Investigating a top-down mechanism in working memory with concurrent TMS-fMRI

Eva Feredoes
School of Psychology & Clinical Language Sciences
Centre for Integrative Neuroscience and Neurodynamics
University of Reading

Distractors during WM retention

- Interference from external distractors are a significant source of forgetting
- Dorsolateral prefrontal cortex (DLPFC) controls the effects of distractors during retention
- DLPFC interacts with posterior retention-related regions

Q: How does DLPFC control distractor effects?

- Memory target enhancement (Sakai et al.)
- Distractor suppression (Chao & Knight)

➡ TMS in ‘physiological probe’ mode, during fMRI, to show causally the influence of DLPFC on visual areas during distraction

Concurrent TMS-fMRI

- The effect of TMS propagates to connected areas & modulates BOLD signal

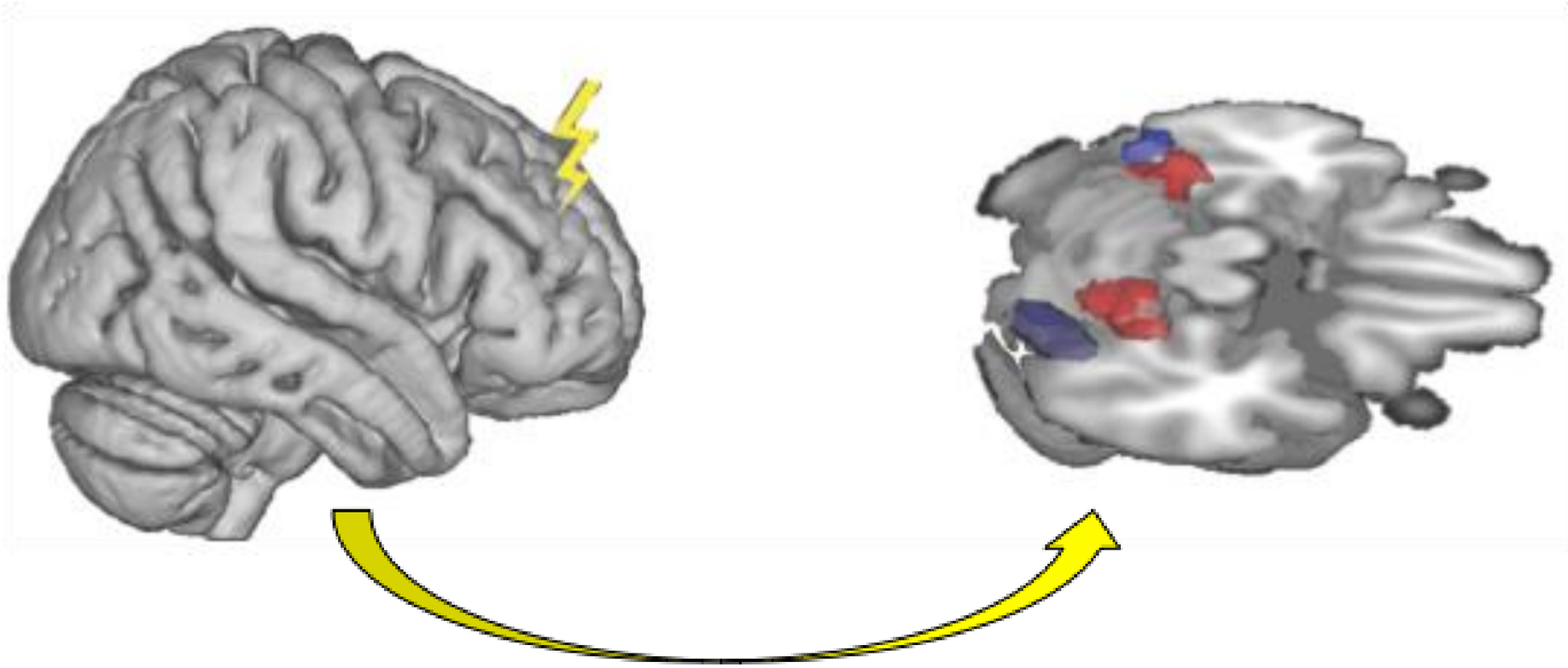
➡ physiological probe

- Connectivity is determined by the functional state of regions at the time of task performance

- Concurrent TMS-fMRI can therefore provide a causal measure of functional connectivity (see work by e.g., Bestmann; Ruff)

