Within-category decoding of attended vs. unattended items in short-term memory

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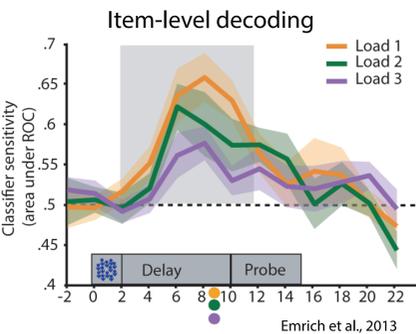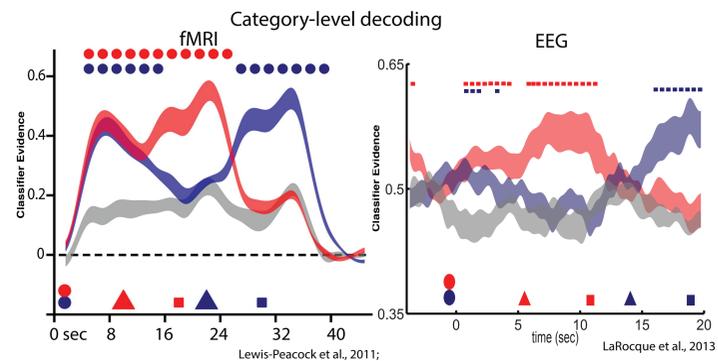
Introduction

Several models of short-term memory (STM) posit distinct states for items held inside and outside the focus of attention.
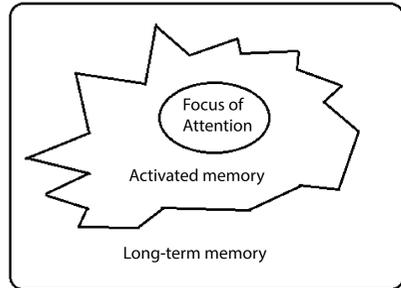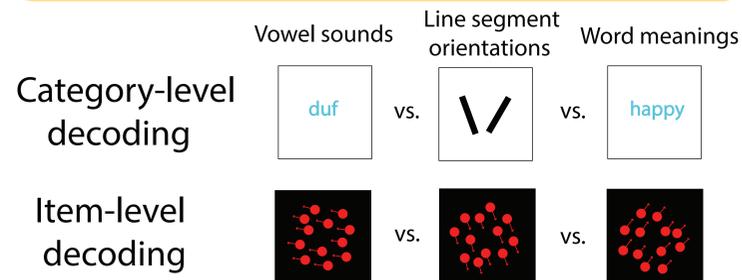

Cowan 1993

Recent work using multivariate pattern analyses (MVPA) decoded the category of memory items held inside the focus of attention; however, no evidence could be found for items outside the focus of attention.

Category-level decoding

fMRI — EEG

Lewis-Peacock et al., 2011; LaRocque et al., 2013
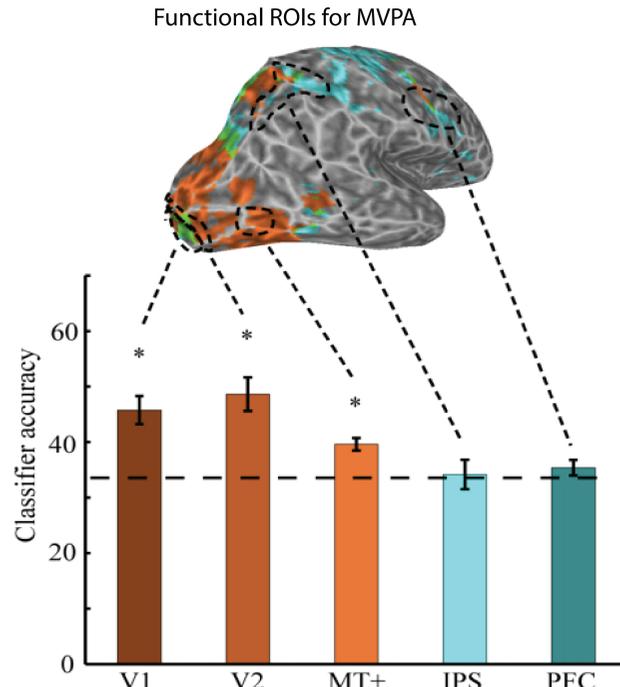
Item-level decoding

Additionally, recent work suggests that a memory item can be decoded when multiple items are simultaneously retained in STM, with no attention manipulation. It is unclear how to relate this result to previous category-level decoding.

Emrich et al., 2013

Can item-level decoding of fMRI data find evidence for items retained in memory but outside the focus of attention?

