Delay-period activity of the parietal cortex depends on working memory load

Michael J. Starrett, Olivia Gosseries, Joshua J. LaRocque, Elyana Saad, Nelson Cowan, Bradley R. Postle

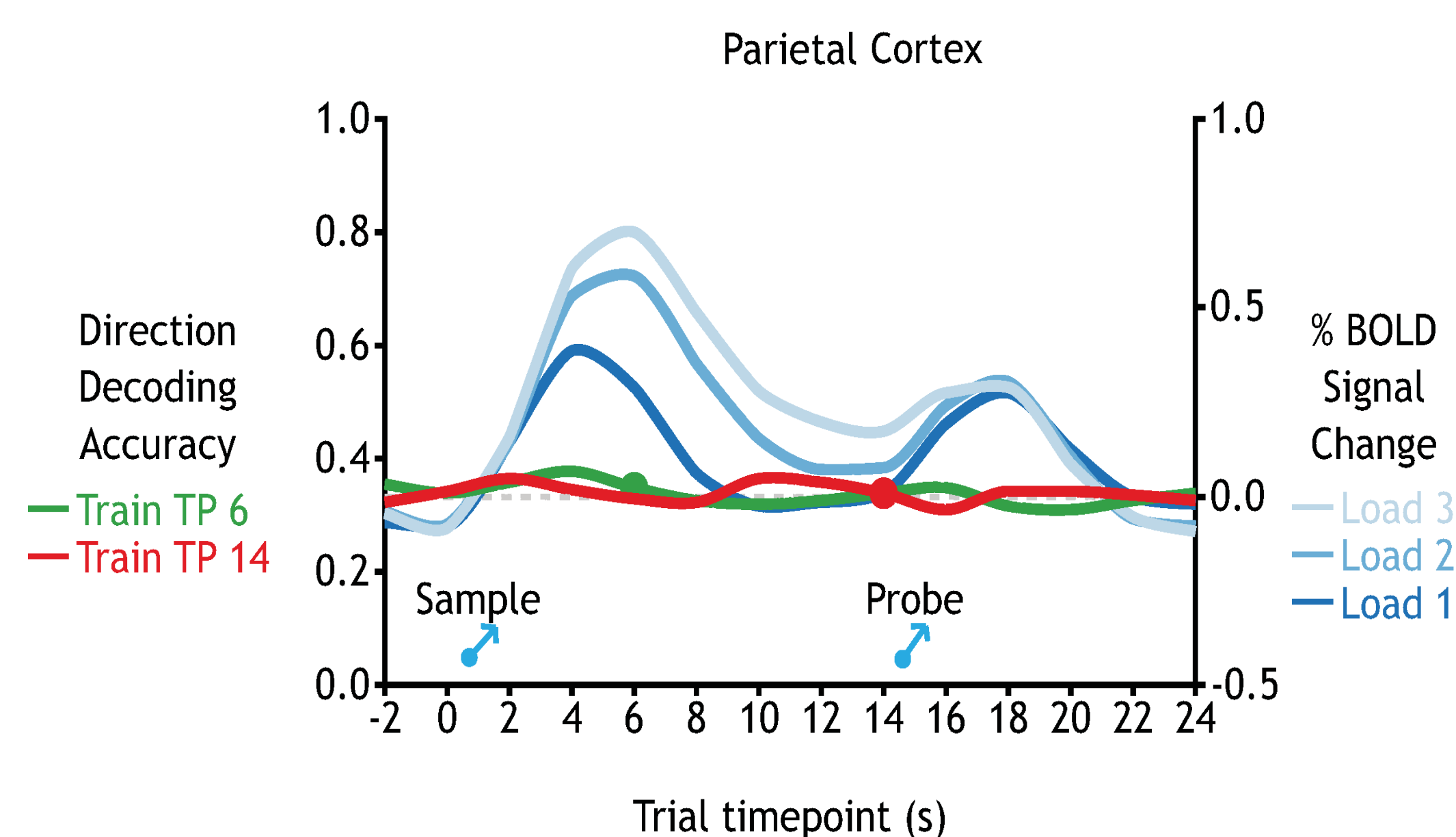Departments of Psychology and Psychiatry, University of Wisconsin-Madison, USA.

