



The Representation of Stimulus Identity for Multiple Items in STM Revealed Using fMRI Classification

Stephen M. Emrich, Adam C. Riggall, Joshua J. LaRocque, Bradley R. Postle

Department of Psychiatry, Department of Psychology - University of Wisconsin - Madison

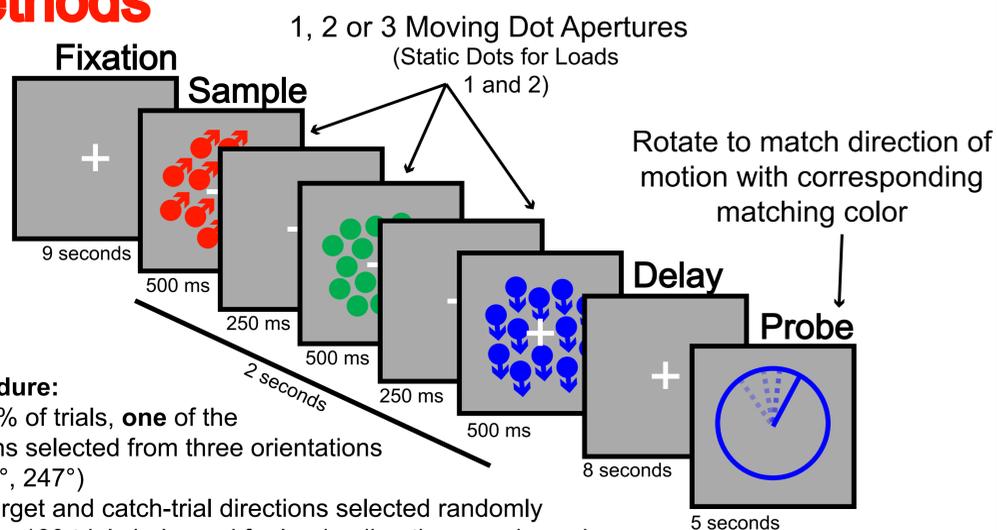


semrich@wisc.edu NIH MH064498 (B. R. P.)

Introduction

- How is information retained in STM? Traditionally, load-sensitivity of (univariate) signal intensity, often observed in intraparietal sulcus (IPS) and prefrontal cortex (PFC), has been taken as a hallmark of STM storage. Multivariate pattern-classification (MVPC), however, indicates that information can be decoded during the delay from areas supporting sensory encoding (e.g., in extrastriate cortex; Harrison & Tong, 2009). Here, we address this discrepancy by applying MVPC to fMRI data from a task manipulating STM load.

Methods



Procedure:

- On 90% of trials, one of the directions selected from three orientations (7°, 127°, 247°)
- Non-target and catch-trial directions selected randomly
- Perform 180 trials balanced for load x direction x probe order

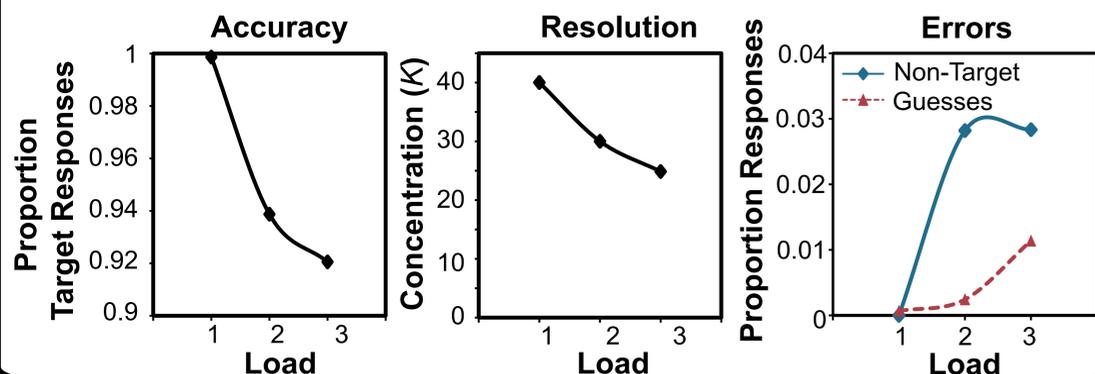
fMRI Scanning Parameters:

- Gradient-echo, echo-planar pulse sequence (2 s TR, 25 ms TE) acquired with a whole-brain 64 x 64 matrix (39 sagittal slices, 3.5 mm isotropic)

Analysis:

- Behavioral performance assessed using 3-component model (Bays et al., 2009)
- Univariate GLM used to identify parametric sample- and delay-evoked activity
- MVPC performed using L2-regularized logistic regression
- Training of classifiers for direction and load performed on one volume (late delay or ITI [control]), then swept across remainder of time series
- Evidence, taken from the classifier estimate (from 0 to 1) that the pattern of BOLD activity matched the category (e.g., direction), used to index performance

