Flexible readout of stable cortical representations support motion visibility perception

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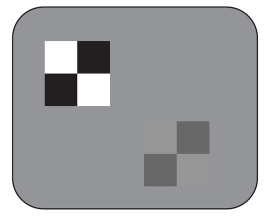
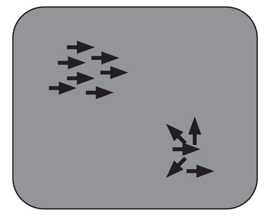
1. Introduction

Changes in sensory representation improve sensitivity during context-dependent behavior, e.g. judgment of motion visibility:

Contrast
The relative luminance to a gray background



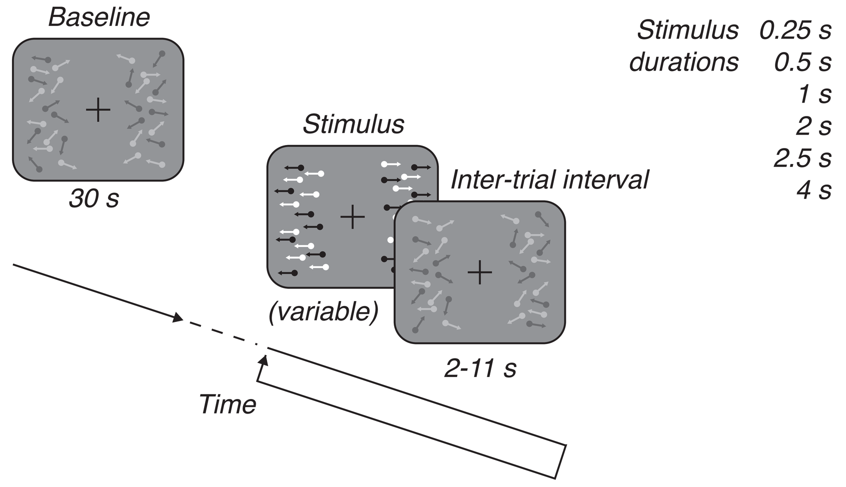
Coherence
The proportion of dots moving in the same direction



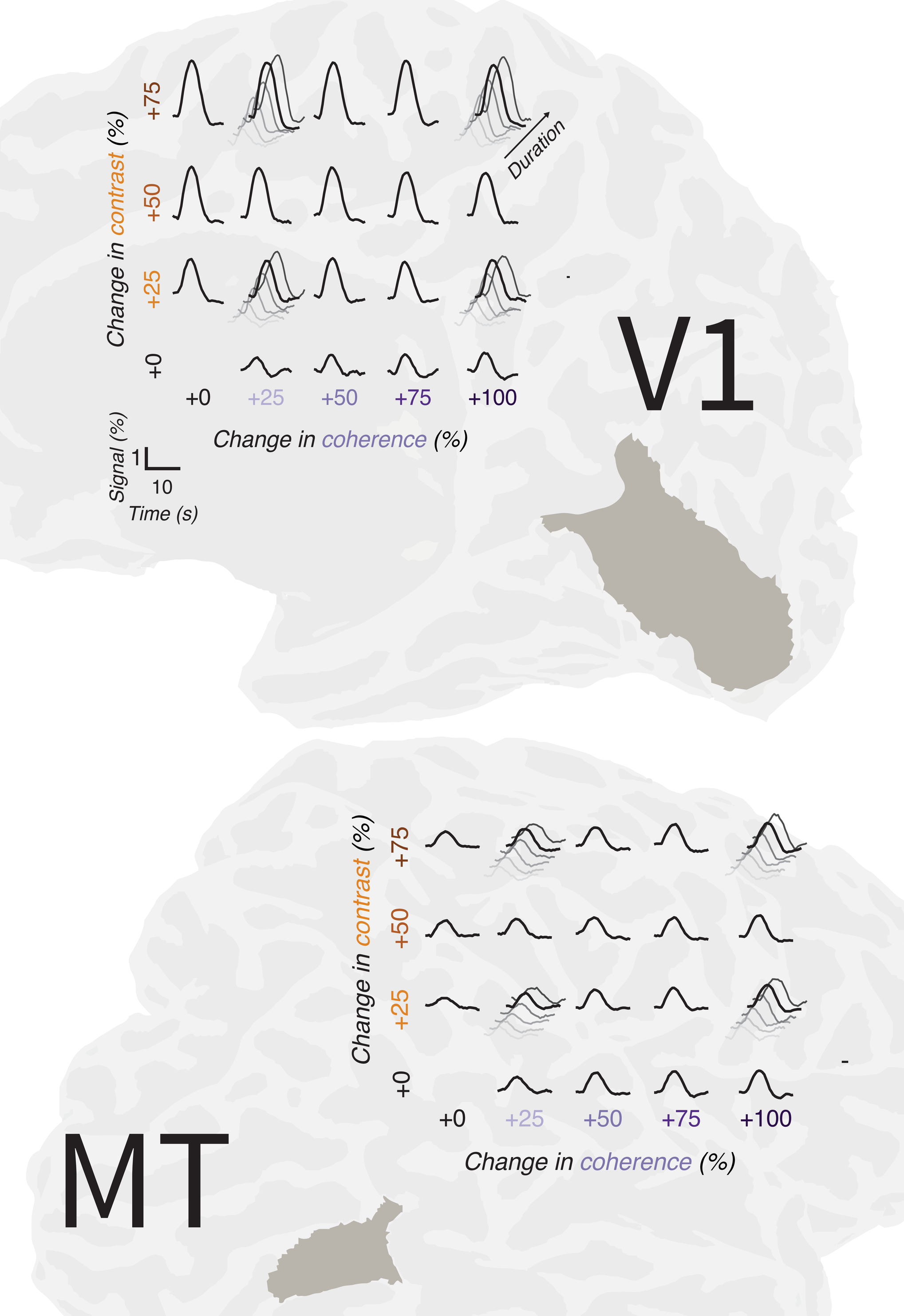
Although the benefits of enhancing representations are clear, there are situations in which changing sensory representations means losing information about unattended stimuli.