Background

Multivariate pattern analysis (MVPA) studies of visual short-term memory (VSTM) indicate that elevated delay-period activity often does not carry stimulus information [1, 2].

Parietal Cortex

Direction Decoding Accuracy

% BOLD Signal Change

Train TP 6
Train TP 14
Load 3
Load 2
Load 1

Sample — Probe

Trial timepoint (s)

Hypothesis: anterior Intraparietal Sulcus (aIPS) activity reflects increased demands on the selection mechanisms of a domain-general attentional system, such that more activity is required to select and sustain attentional prioritization with each additional item that is added to the load.
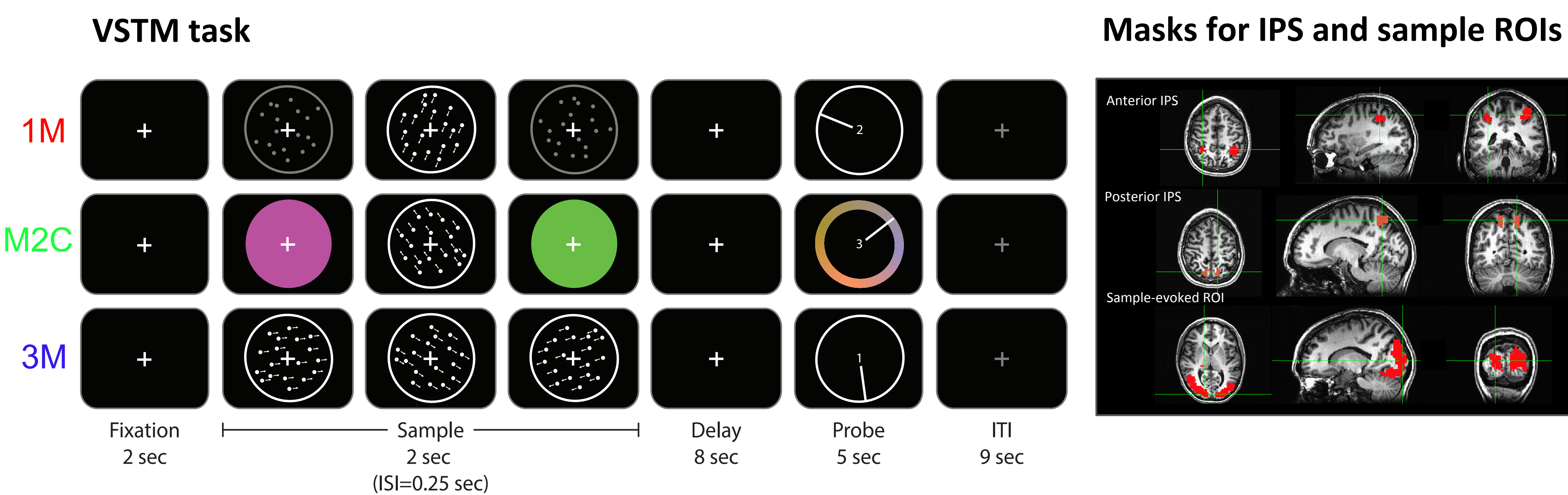
IPS
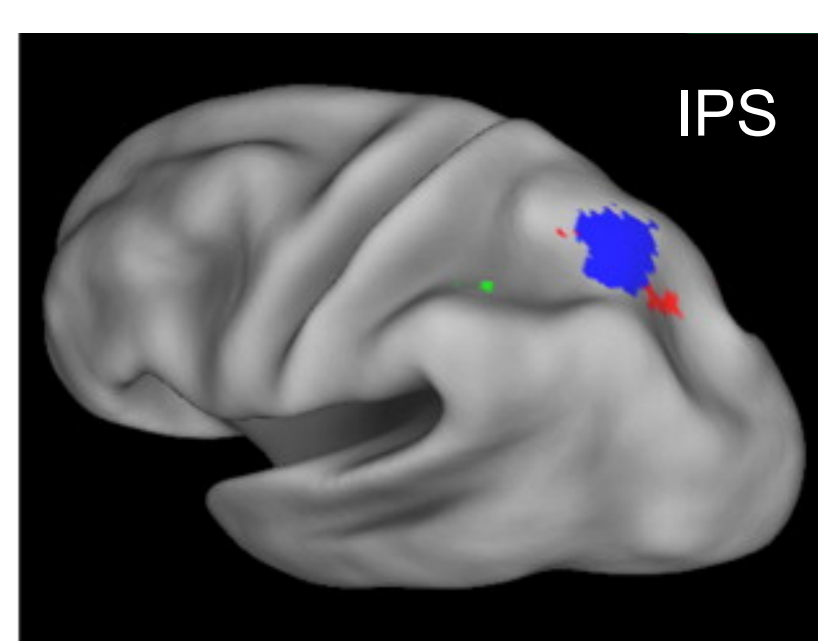
Conclusions

