Responses to radial frequency patterns in lateral occipital visual field maps LO1 and LO2 during shape and orientation discriminations

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Background

• Lateral occipital cortex (LO) is implicated in object and shape processing (1).
• LO can be divided into at least two retinotopic areas: LO1 and LO2 (2), which overlap partially with object selective LO (3).
• Past research shows a double dissociation where LO1 and LO2 are causally involved in orientation and shape discrimination, respectively (4).
•We examined how fMRI responses from LO1 and LO2 fluctuated as a subjects alternated between orientation and shape discriminations of a pair of radial frequency patterns.
• The stimuli were held constant across tasks.

Methods

•15 subjects, all with normal or corrected to normal visual acuity.
•Staircasing methods were used to acquire 76% correct thresholds for orientation and shape discrimination tasks.
•Subjects performed the two tasks in a block fMRI experiment.
•Retinotopic mapping was used to identify regions of interest.

Task and stimuli

- Two 3-lobed radial frequency patterns were presented simultaneously and bilaterally (see Figure 1).
- Stimuli differed in both orientation and shape according to 76% correct thresholds identified using staircasing methods.
- Orientation task: Which of the two stimuli is more clockwise?
- Shape task: Which of the two stimuli is spikier?
- Subjects performed these tasks in fMRI.

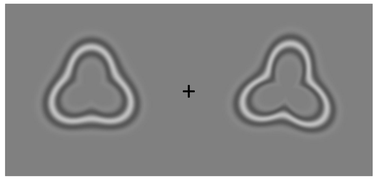

Figure 1: Two 3-lobed radial frequency patterns were presented simultaneously and bilaterally. The standard stimulus (left) had the same shape every trial and one of 5 possible orientations. The test (right) differed from the standard in both shape and orientation according to 76% correct thresholds.

fMRI block design

- Subjects alternated between blocks of orientation and shape discrimination, separated by fixation periods.
- 8 trials per block, 12 blocks of each task in one run.
- Each subject completed 3 runs.

Retinotopic mapping

•LO1 and LO2 were successfully identified in at least one hemisphere of all subjects and in both hemispheres of 11/15 subjects for subsequent region of interest analyses.
•V1 and V4 were also identified for control analyses to ensure there were no differences in low-level or contour features between both tasks.

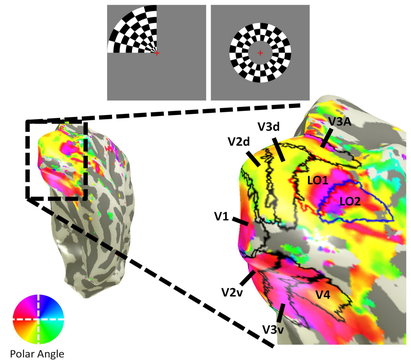

Figure 2: Checkerboard Ring and Wedge stimuli were used for retinotopic mapping procedures. Phase-encoded responses were projected onto inflated cortical surfaces for visualisation. Responses to the rotating wedge stimulus in the right hemisphere of an example subject are shown.

Results: Whole brain analysis

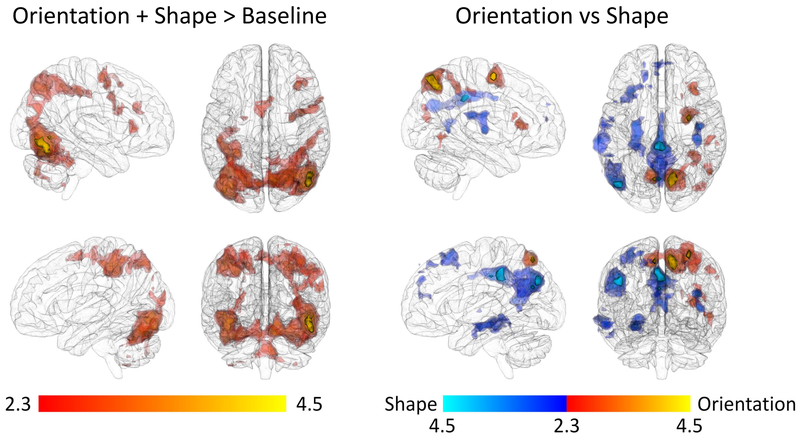

Figure 4: A general linear model was used to identify brain regions that responded to both tasks compared to baseline (left) and regions to responded preferentially to one task over the other (right). Average groups responses are shown on the MNI 152 brain. Data are thresholded (Z > 2.3) and cluster corrected (p < .01).

Results: Region of interest analysis

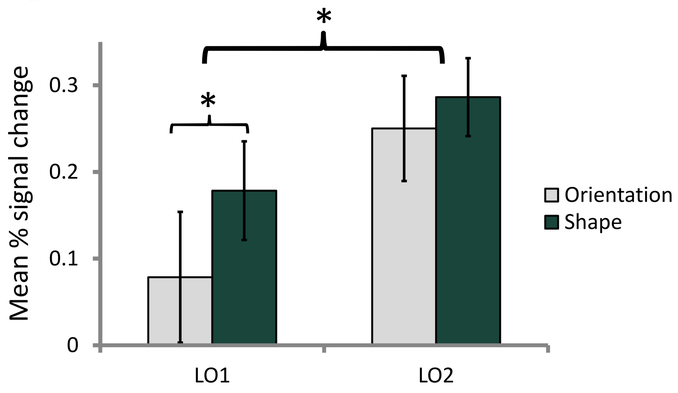

Figure 3: Mean % signal change in LO1 and LO2 (averaged across hemispheres) for orientation and shape discrimination. Asterisks denote a significant difference in response amplitudes between LO1 and LO2 (task x site repeated measures ANOVA: significant effect of site, F(1, 14) = 6.65, p = .022, significant site by task interaction, F(1, 14) = 6.39, p = .024), and a significant difference between responses within LO1 to the two tasks (simple effects analysis: F(1, 14) = 8.98, p = .010). Additionally, paired samples t tests found no significant differences between responses to the two tasks in V1 (t(13) = 0.09, p = .930) or V4 (t(14) = -1.02, p = .324).

Conclusions

•LO2 responded more strongly to the radial frequency pattern stimuli than LO1.
•Directed attention to the orientation or shape of our stimuli modulated responses in LO1 but not LO2.

•Together, our tasks stimulated large regions of visual and parietal cortex, consistent with studies on feature-based attention (5), with the largest responses occurring in object-selective LO.
•Contrasting responses to the two tasks against one another revealed a number of partially lateralised brain regions that responded preferentially to one task over the other.
•We speculate these task-specific networks may reflect different strategies employed for the two tasks.
•For example, the orientation-specific and shape-specific regions we identified overlap with networks involved in mental rotation and visual working memory, respectively.

References

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