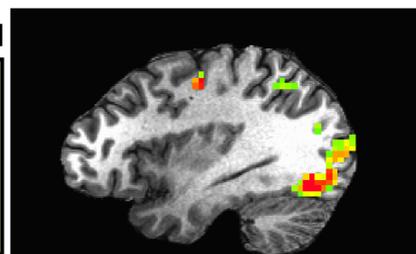
Results: Behavior - Mixture Model



ROIs: GLM analysis

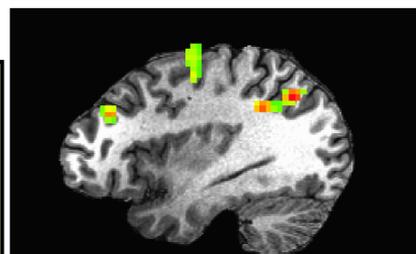
Sample-Evoked

Includes areas of striate and extrastriate visual cortex, MT, and IPS

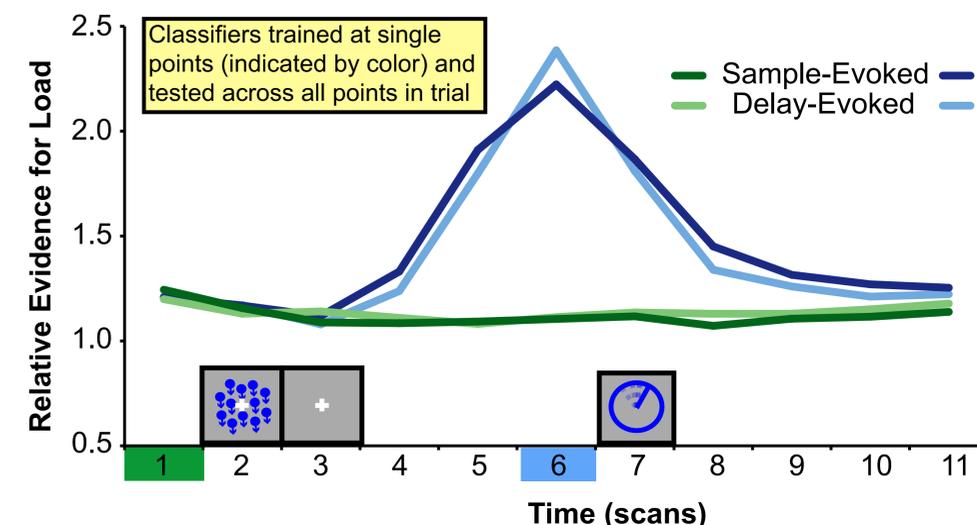


Delay-Evoked

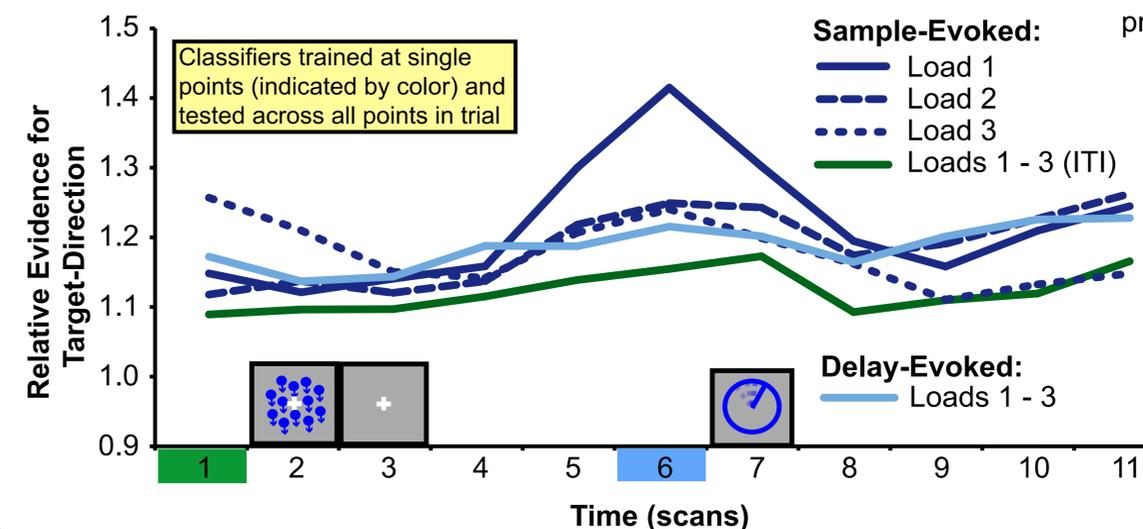
Includes primarily superior IPS, and pre-frontal cortex



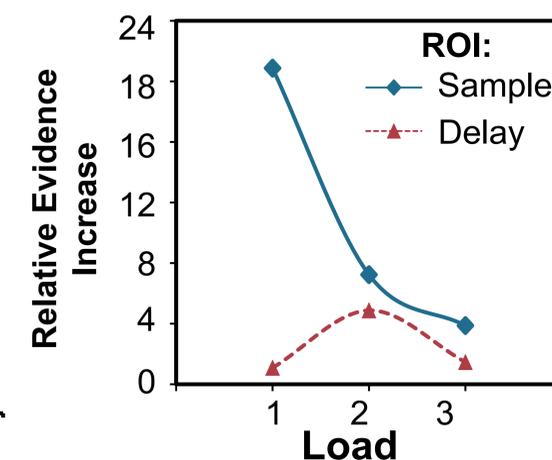
Results: Classifier Evidence for Load



Results: Classifier Evidence for Direction



Evidence score calculated as ratio of evidence for target direction to evidence for mean of un-presented directions



Discussion

- The contents of VSTM can be successfully decoded from fMRI signal using MVPC, even when multiple items are maintained in memory.
- Those areas that demonstrate increased activation during the delay period of a STM task may not contain information about the identity of the memoranda.
- Instead, areas that mediate the sensory perception and encoding of information may support the maintenance of information in STM, even in the absence of sustained delay-period activity.
- The decrease in STM performance (accuracy) with load may be associated with a decrease in neural evidence for information in sensory encoding areas.
- The MVPC index of neural evidence (observed during the delay period) may not reflect the fidelity of STM representations.

References

- Bays P. M., Catalao R. F. G., Husain M. (2009). The precision of visual working memory is set by allocation of a shared resource. *Journal of Vision*, 9(10):7, 1–11.
- Harrison SA, Tong F. Decoding reveals the contents of visual working memory in early visual areas. *Nature*. 2009 Apr 2;458(7238):632-5.