

Probabilistic predictions sharpen expected action-outcome representations in V1

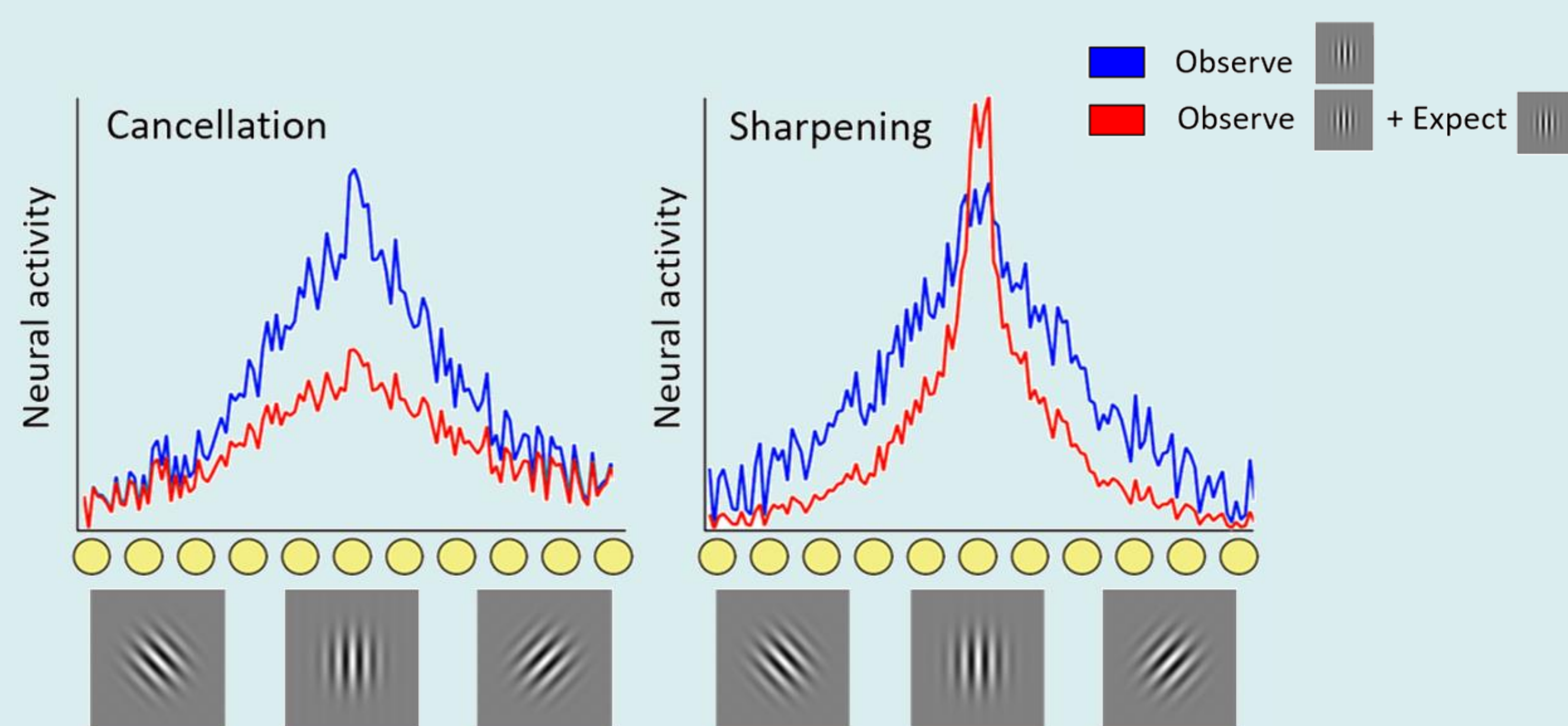
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Introduction

