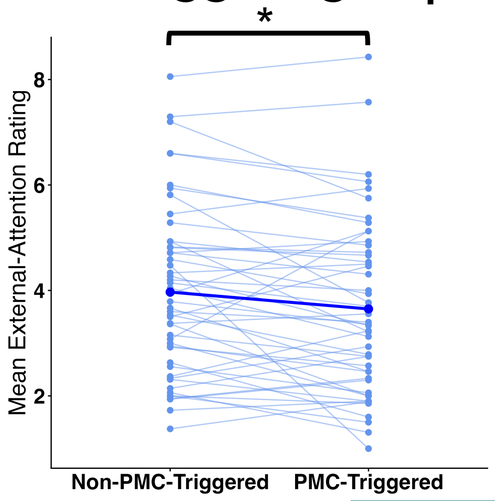


dalC-triggering Did Not Capture Higher Arousal



- Linear mixed-effects modeling revealed **no significant difference in arousal ratings** between dalC-triggered trials and non-dalC-triggered trials (*b* = –0.02, 95% CI [-0.25, 0.20], df = 39.7, t = –0.21, *p* = .84).
- **20 out of 42 subjects (47.6%)** included in the model had **higher mean arousal scores** during dalC-triggered trials.

PMC-triggering Captured Lower External-Attention



- Linear mixed-effects modeling revealed **significantly lower external-attention ratings during PMC-triggered trials** (*b* = –0.30, 95% CI [-0.55, -0.06], df = 45, t = –2.50, *p* = .016).
- **33 out of the 49 subjects (67.3%)** included in the model had **lower mean external-attention scores** during PMC-triggered trials.

CONCLUSIONS

- The present study demonstrates the **first proof-of-concept validation of real-time fMRI-triggered experience sampling.**
- Lack of support for **H1** suggests the neural substrates of subjective arousal may differ from task-evoked physiological arousal.[6,7]
- Our support for **H2** offers a novel perspective to the established relationship between decreased external-attention and PMC activation.
- Using the rt-fMRI-ES method in future work could enable better understanding of the neural signatures of various thought forms.
- Findings underscore the importance of linking spontaneous brain activity during resting state to ongoing mental experiences.

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