

Responses to shape from form coherence in the lateral occipital cortex

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Background & Rationale

- Do retinotopic regions LO-1 and LO-2¹ respond to second order contours?
- LO-1 shows orientation sensitivity for both second order gratings² and second order edges³, whereas LO-2 appears to lack sensitivity to these cues
- However, LO-1 is causally involved in grating orientation processing, whereas LO-2 is causally involved in shape processing⁴
- We hypothesised that if second order cues were used to define a shape, then LO-2 would show significantly greater activation than LO-1
- We also expected significant activity in the Lateral Occipital Complex (LOC) for second order shapes

Methods & Design

- Block Design fMRI study
 - 10s blocks with 1 stimulus per second
 - 16 blocks per stimulus condition
- N = 12 (after 5 excluded due to motion)

Three conditions:

- Baseline**
Field of pseudo-randomly oriented lines
- Fixed Orientation**
As above, with RF Shape* presented at a fixed orientation within a given block (see 'Second Order Stimuli')
- Random Orientation**
RF Shape presented at random orientations within a given block

- Participants viewed the stimulus passively, fixating on a central red cross

* RF Shape = Three-lobed Radial Frequency Pattern

Retinotopy & Localiser

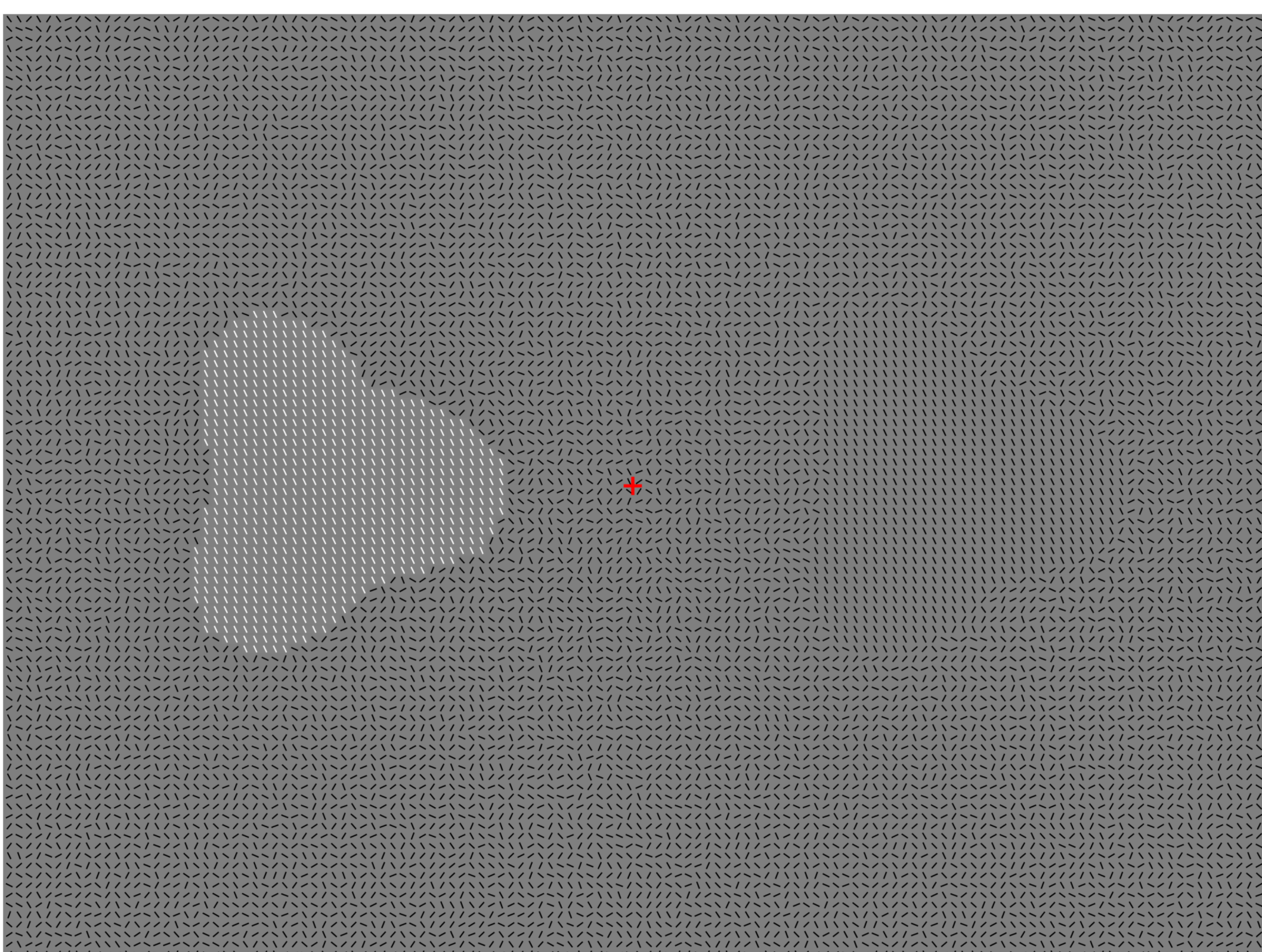
Retinotopy

- Checkerboard stimuli; counter-clockwise rotating wedges & expanding rings
- Saved V1 bilaterally, plus LO-1 and LO-2 in the clearest hemisphere of each participant