Causal evidence for frontal involvement in memory target maintenance by posterior brain areas during distractor interference of visual working memory

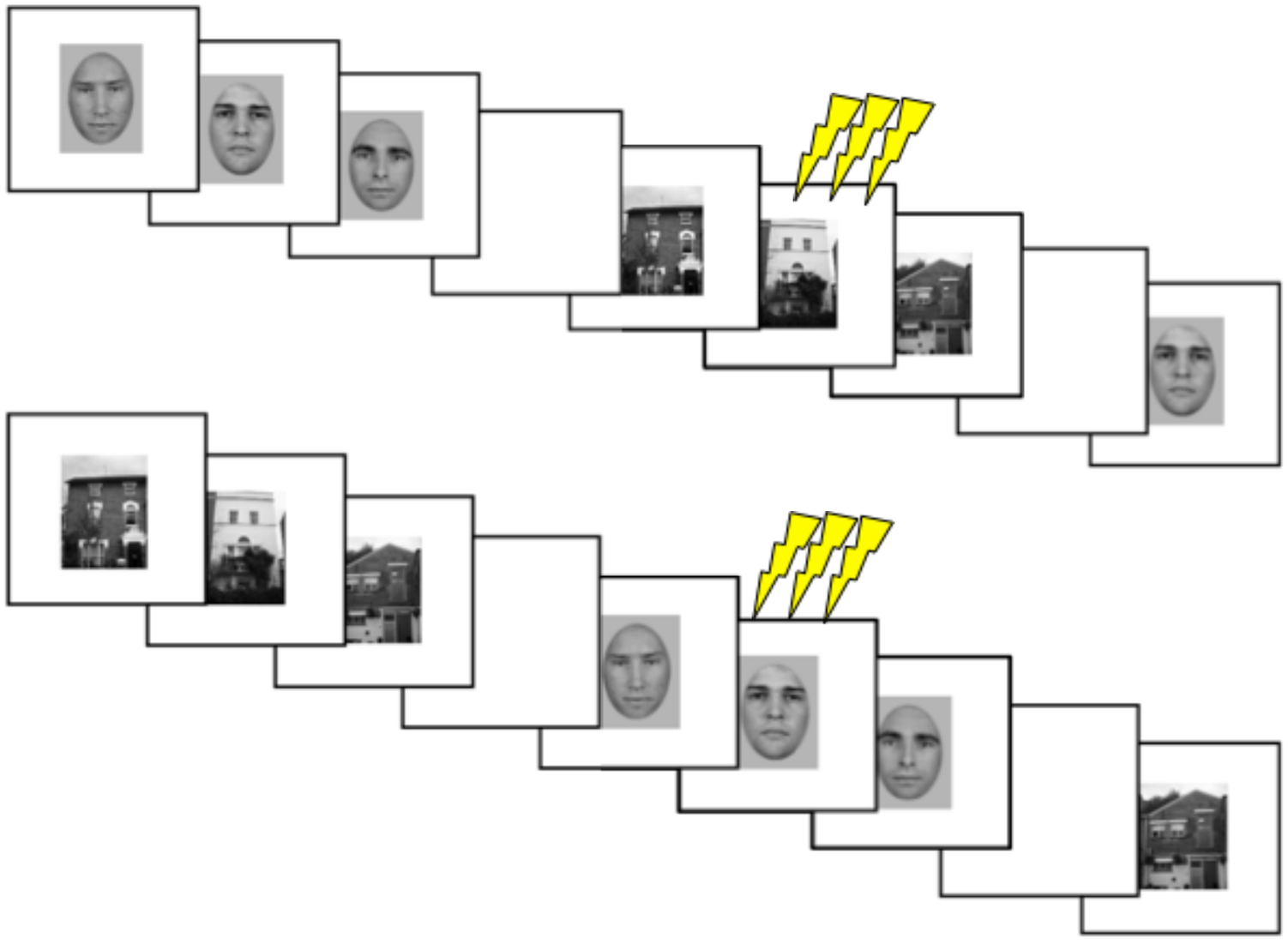
- Apply TMS to right DLPFC during retention in the presence (vs absence) of distractors



- Test for remote effects on BOLD in posterior areas representing memory targets or distractors