Although behavioral data and BOLD activity in aIPS are consistent with inter-item interference, MVPA results suggest that aIPS: 1) does not represent stimuli; 2) encodes load; 3) encodes trial identity. These are characteristics of a *source* of attentional control. In contrast, it is posterior, sample-evoked regions that represent stimuli in a manner that tracks psychophysical precision.

References and acknowledgement
[1] Riggall, A.C., Postle, B.R. (2012). The relationship between working memory storage and elevated activity as measured with functional magnetic resonance imaging. J Neurosci. 19;32(38):12990-08.
[2] Emrich, SM., Riggall, A.C., Larocque, J.J., Postle, B.R. (2013) Distributed patterns of activity in sensory cortex reflect the precision of multiple items maintained in visual short-term memory. *J Neurosci.* 33(15): 6516-23). [3] 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. This study was supported by NIH MH095984, the Belgian American Education Foundation and the Wallonie-Bruxelles International.
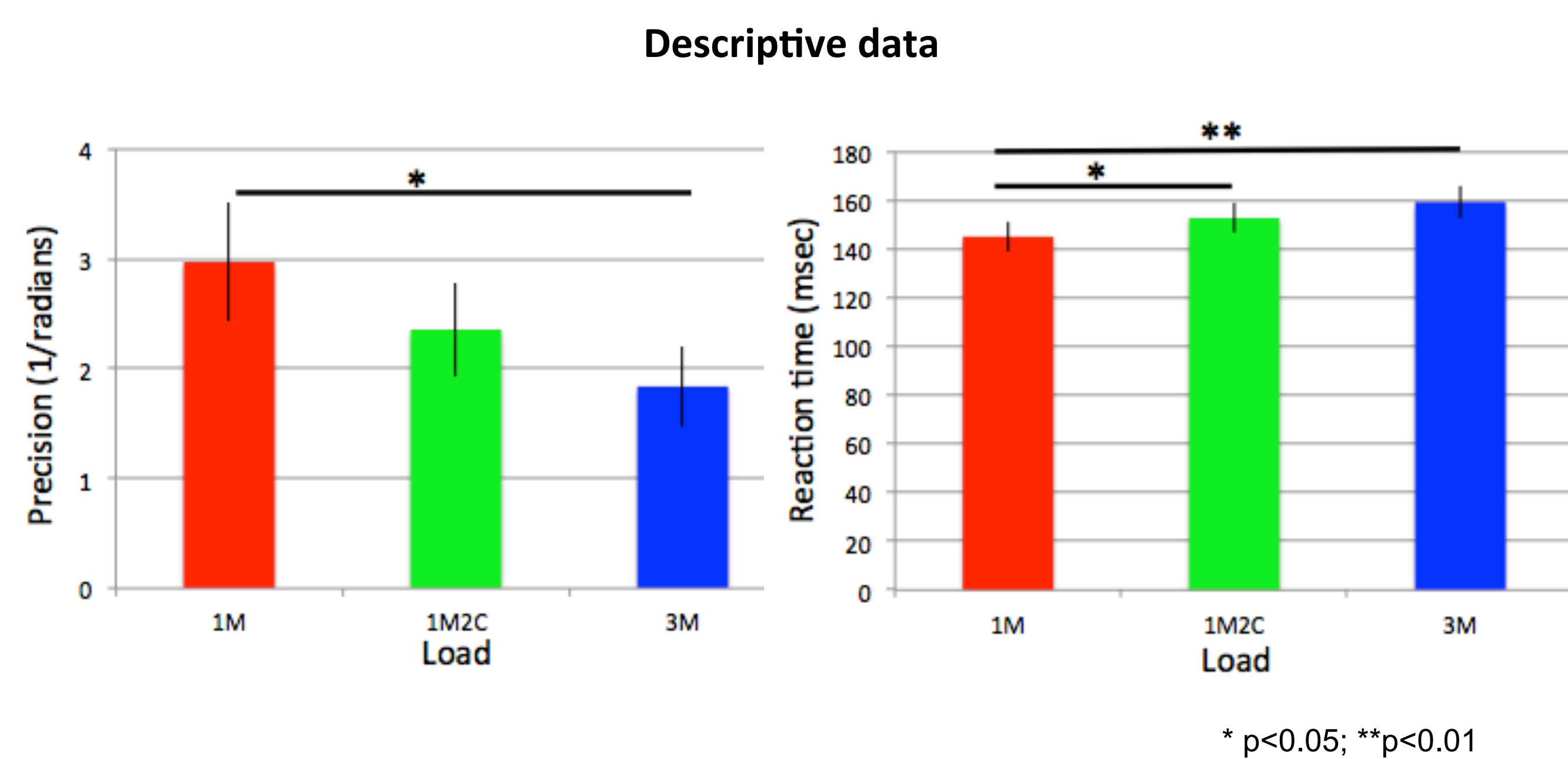
Methods

