NEURAL SIGNATURES OF VARIABLE BELIEFS INCREASE WITH TASK LEARNING IN V1

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Previous work has suggested that "top-down," especially task-dependent, sources of variability are some of the dominant modes of trial-to-trial variability in sensory neurons' responses. It has also been hypothesized that such top-down modulators can be understood as representing "variable beliefs" about task-relevant features of the stimulus in a probabilistic inference framework of perception, where task-based expectations act as a *prior* [1].

A stronger test of this hypothesis would be to measure (a) the emergence of task-dependent correlations over the course of learning a task, and (b) a change in the correlation structure on short timescales as the task context is changed [2]. The probabilistic inference framework predicts the task-relevant component of correlations would be proportional to the product of neural sensitivities to the stimulus. This means that such correlations would *increase* over the course of learning, while a purely feedforward framework would predict the opposite trend (assuming perceptual learning reduces these "information-limiting" correlations [3]).

We present preliminary results from two macaque monkeys learning two versions of an orientation-discrimination task. Populations of V1 neurons were recorded over the course of training. Training included four phases: a cardinal discrimination task, an oblique discrimination task, interleaved task-switching, and finally task switching with V2 inactivated by cooling. We regressed pairs of neurons' correlations against the product of their sensitivities to the task-relevant stimulus dimension, quantifying the amount of task-dependent correlations present each day.

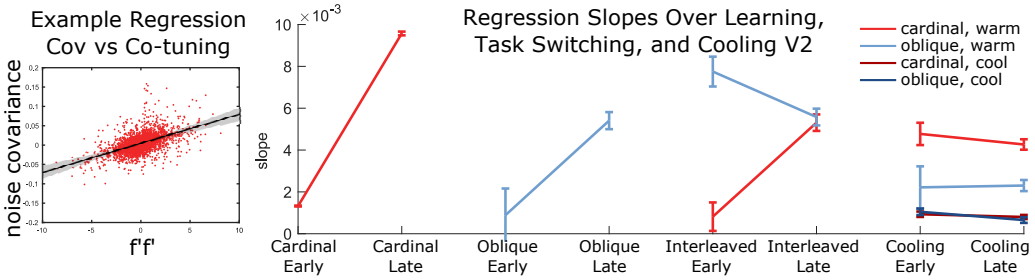

Figure 1: Data from first monkey only. **Left:** We quantify the amount of task-dependent correlations as the slope of the relationship between pairs of neurons' covariance and the product of their sensitivities. **Right:** Amount of task-dependent correlations over "early" and "late" halves of each training phase. At all time points, this is correlated with performance on the task (not plotted), suggesting a consistent positive relationship between performance and differential correlations across learning.

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References: [1] Haefner, Berkes, Fiser, 2016, *Neuron* 90(1). doi 10.1016/j.neuron.2016.03.020 [2] Cohen, Newsome, 2008, *Neuron* 60(1). doi 10.1016/j.neuron.2008.08.007 [3] Moreno-Bote, Beck, Kanitscheider, *et al*, 2014, *Nature Neuroscience* 17(10). doi 10.1038/nn.3807