Feredoes et al. (2011) *PNAS*

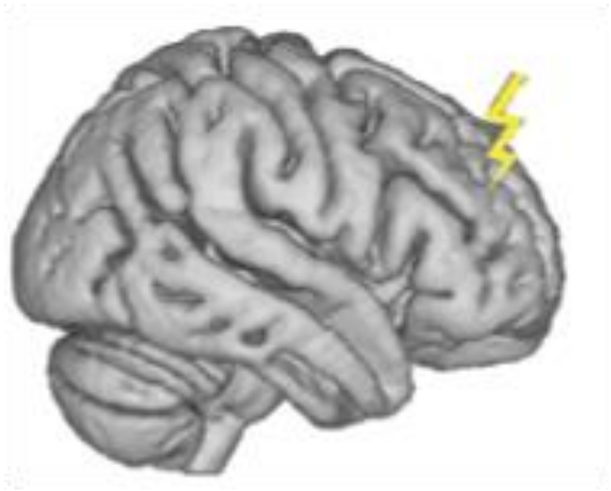
WM task with (& without) distractors



n.b. Memory targets & distractors always from the opposite category

Feredoes et al. (2011) *PNAS*

Predictions



- Expect no role of DLPFC (so no remote effects of TMS on BOLD) without distractors

- But on distractor-present trials, can distinguish between:

Target enhancement:

➡ remote impact on posterior regions representing memory targets

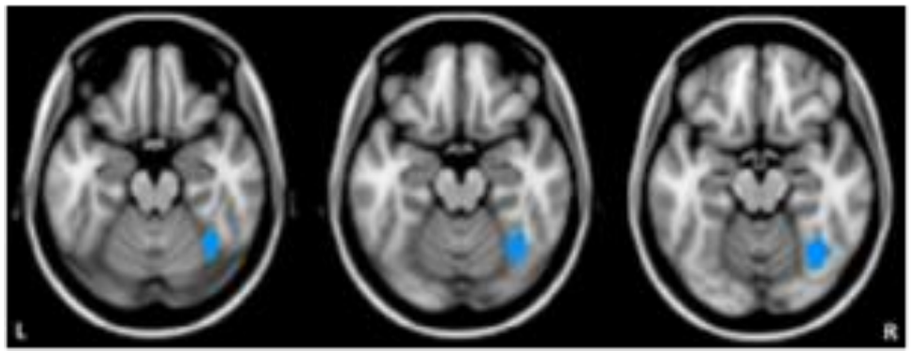
Distractor suppression:

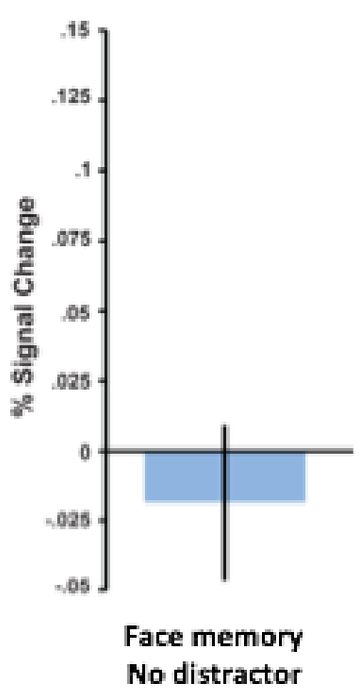
➡ remote impact on posterior regions representing distractors