2. BOLD signal measurements

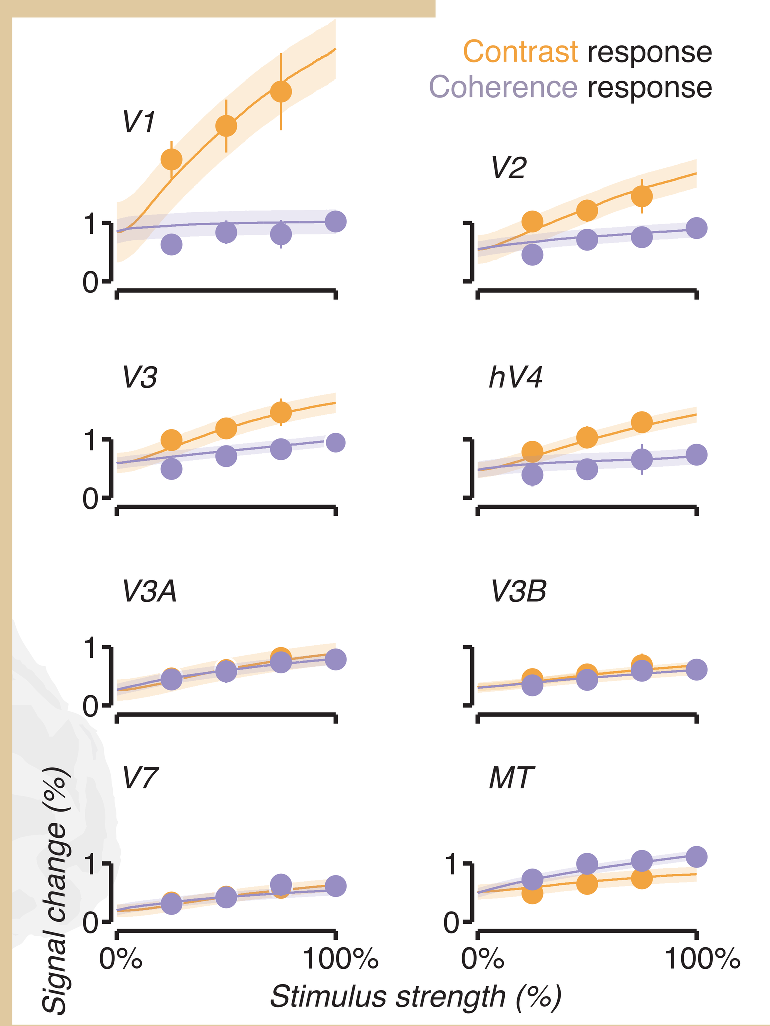
We studied contrast and coherence, two visual features that independently control the visibility of motion. Each feature is represented by monotonic increasing response in visual cortex, in overlapping regions[1].