LOC Localiser (4 participants)

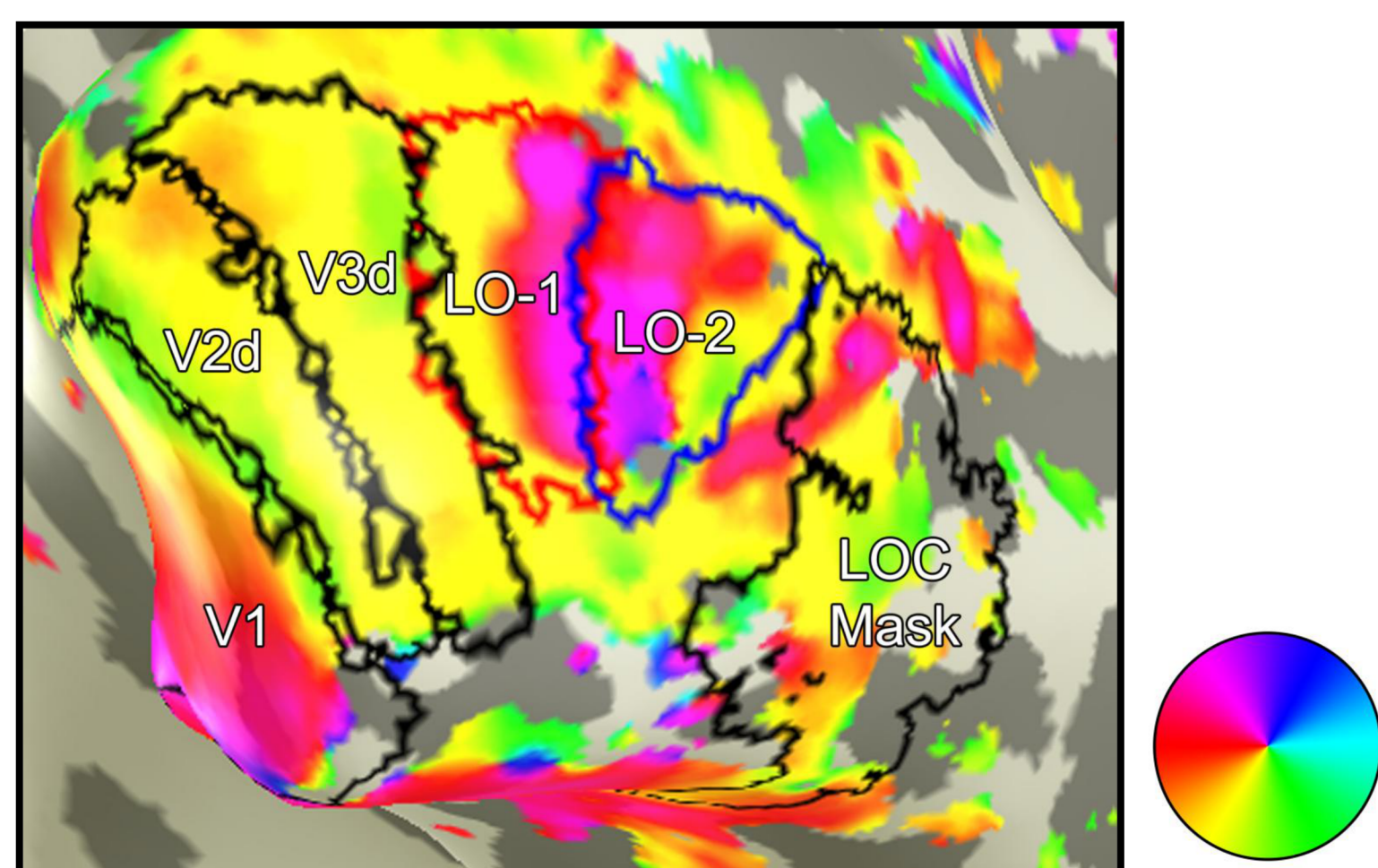
- Objects Vs. Scrambled Objects contrast
- Used to provide some context for results
- LOC mask created in MNI space using lenient ($Z > 1.65$; $p < .05$) cluster-corrected whole brain analysis