Feredoes et al. (2011) *PNAS*

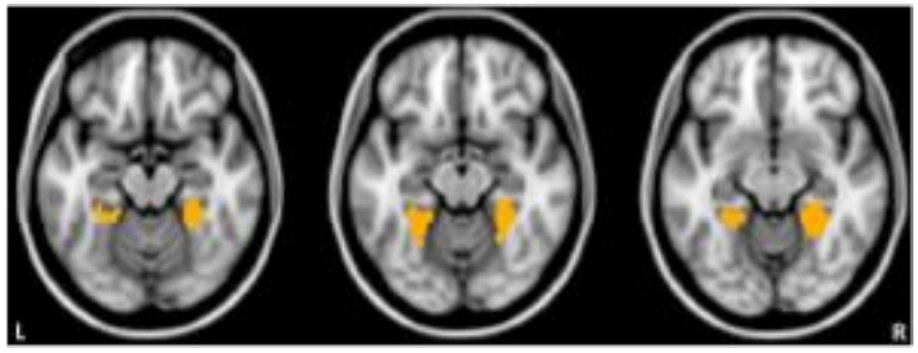
ROI Results

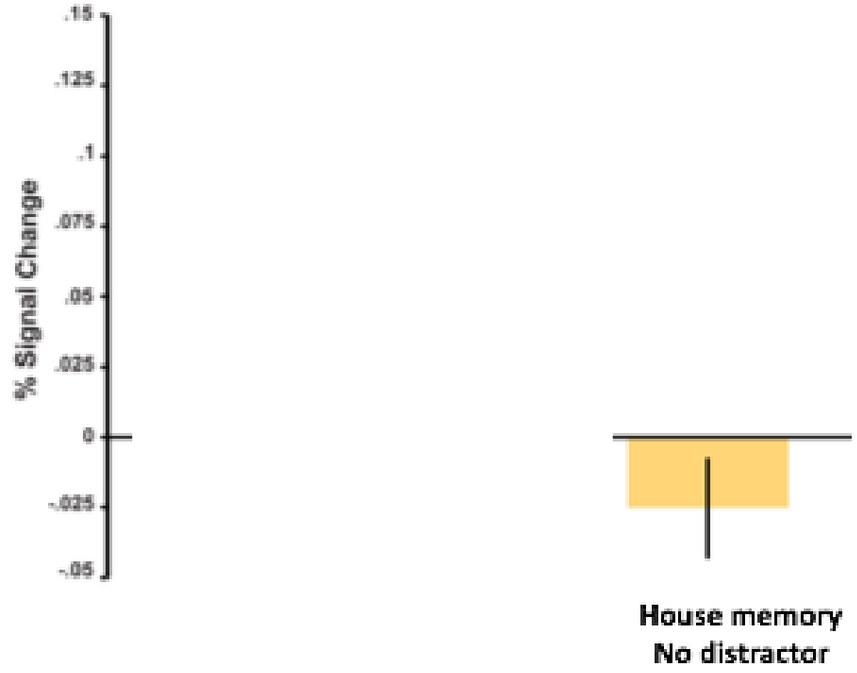
right FFA





bilateral PPA





Feredoes et al. (2011) *PNAS*

Conclusions

• No remote TMS effects for distractor-absent trials. “Simple” delay period maintenance does not require DLPFC

• Remote effects of right DLPFC TMS in presence of distractors were on posterior regions representing current *target* not current distractor

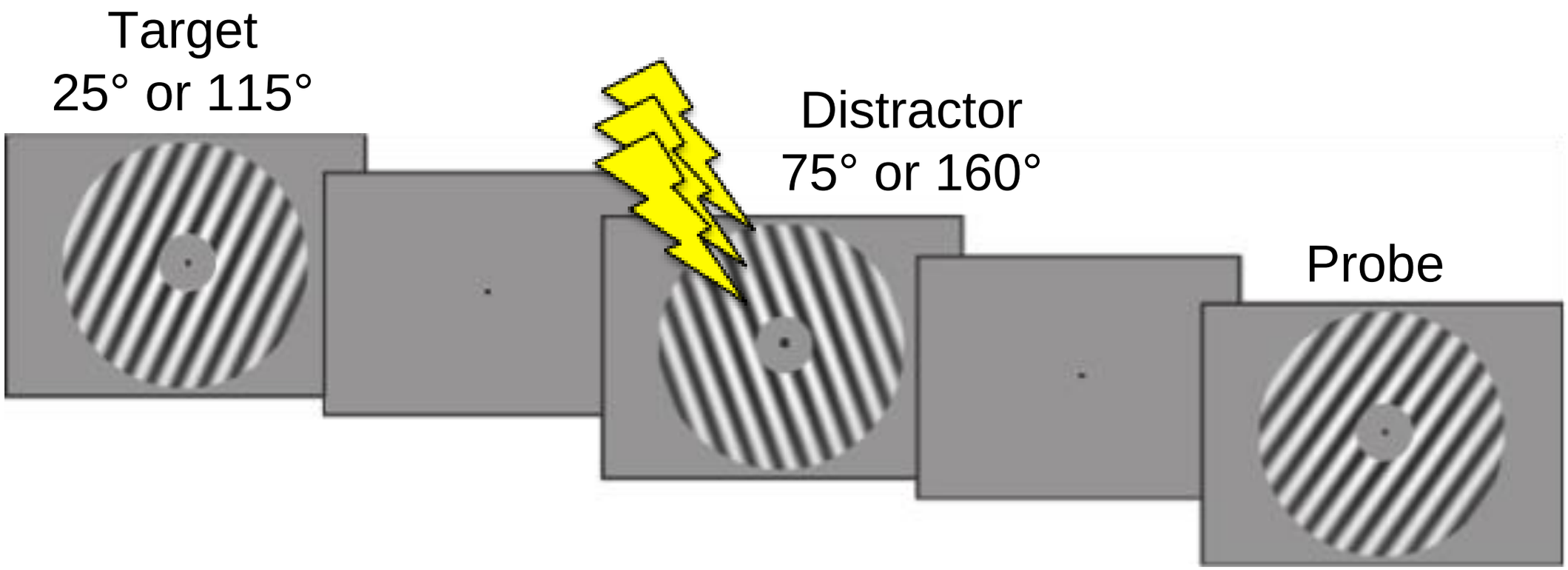
• Supports a *target protection* account of top-down DLPFC control in WM