11 observers
4-6 hrs

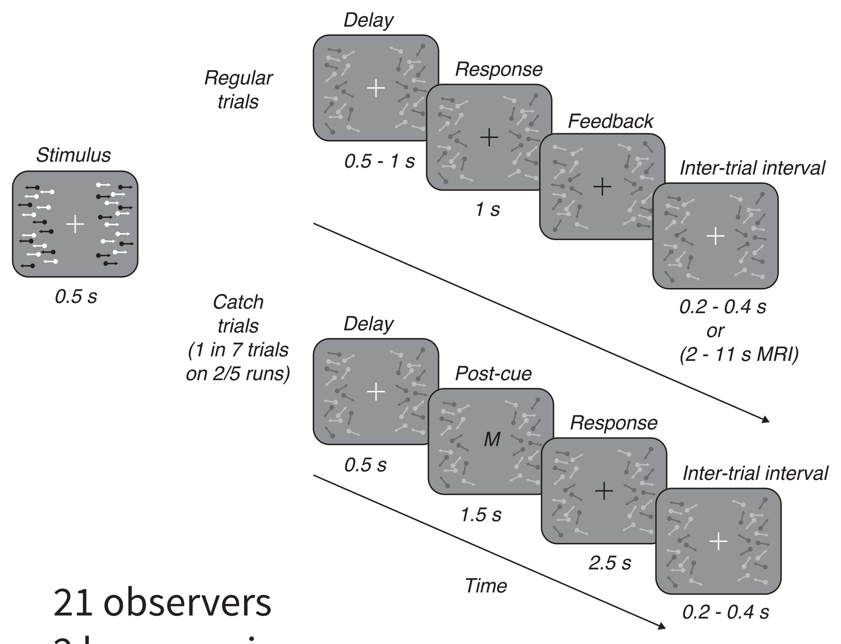


Visual cortex

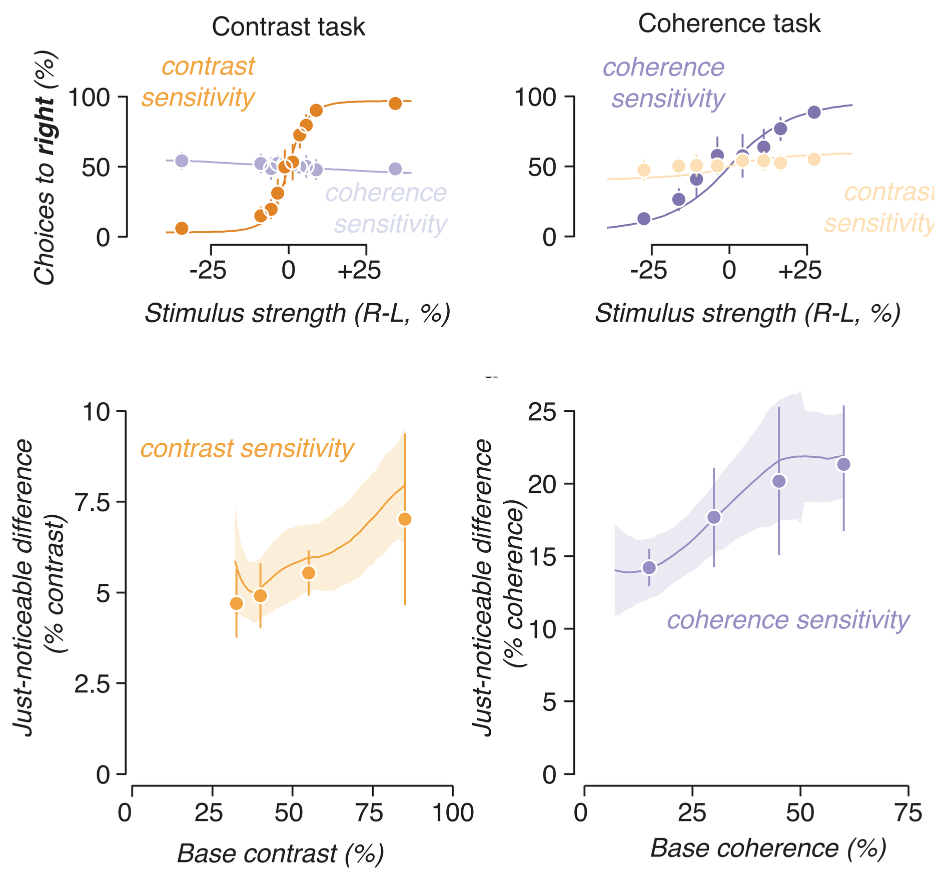


3. Perceptual sensitivity

We measured how well participants could discriminate small increments in contrast and motion coherence. Observers were able to discriminate each feature independently of the other.

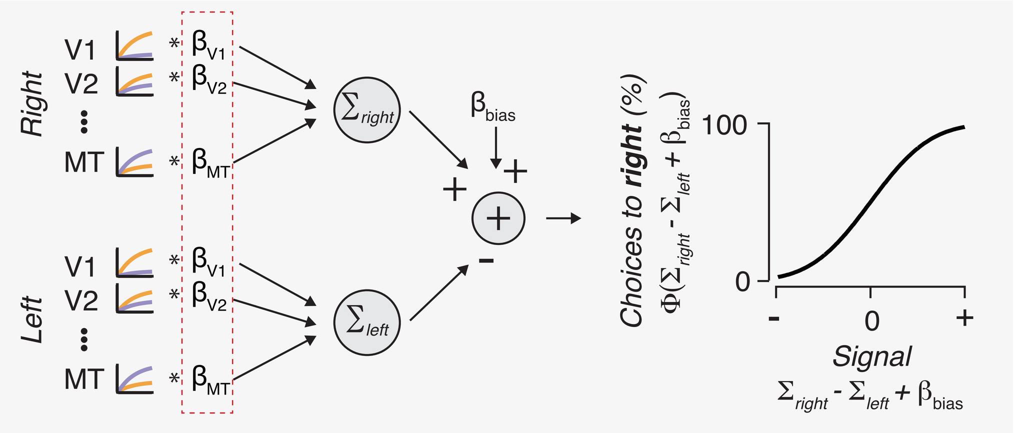


21 observers
2 hrs scanning