Category-level decoding: Vowel sounds (duf) vs. Line segment orientations (\ /) vs. Word meanings (happy)

Item-level decoding
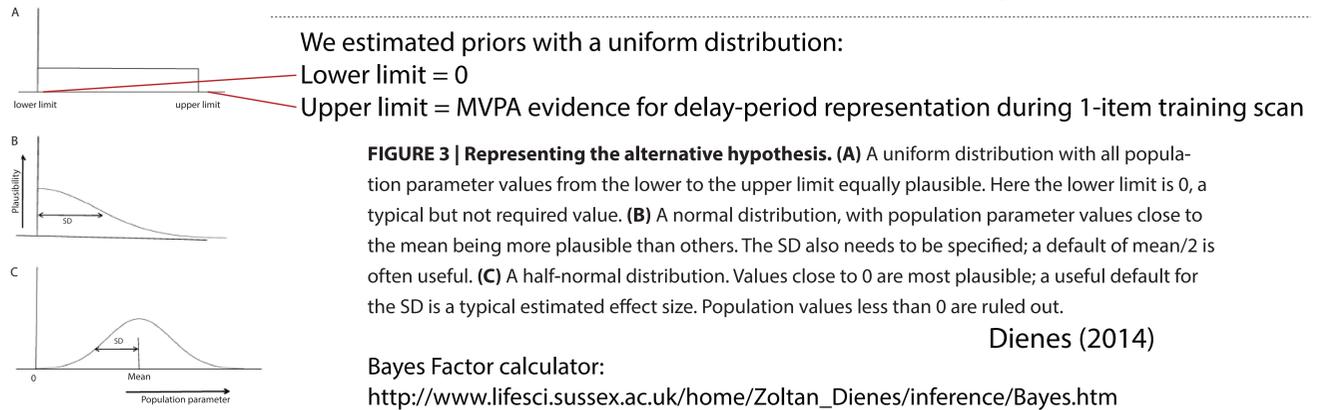
Results

Functional ROIs for MVPA

This failure to recover delay-period stimulus information from frontoparietal regions replicates previous findings (Riggall & Postle, 2012; Emrich, Riggall, et al., 2013).

New question addressed here: When decoding at the item level, does MVPA evidence for the UMI differ from baseline? Novel approach is to specify an a priori distribution of the null in order to calculate Bayes factors.

Cue-repeat — Cue-switch

cued / uncued / absent
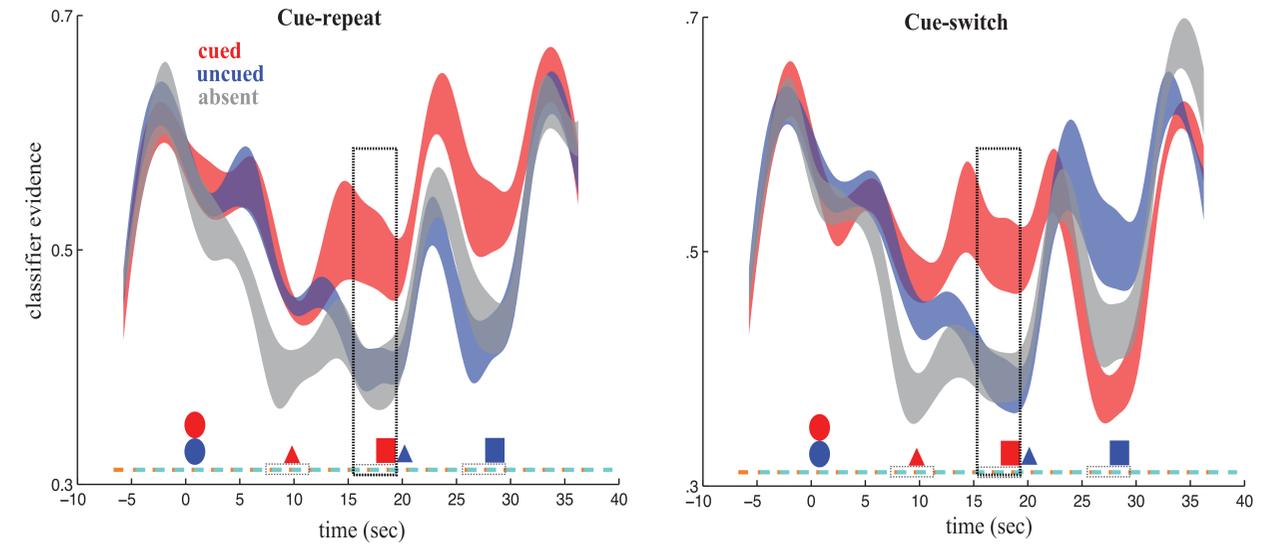
Bayes factors: 3.92; 0.39   Bayes factors: 9.73; 0.22

(I.e., it is 3.92 ("repeat") and 9.73 ("switch") times more likely that AMI is greater than baseline then that it is same as baseline; and it is 2.56 and 4.55 times more likely that UMI is same as baseline than that it is greater than baseline.)