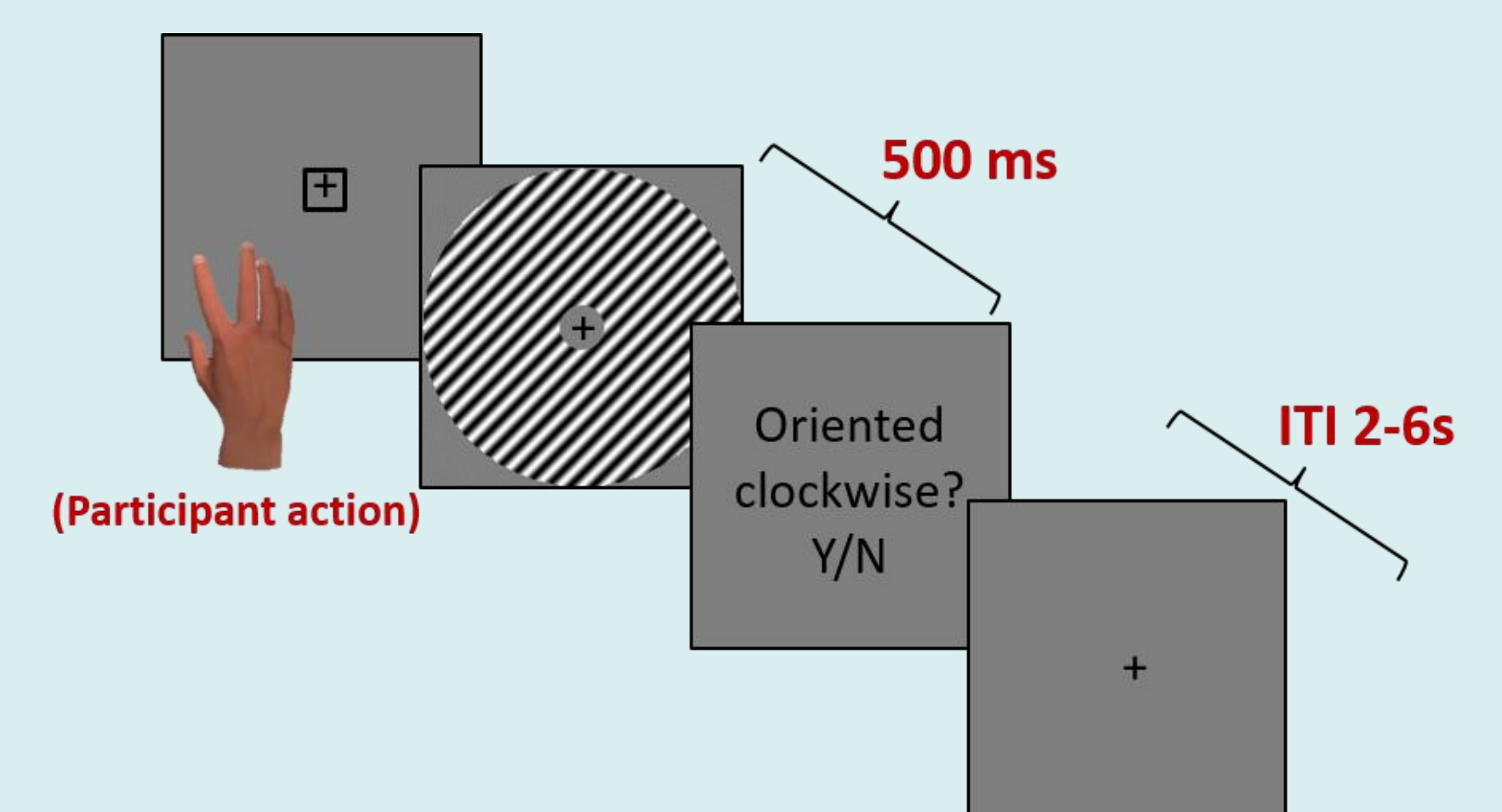
- **Cancellation models (action literature)** → expected sensory consequences of action are ‘cancelled’ from the subsequent percept to prioritise any unexpected events¹.
- This results in reduced neural signal for expected stimuli relative to unexpected signals
- **Bayesian accounts (wider sensory cognition literature)** → in an inherently noisy environment, it is adaptive to combine our sensory inputs with prior knowledge to perceive, on average, what we expect².
- This may result in a sharpening of neural activity representing the expected outcomes amongst relative suppression in units tuned to unexpected outcomes.