4-6 hrs behavior



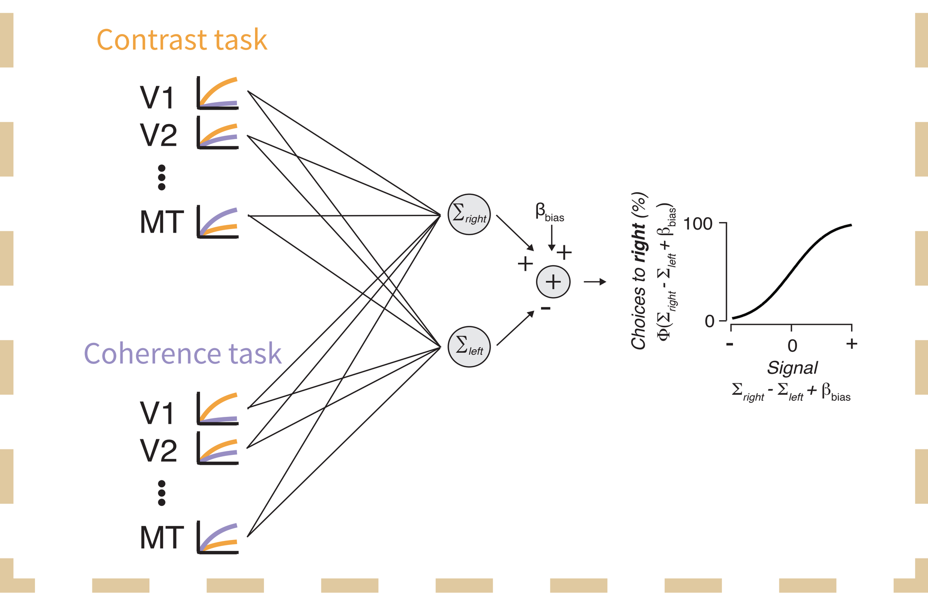
4. Linking model

A linking model is a computational description of the steps that lead from sensory representation to perceptual decisions. We extended an existing model of contrast discrimination to two features by allowing the population representation in different cortical areas to be weighted in a context-dependent manner.