- 12 subjects (3 females, 25±4 years old)
- VSTM tasks in 3T MRI: 6 runs of 30 trials and 3 runs of 24 trials (for behavior only) with 3 trial types (1Motion, 1Motion2Colors, 3Motions) and 2 loads (1 and 3).
- Analyses: mixture-model [3] and descriptive for behavior, preprocessing, general linear model and multivariate pattern analysis (MVPA, leave-one-trial-out approach) for fMRI.
- IPS masks based on introspection of individual delay BOLD activity and anatomy, sample masks based on individual sample BOLD activity.
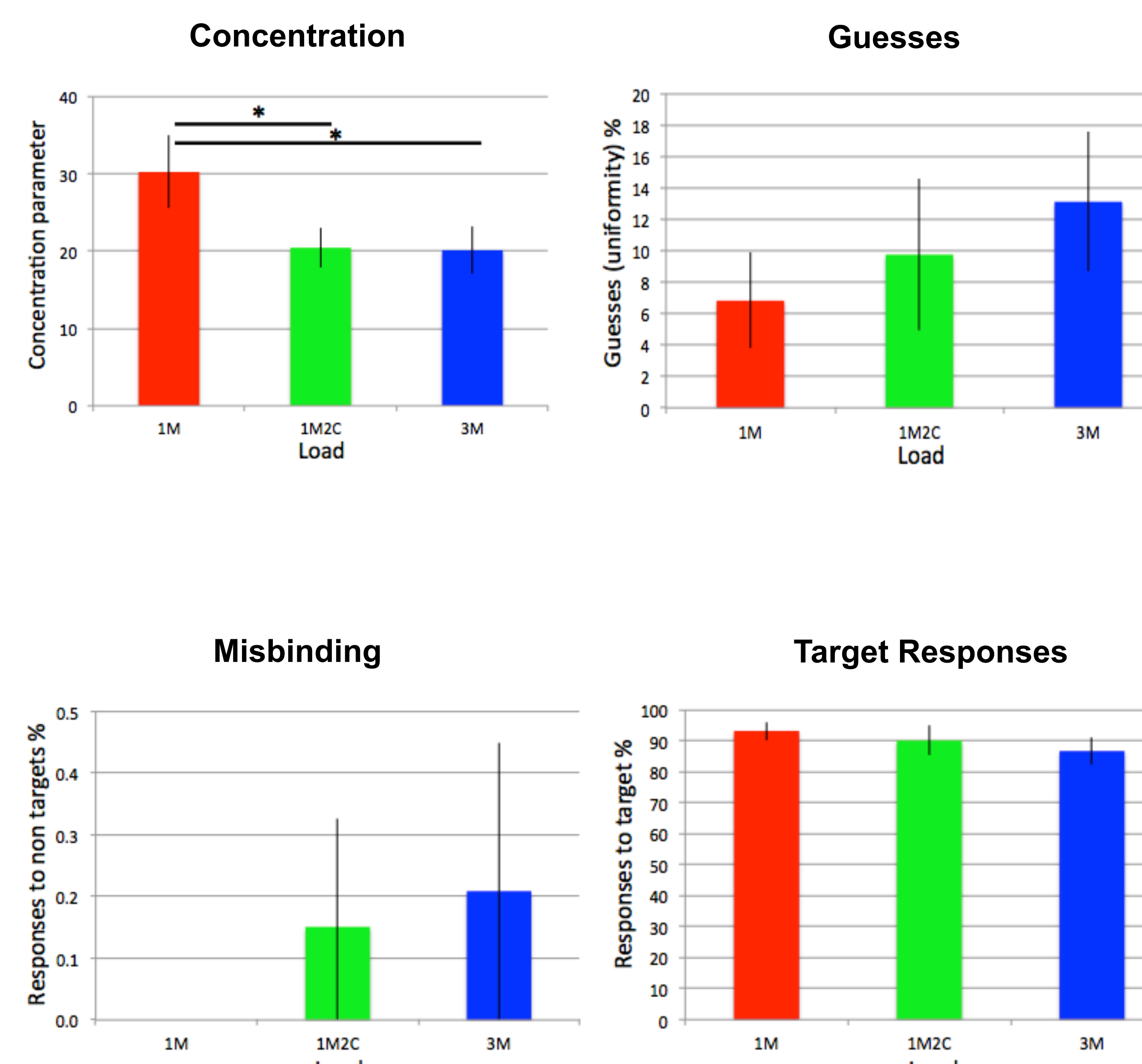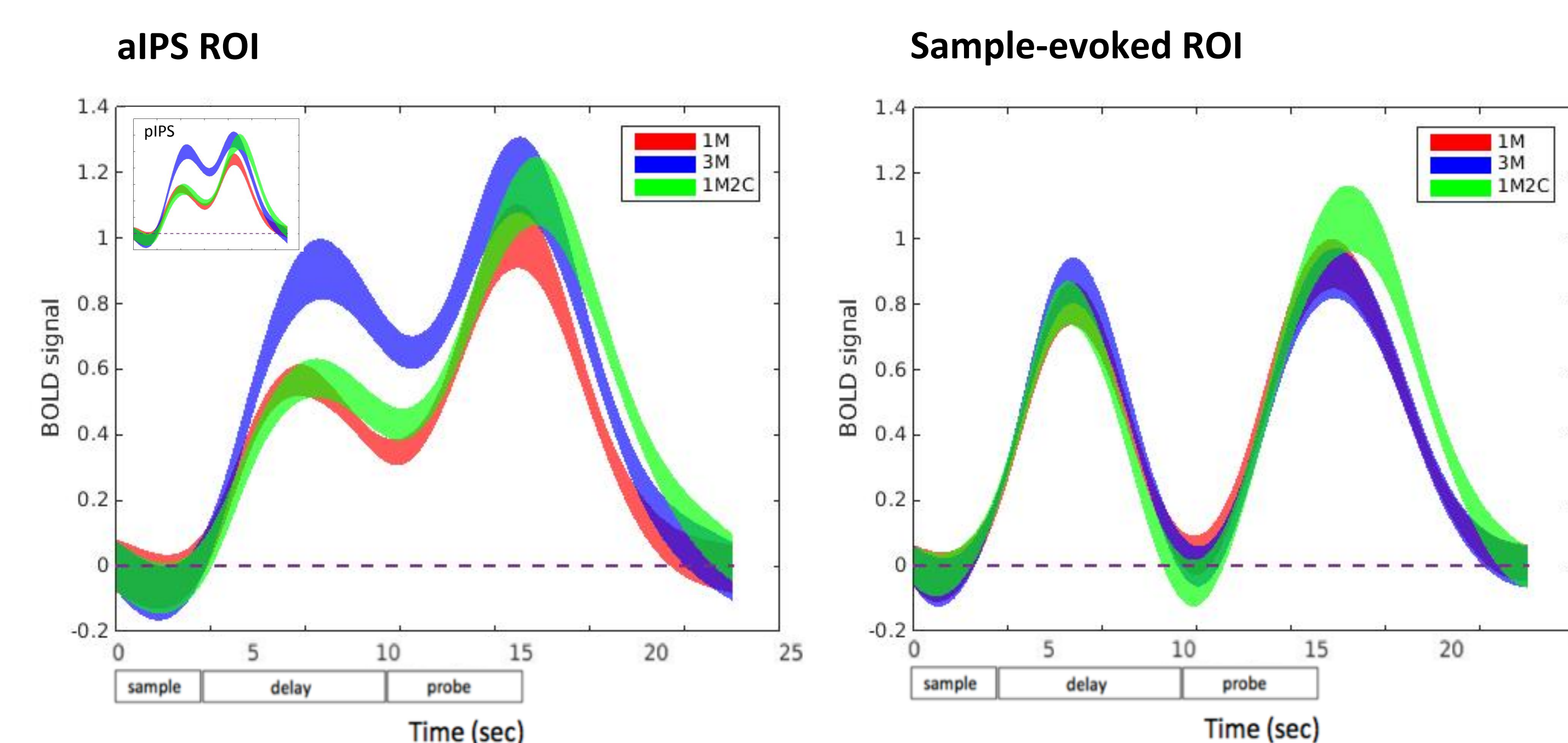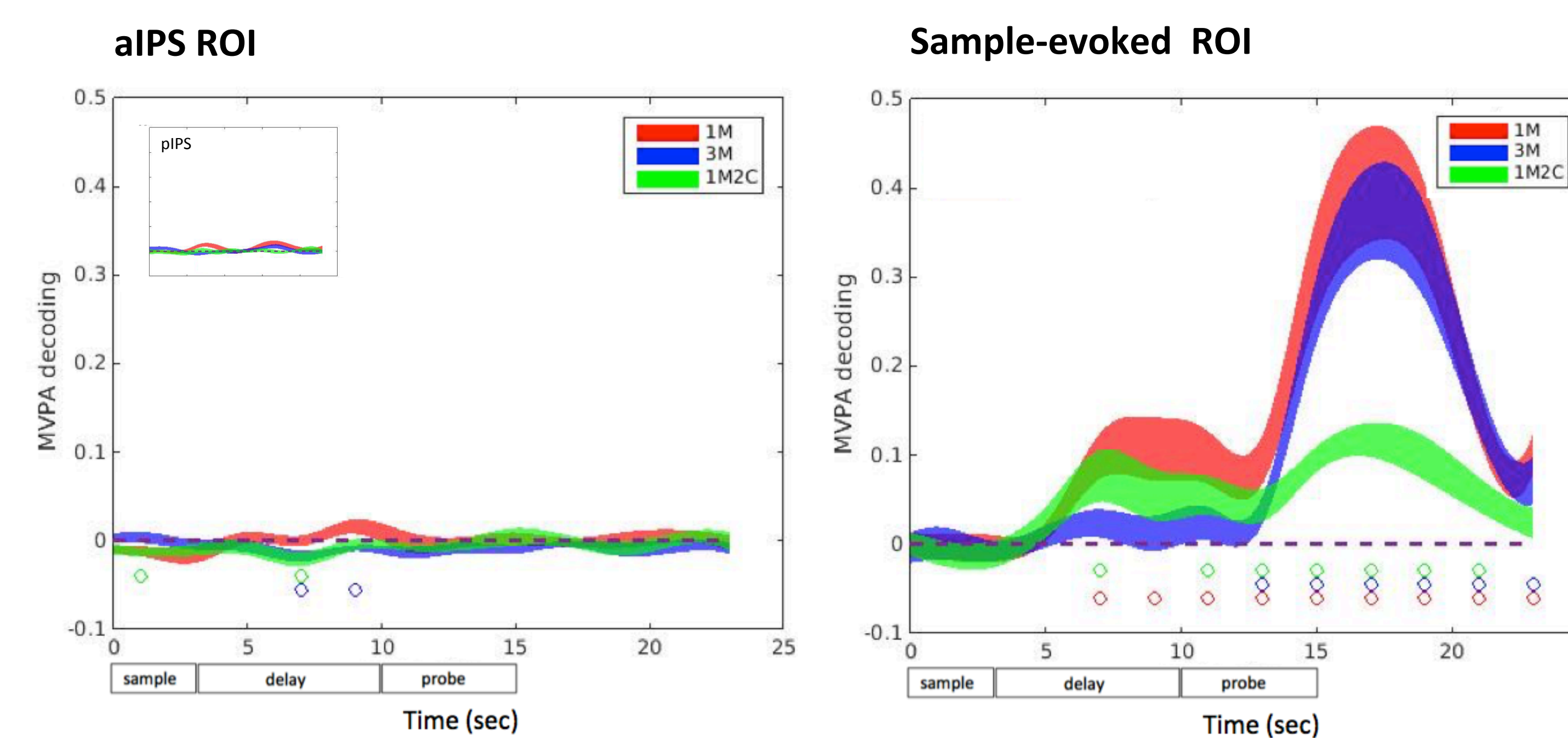
VSTM task