We estimated priors with a uniform distribution:
Lower limit = 0
Upper limit = MVPA evidence for delay-period representation during 1-item training scan

FIGURE 3 | Representing the alternative hypothesis. (A) A uniform distribution with all population parameter values from the lower to the upper limit equally plausible. Here the lower limit is 0, a typical but not required value. **(B)** A normal distribution, with population parameter values close to the mean being more plausible than others. The SD also needs to be specified; a default of mean/2 is often useful. **(C)** A half-normal distribution. Values close to 0 are most plausible; a useful default for the SD is a typical estimated effect size. Population values less than 0 are ruled out.

Dienes (2014)

Bayes Factor calculator:
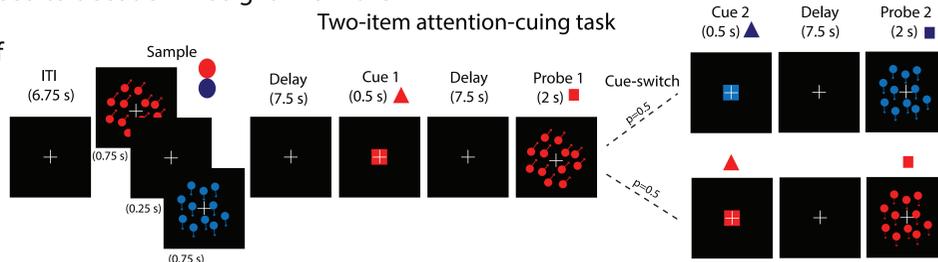http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/Bayes.htm
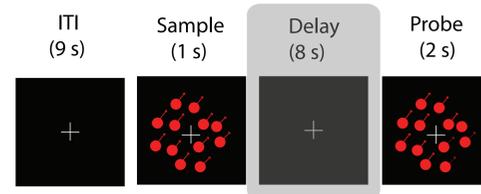
Task and Methods

Subjects (N=8) performed alternating blocks of a one-item delayed-recognition task and a two-item delayed-recognition task with retroactive cues. Neural activity was measured by fMRI in a 3-Tesla scanner.

The stimuli were circular apertures filled with dots coherently moving in one of three canonical directions (73, 193, 313 degrees).
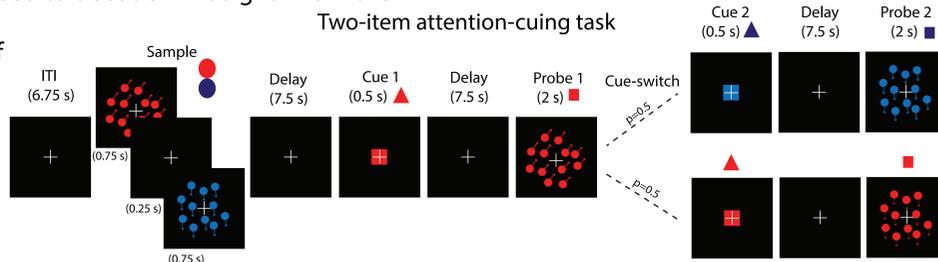
MVPA classifiers were trained to decode direction of motion on fMRI signal from the delay period of the one-item task. These classifiers were validated using leave-one-out cross validation. The classifiers were then used to decode fMRI signal from the entirety of the two-item task. Classifier estimates of the evidence for cued, uncued, and not present directions of motion were averaged across trials.

One-item classifier training task

ITI (9 s) — Sample (1 s) — Delay (8 s) — Probe (2 s)

Two-item attention-cuing task

Sample — Delay (7.5 s) — Cue 1 (0.5 s) — Delay (7.5 s) — Probe 1 (2 s) — Cue-switch

Cue 2 (0.5 s) — Delay (7.5 s) — Probe 2 (2 s)

ITI (6.75 s)

Conclusions

• Item-specific information can be decoded from neural activity *only for items in the focus of attention*, replicating and extending previous category-level decoding results.

• Bayesian analysis yields affirmative, quantitative evidence that the UMI is not held in an active state.

• The retention of memory items outside the focus of attention may be accomplished by a structural trace rather than an active trace.

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