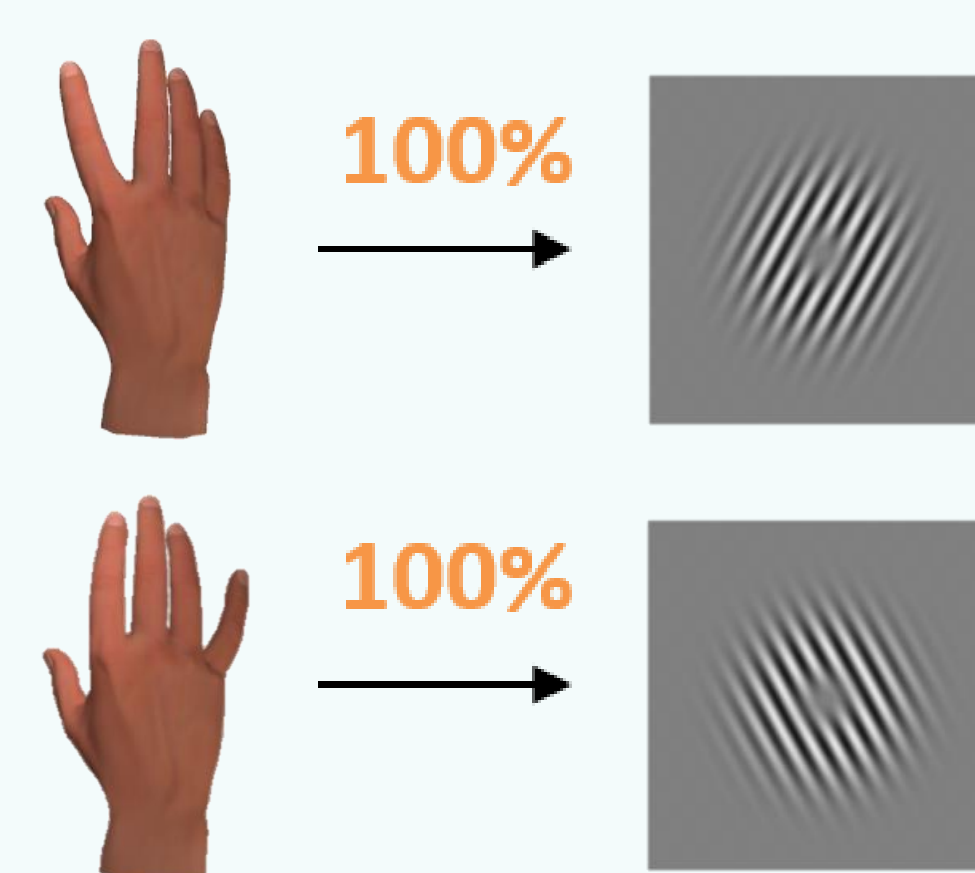
Methods

Behavioural task

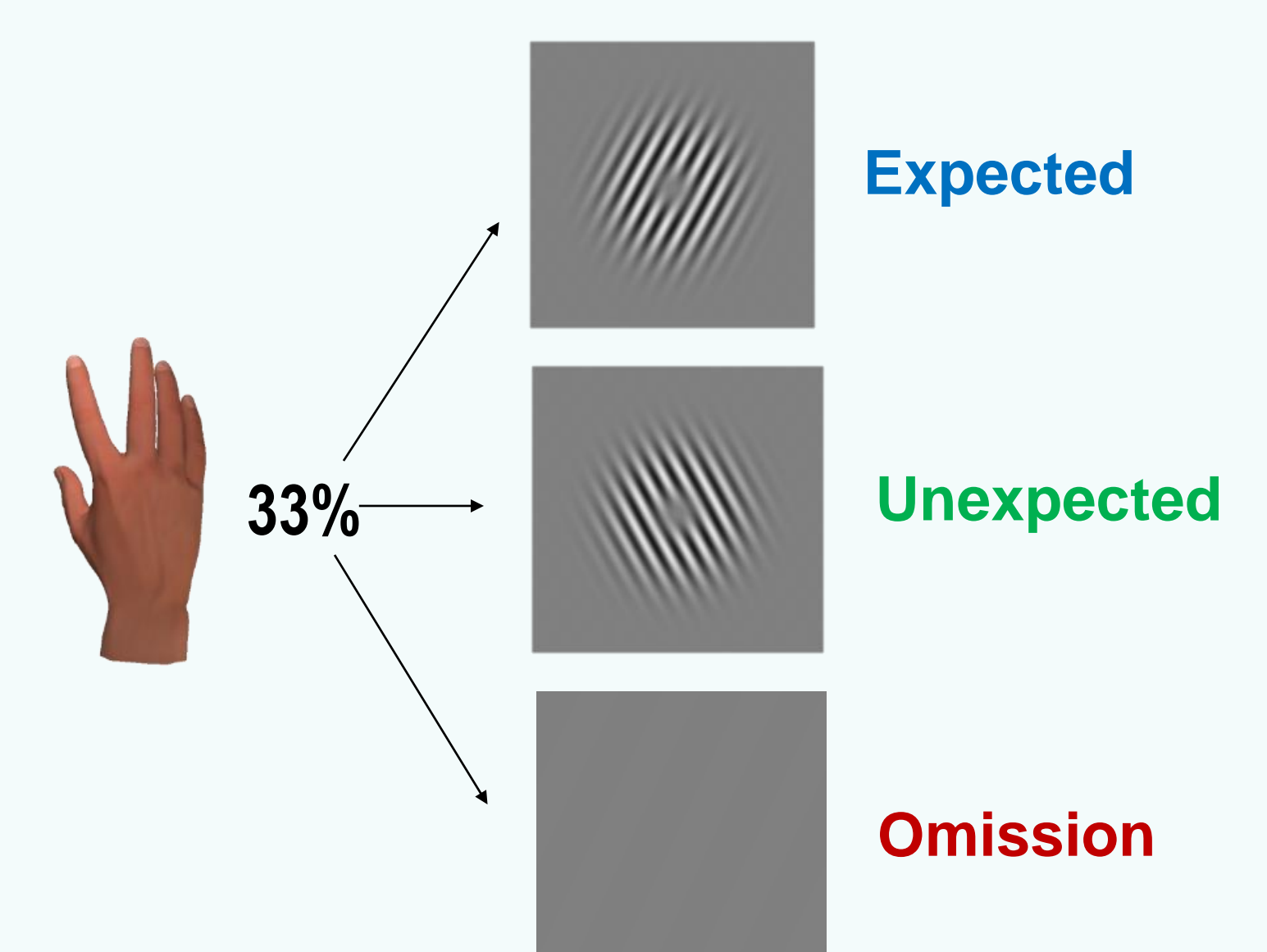
- Participants perform index and little finger abductions and observe oriented grating stimuli
- **Training:** action perfectly predicted the stimulus orientation
- **Test (in scanner):** contingency degraded so that action produced the Expected (33%) or Unexpected (33%) stimulus, or no stimulus (33%)
- Orientation task – participants asked the orientation of the stimulus, e.g. ‘clockwise?’
- Respond ‘yes’ or ‘no’