Second Order Stimuli



- An RF shape was presented bilaterally in the fixed and random orientation conditions (absent in baseline condition)
 - Defined using a region of coherently oriented lines
 - Average radius is 4.8° visual angle
 - Centres are 10° from fixation
- The left-hand side shape has been highlighted above, the right-hand side shape is as it would normally be presented
- The orientation of every local element changed once per second in a given block

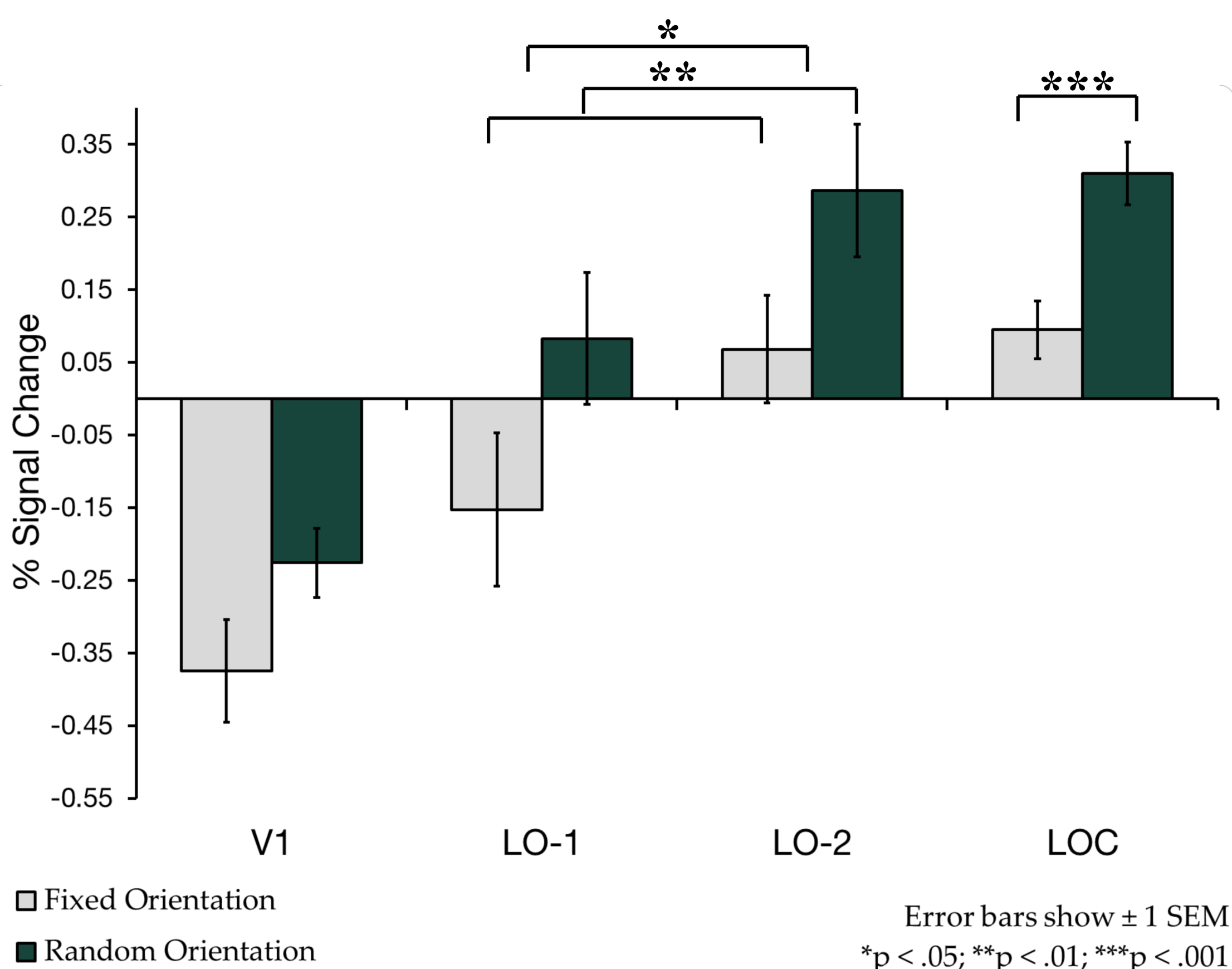
Regions of Interest



- An example retinotopic map from the right hemisphere of one participant;
- The LOC mask was back-transformed into individual space for illustrative purposes