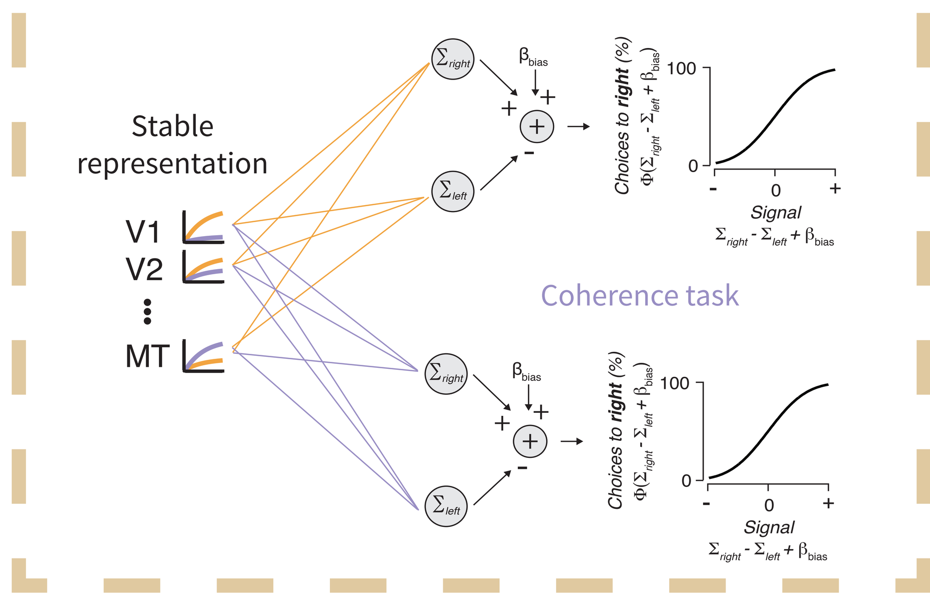


The implementation of the weights could occur through sensory change, or by a downstream process.