Training



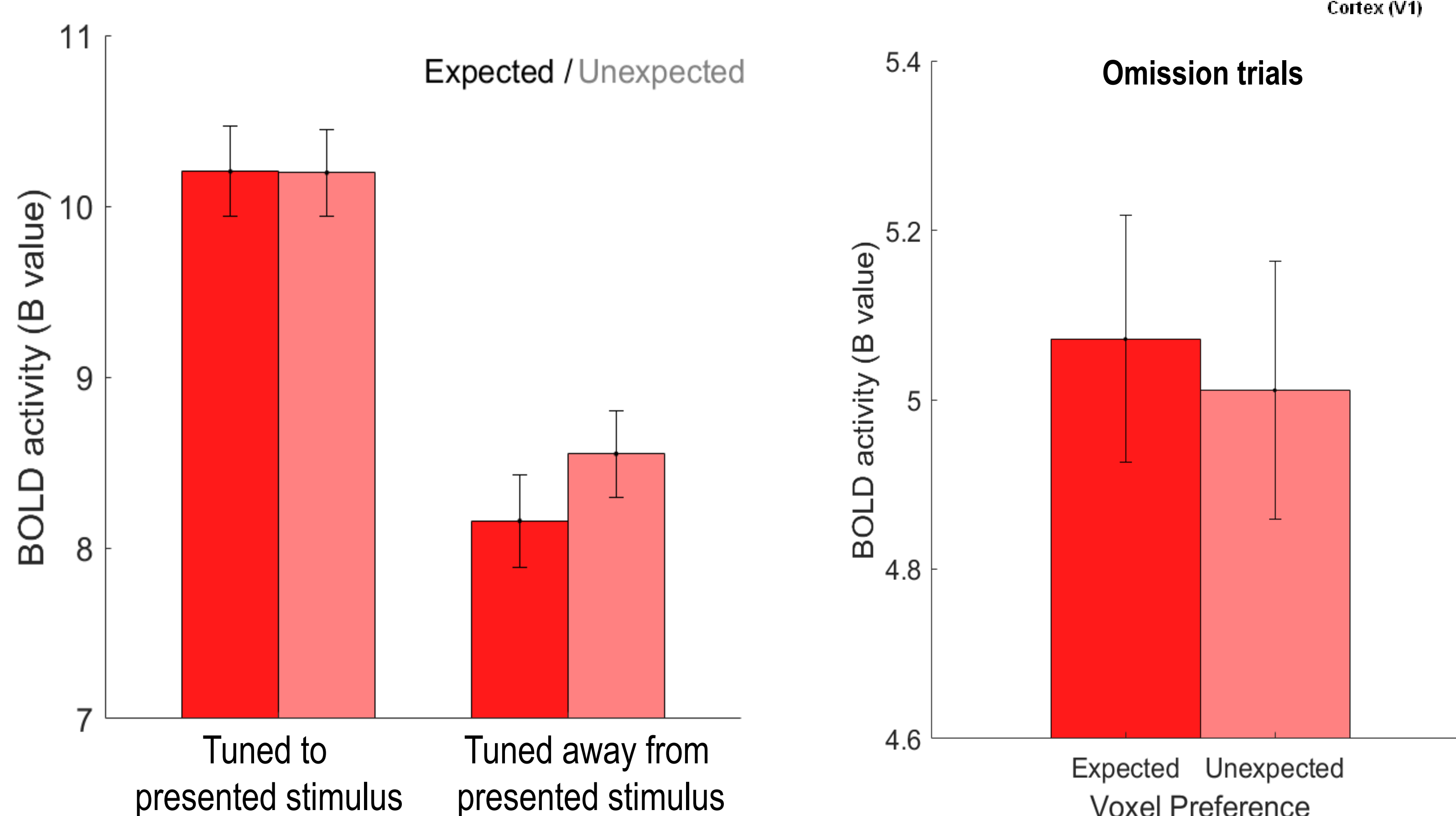
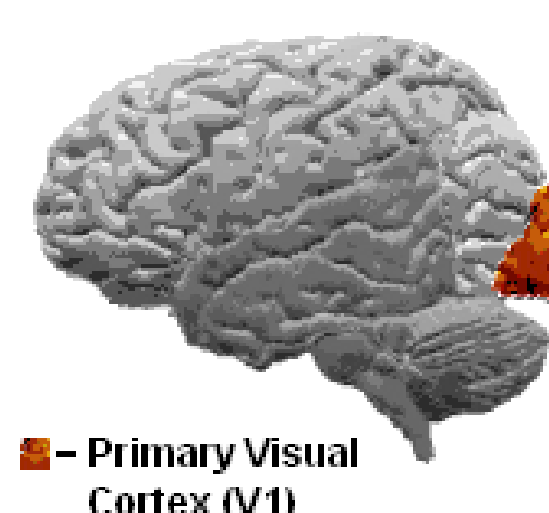
Test (in scanner)



Results – Univariate analysis

Can Sharpening explain activity patterns associated with action predictions in V1?