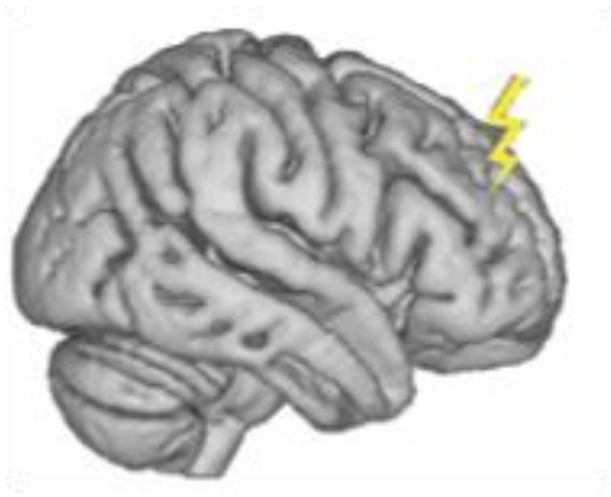
But how are distractors from the *same* visual category dealt with?

- Most detrimental effects of distractors occur when they are very similar to targets
- Feredoes et al. (2011) used targets and distractors from *different* visual categories
- Same category stimuli have been difficult to disentangle with event-related fMRI
- Multivoxel pattern analysis (MVPA) can distinguish between visually similar stimuli within the same brain areas

Q: When targets and distractors rely on the same brain areas, is target enhancement sufficient or is distractor suppression also invoked?

TMS-fMRI-MVPA





Disruptive TMS applied to right DLPFC

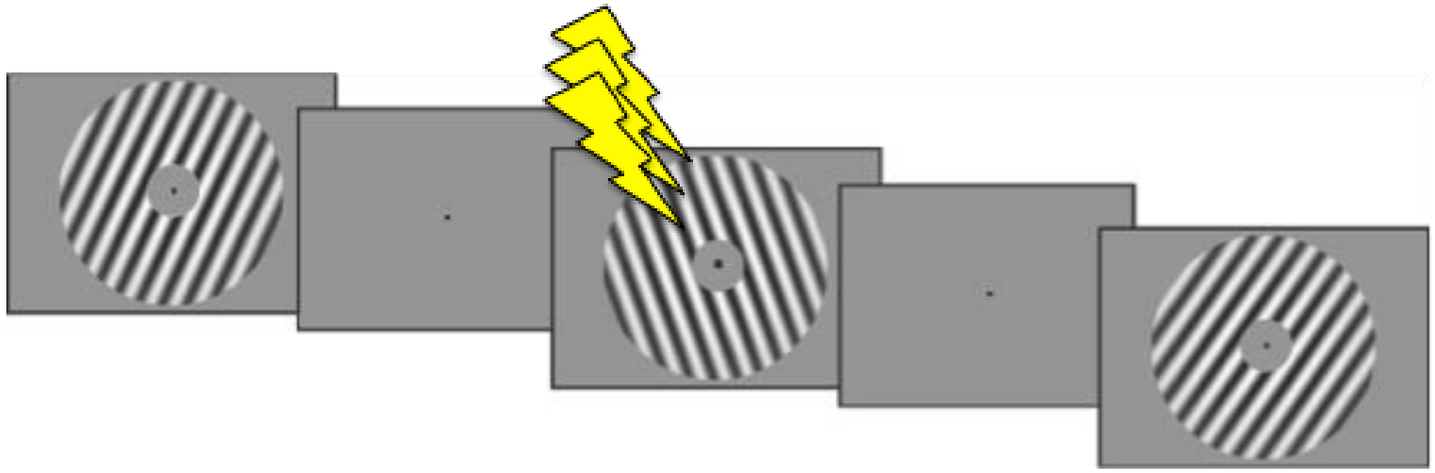
(interleaved with ineffective control TMS)