Fixed readout

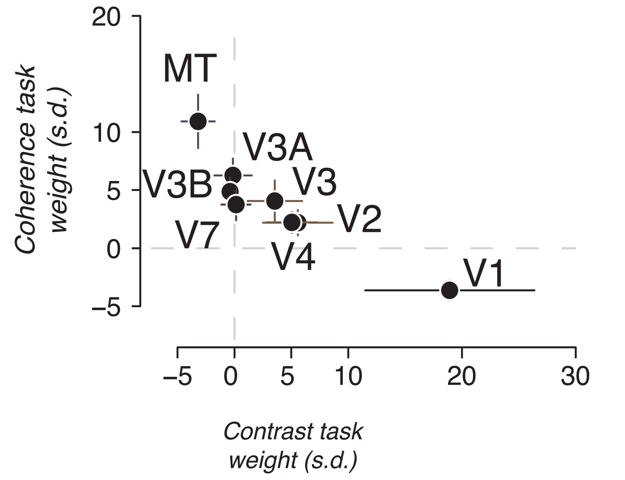


Flexible readout

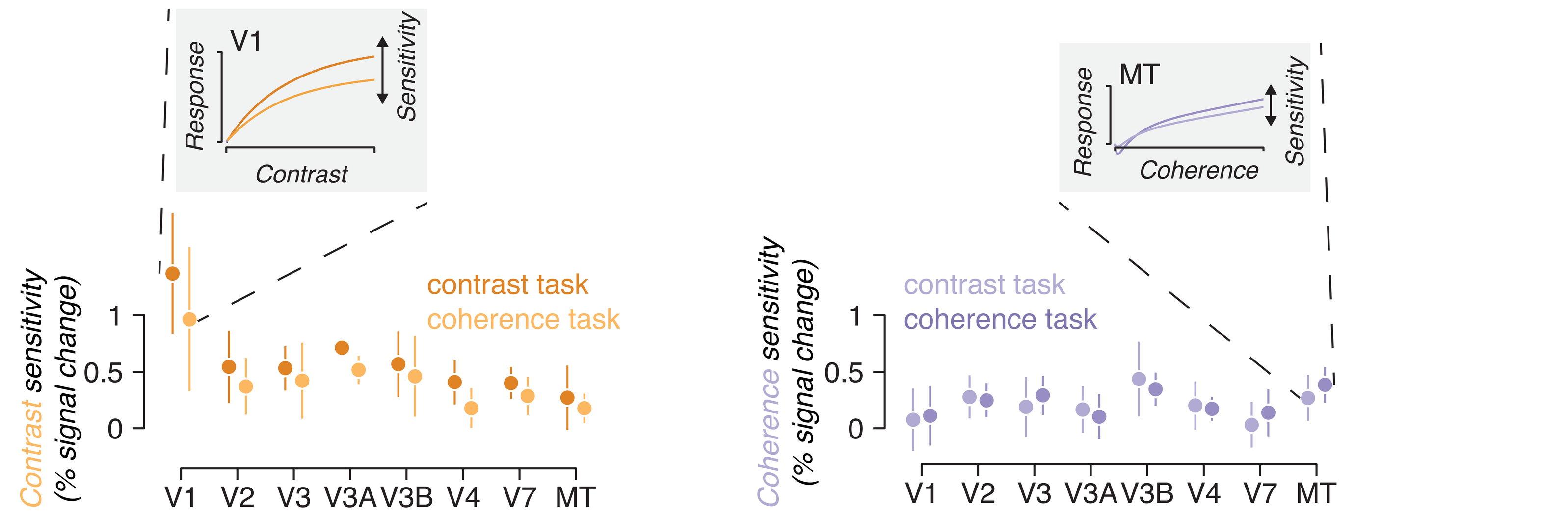


5. Fixed readout?

If the weights in the linking model are implemented by sensory change, then as context changes we should see large shifts in sensitivity.



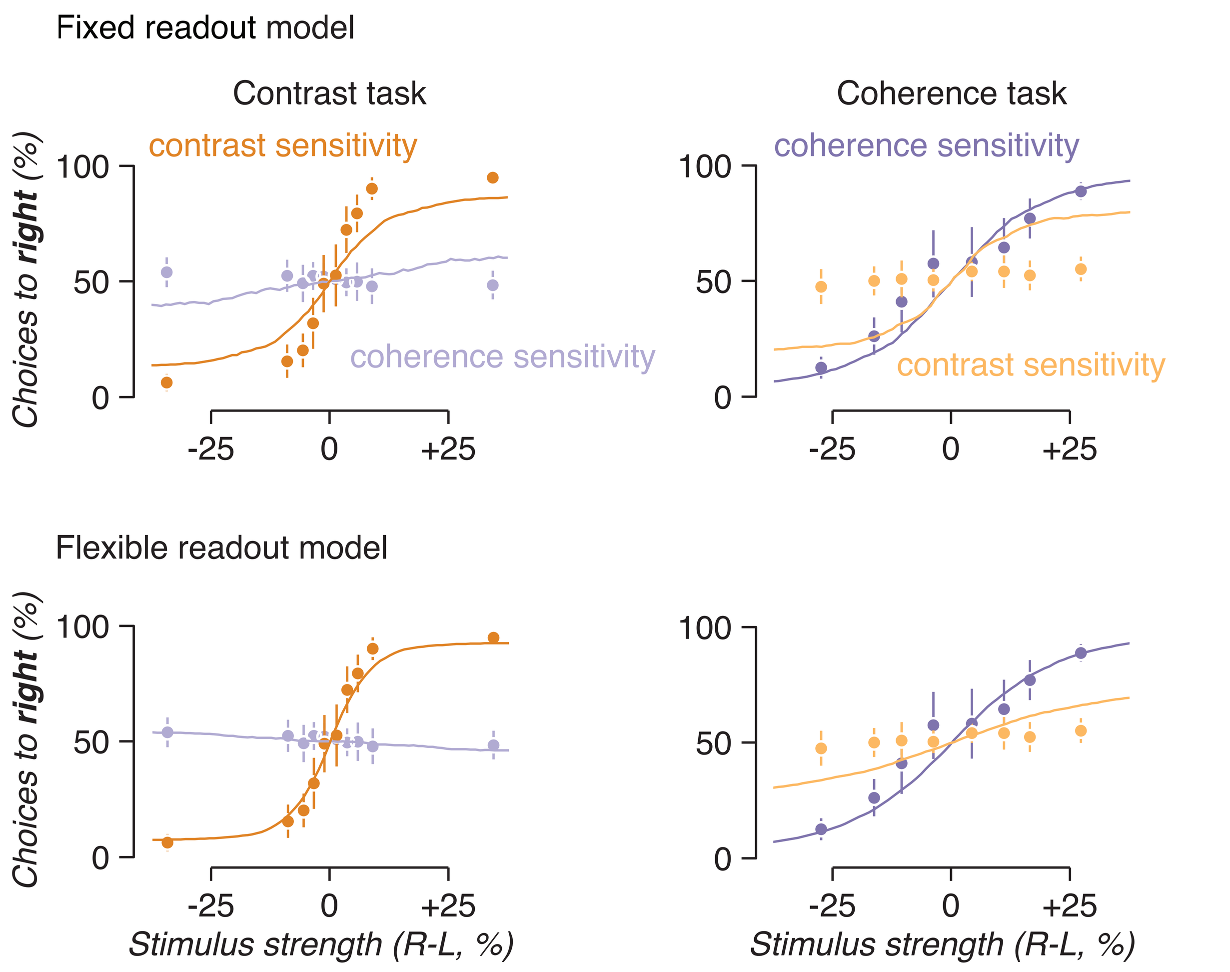
When observers performed each task we only found small changes in sensitivity, not at the right scale to support behavioral adaptability.