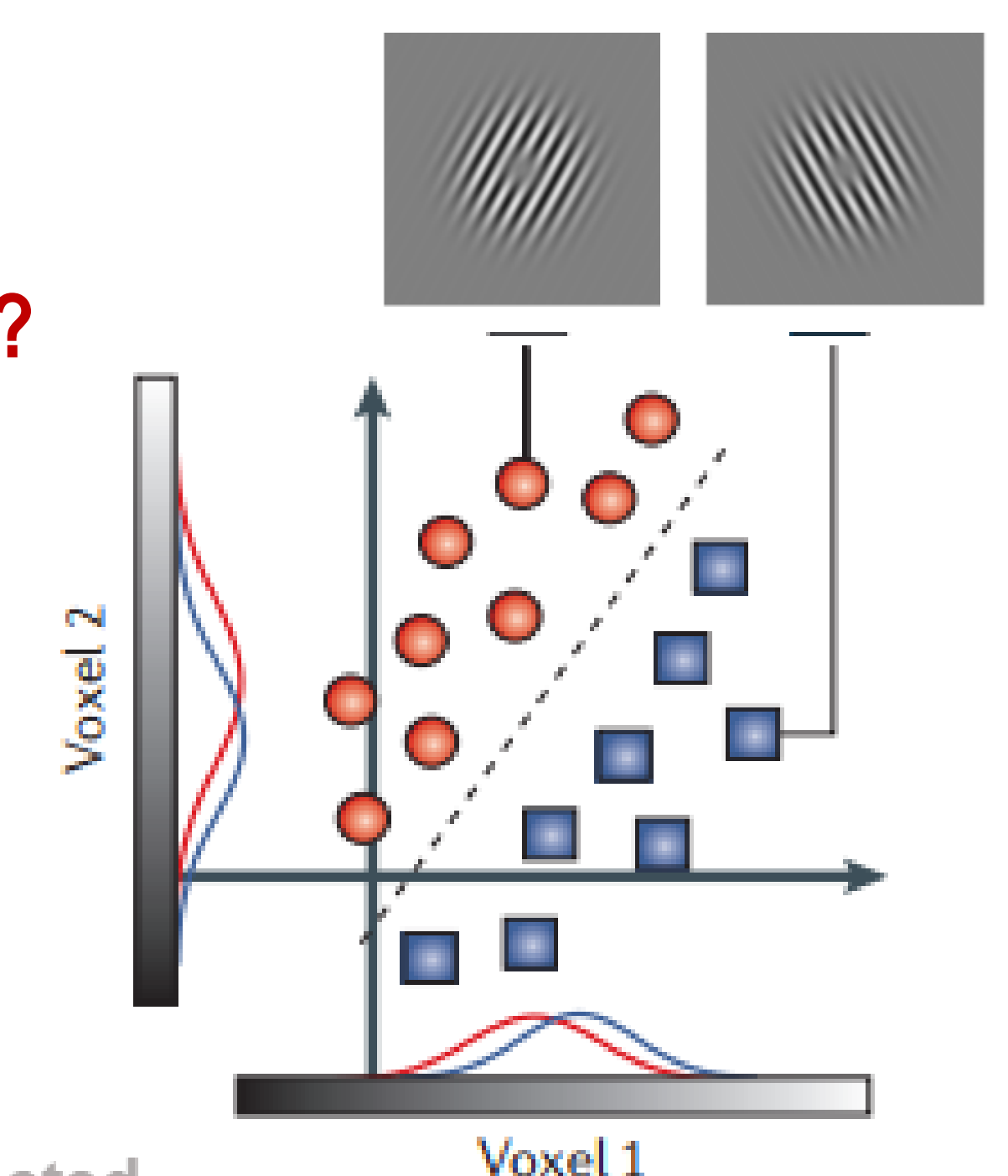
- Stimulus-specific univariate analysis
- Expectation suppression found only in voxels tuned away from the stimulus, consistent with Sharpening
- Predictive template for stimuli expected but actually omitted.