1M
1M2C
3M

Fixation 2 sec | Sample 2 sec (ISI=0.25 sec) | Delay 8 sec | Probe 5 sec | ITI 9 sec

Masks for IPS and sample ROIs

Anterior IPS
Posterior IPS
Sample-evoked ROI

Results

Behavior

Descriptive data

Precision (1/radians) — Load — 1M, 1M2C, 3M

Reaction time (msec) — Load — 1M, 1M2C, 3M

* p<0.05; **p<0.01

Mixture model

Concentration — Concentration parameter — Load

Guesses — Guesses (uniformity) % — Load

Misbinding — Responses to non targets % — Load

Target Responses — Responses to target % — Load

BOLD activity

aIPS ROI

1M
3M
1M2C

pIPS

BOLD signal — Time (sec)

sample delay probe

Sample-evoked ROI

1M
3M
1M2C

BOLD signal — Time (sec)

sample delay probe

MVPA of stimulus identity (direction of motion)

aIPS ROI

1M
3M
1M2C

pIPS

MVPA decoding — Time (sec)

sample delay probe

Sample-evoked ROI

1M
3M
1M2C

MVPA decoding — Time (sec)

sample delay probe

MVPA of load (1M vs [(1M2C+3M)/2]

aIPS ROI

pIPS

MVPA decoding — Time (sec)

