Temporal properties of shape processing across visual areas: fMRI and MEG studies

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Introduction

Processing of shape information requires the involvement of different visual areas. Recent studies (Altman et al., 2003) have shown that global information about shapes is processed in both early ventral (i.e., V1, V2,VP, V4) and higher occipitotemporal visual areas (i.e. Lateral Occipital Complex - LOC). However, the temporal properties of shape processing across visual areas in the human brain are largely unknown. We addressed this question in a combined fMRI and MEG study (Experiment 1) that made use of the high spatial resolution of fMRI and the temporal resolution of MEG. We used an event-related adaptation paradigm in which lower neural responses are observed for two identical than for two different consecutively-presented stimuli in each trial (Kourtzi et al., 2001). The stimuli were closed contours that consisted of collinear Gabor elements. We tested the analysis of local vs. global shape features across areas with different temporal processing properties.

Methods

fMRI

Siemens 1.5T Scanner
Head Coil
11 axial slices
Voxel size: 3.0 x 3.0 x 3.0 mm
CTF whole-cortex MEG System
151 Channels
3 Localization Coils
Sampling rate: 312.5 HZ

MEG

Stereology: 3D attenuation
Sampling rate: 2.5 kHz

Stimuli for Localization of the LOC

Experiment 1: fMRI-Study

Question
Are there different temporal properties in the processing of shape information across human visual areas?

Regions of Interest: LOC / Retinotopic Areas

Stimuli and Conditions

Stimulus 1
ISI 100ms
Stimulus 2
ISI 400ms

Experiment 1: MEG-Study

Results: Identical vs. Different (n=12)

Summary
Significantly stronger responses for different than identical shapes were observed in occipital regions for the short ISI and temporal regions for the long ISI.

Screened

Corrected t-test Map

Field of Interest analysis for the LOC showed adaptation effects both in the LOC, but not in V1.

Summary
Increased fMRI responses for Global Shape Changes were observed both in V1 and the LOC.

Experiment 2

Question
What features of shapes are processed in early and higher visual areas?

Stimuli and Conditions

Stimuli T ype
Identical
Local Change
Global Change
Local+Global Change

Results (n=8)

Summary
Increased fMRI responses for Local Orientation Changes were observed both in V1 and the LOC.

Increased MEG responses for Local Orientation Changes were observed in the LOC, but not in V1.

We found no significant effect of task-dependent attention.

General Discussion

Neural populations in early and higher visual areas encode global shape and feature information.

Adaptation effects were observed for the short and the long ISI in the LOC, but only for the short ISI in early visual areas. These results suggest a transient manner of shape processing in early visual areas.

The MEG adaptation effects occurred at longer latencies for the short ISI than for the long ISI. These results suggest feedback mechanisms on shape processing in early visual areas.

Responses in early and higher visual areas were increased across global shape changes. These findings provide further evidence for the role of feedback mechanisms in shape processing.