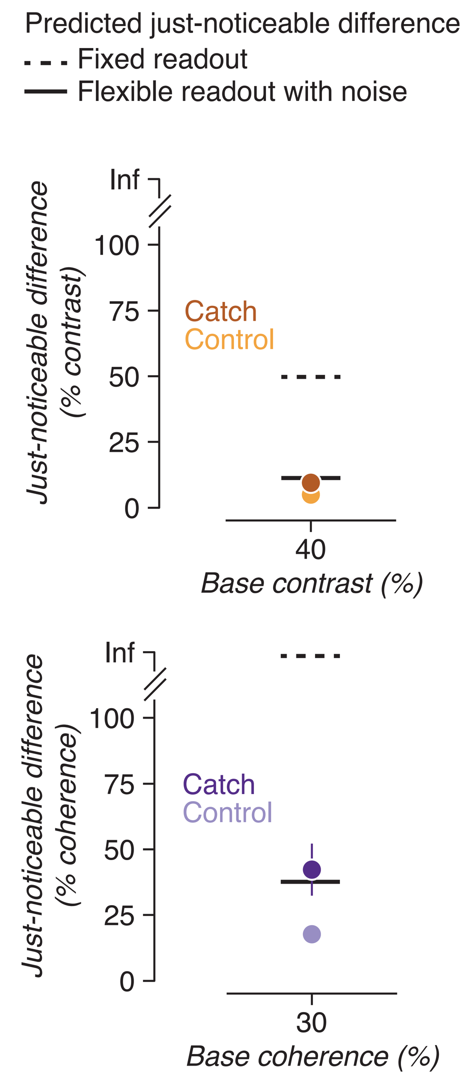


6. Flexible readout.

Using the sensitivity in each context we formally tested the fixed readout and flexible readout models and found that only the flexible readout model could fit the data (left).

In an uncertain world keeping sensory representations stable is a benefit. On unexpected "catch" trials observers were asked to change their mind after preparing to respond. They were able to do this with less loss in sensitivity than a fixed model would predict.





All data shows bootstrapped mean ± 95% CI across subjects.

Contrast response function:

$$R(contrast) = \alpha \frac{contrast^{1.9}}{contrast^{1.6} + \sigma^{1.6}}$$

Coherence response function:

$$R(coherence) = \alpha(1 - e^{\frac{coherence}{\kappa}})$$

1. Birman, D., & Gardner, J. L. (2018). A quantitative framework for motion visibility in human cortex. *Journal of neurophysiology*, 120(4), 1824-1839.
2. Boynton, G. M., Demb, J. B., Glover, G. H., & Heeger, D. J. *Vision Research* (1999).

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