➡ MVPA decoding of targets and distractors maintained in early visual cortex, under control v disruptive TMS

Hypotheses

- Control TMS:

MVPA will decode (enhanced) targets with more accuracy than (suppressed) distractors



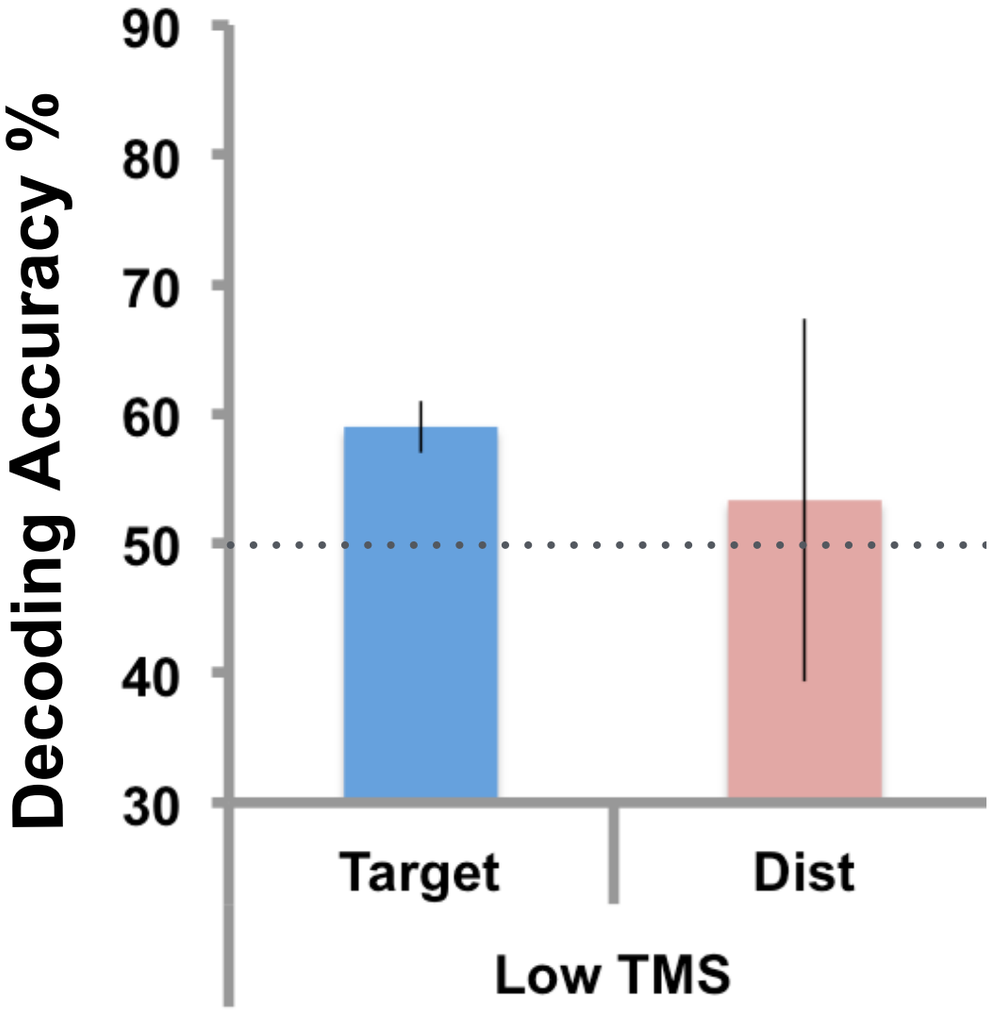
Disruptive DLPFC-TMS:

1. Disrupt target enhancement = *decreased* target decoding

2. Lifting of distractor suppression = i*ncreased* distractor decoding

Preliminary Results

Decoding from early visual cortex (V1-V5)



Conclusions

- DLPFC exerts top-down control over areas retaining information in the service of WM
- Support for the Emergent Property/Sensory Recruitment hypothesis of WM
- Mechanisms are consistent with Biased Competition model of attention: enhancement & suppression of sensory representations
- Are enhancement and suppression mechanisms differentially deployed over different sensory brain areas?

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