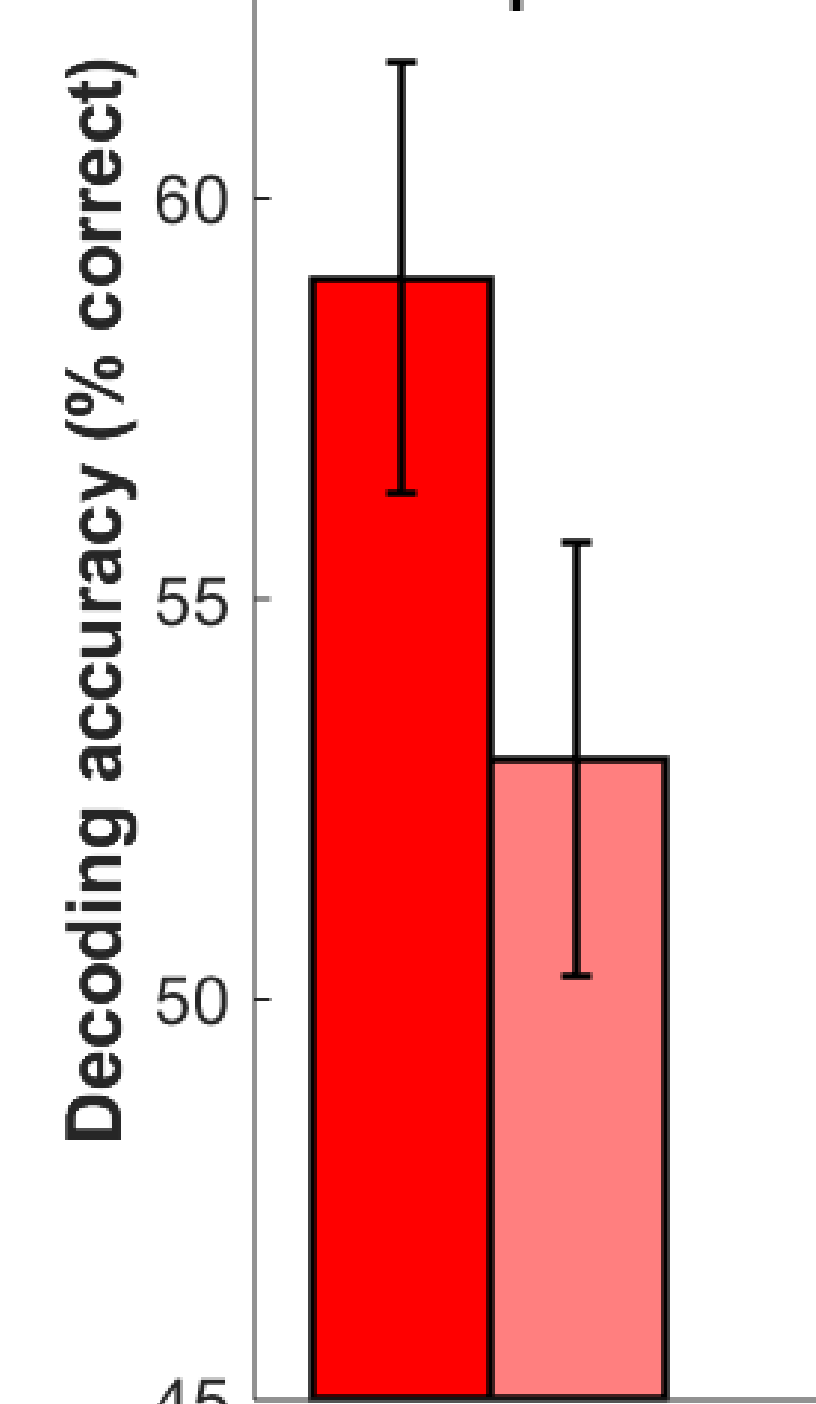
Results – Multivariate pattern analysis

Is there more stimulus-specific information in the signal when it is expected?

- Linear support vector machines (SVMs) were trained to discriminate between CW and CCW orientations.



Expected / Unexpected



- Leave-one-out cross-validation procedure.
- Performed separately on expected and unexpected conditions
- Results show superior classification of observed stimulus orientation when it was expected relative to unexpected.

Discussion

- These findings support neural Sharpening accounts – that expected representations are sharpened, and can even be pre-activated when no stimulus is presented.
- Harder to reconcile with Cancellation accounts suggesting that all expected input is suppressed, and instead suggest that action predictions in early visual areas operate similarly to predictions outside of action.

References:

¹Blakemore, S. J., Wolpert, D. M., & Frith, C. D. (1998). Central cancellation of self-produced tickle sensation. *Nature neuroscience*, 1(7), 635.

²Kersten, D., Mamassian, P., & Yuille, A. (2004). Object perception as Bayesian inference. *Annual review of psychology*, 55.

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