sample delay probe
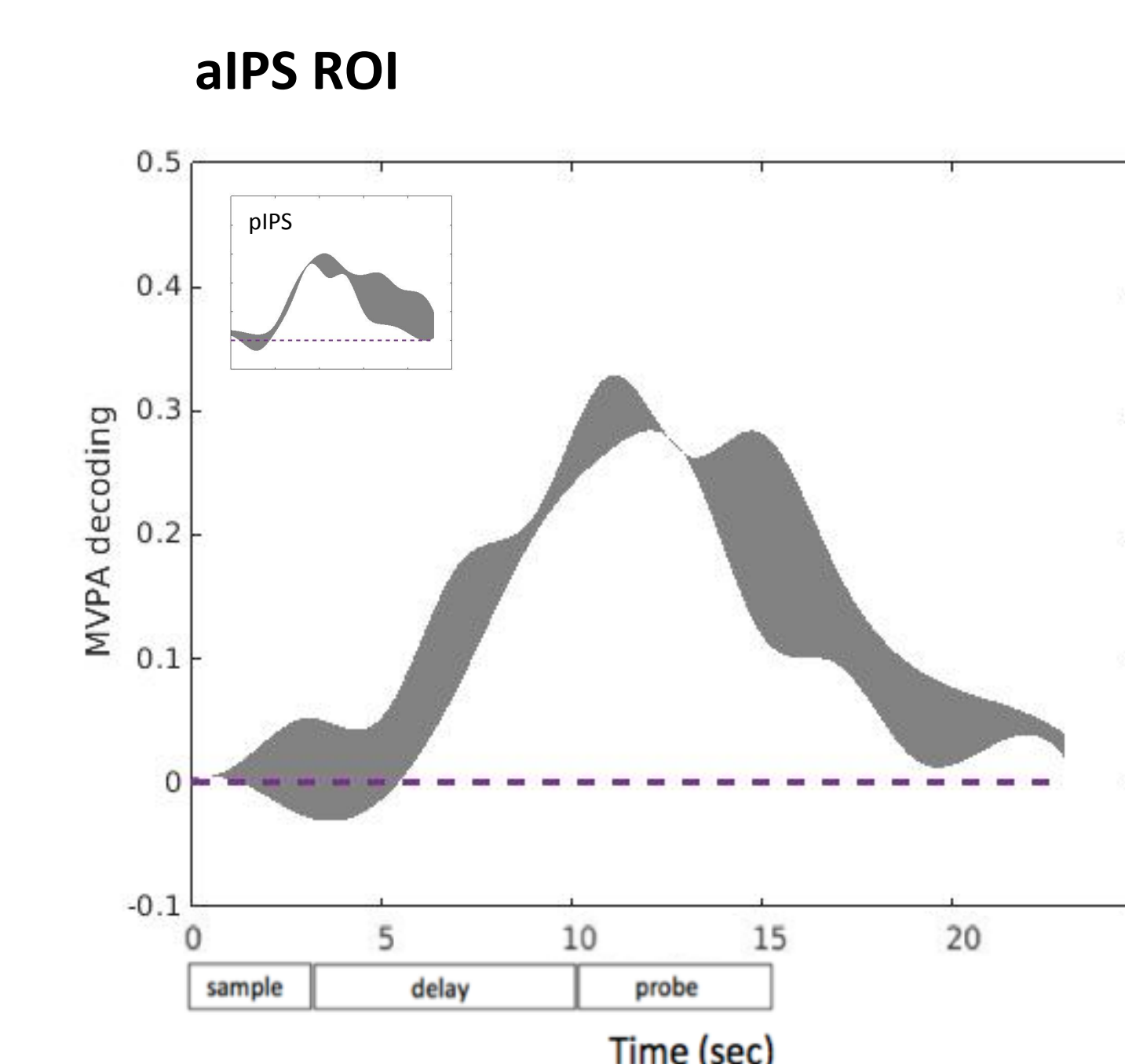
MVPA of trial type (1M2C vs 3M)

aIPS ROI

pIPS

MVPA decoding — Time (sec)

sample delay probe

Behavioral x Neural Precision

Sample ROI, 1M and 3M

R^2=0.49, p=0.008

MVPA decoding — Concentration

Sample ROI, 1M and 1M2C

R^2=0.12, p=0.25

MVPA decoding — Concentration