Results: ROI Analysis

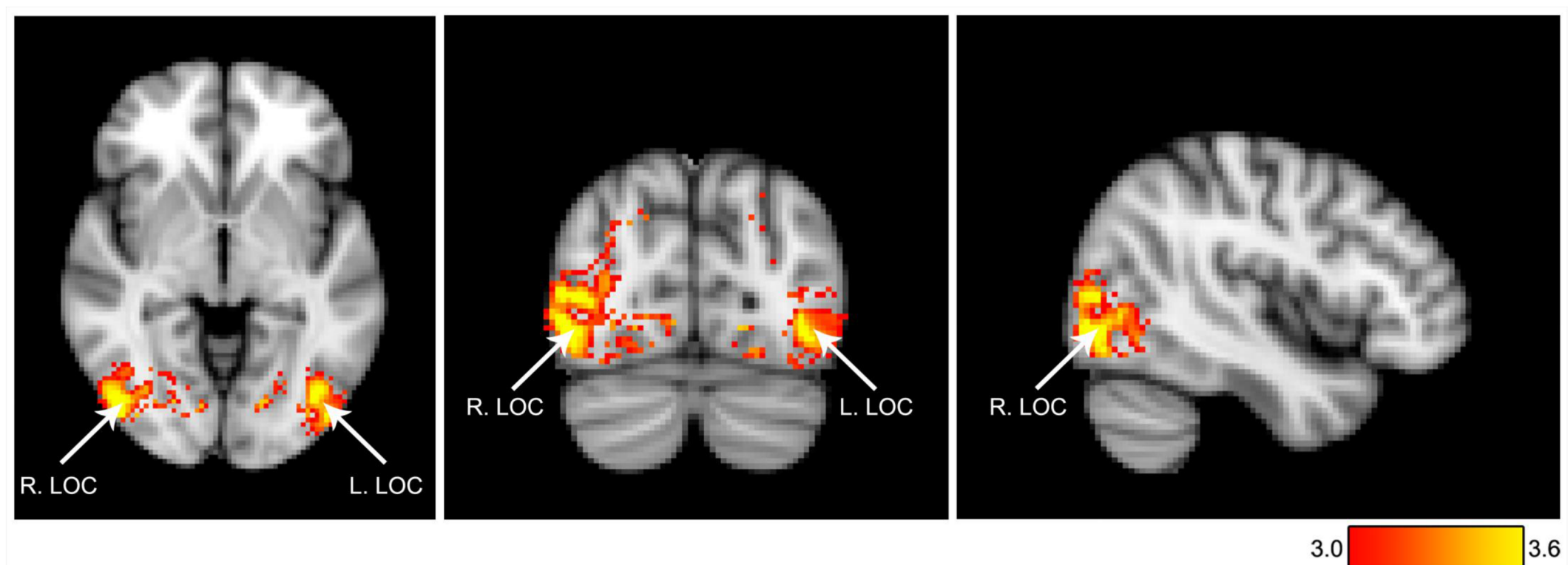
- V1 & LOC collapsed across hemispheres



ROI	ANOVA	STATISTICS
LO-1 / LO-2	ROI x Condition	
	• ROI	$F(1,11) = 06.47, p = .027$
	• Condition	$F(1,11) = 12.27, p = .005$
LOC	• Interaction	$F(1,11) = 00.04, p = .855$
	Hemi. x Condition	
	• Hemisphere	$F(1,11) = 00.40, p = .541$
V1	• Condition	$F(1,11) = 32.33, p < .001$
	• Interaction	$F(1,11) = 00.43, p = .525$
	Hemi. x Condition	
	• Hemisphere	$F(1,11) = 01.86, p = .200$
	• Condition	$F(1,11) = 02.60, p = .135$
	• Interaction	$F(1,11) = 00.05, p = .828$

Results: Whole Brain Analysis

- Small-volume corrected to occipital lobe
- Cluster-corrected ($Z > 2.3$; $p < .05$)
- Both fixed & random orientation > baseline contrasts identified bilateral clusters of activation in Lateral Occipital Cortex
- Random > fixed orientation contrast also identified bilateral clusters (below), which showed strong overlap with the LOC mask (mask centres of gravity added for context)



Discussion

- The results supported our hypothesis that LO-2 would show sensitivity to second order cues, if those cues were used to define shapes
- There was also compelling evidence that the LOC would respond to shapes defined using form coherence
- These results are unlikely to be due to low-level visual differences, based on the lack of significant effects in V1
- However it is possible that V1 adapted to the local elements, which could explain why it was below baseline in both shape conditions

References

- Larsson & Heeger (2006). J. NeuroSci. 26(51):13128-13142
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- Montaser-Kouhsari, Landy, Heeger & Larsson (2007). J. NeuroSci. 27(9):2186-2195
- Silson, et al. (2013). Nat. Neurosci. 16(3):267-269