Cerebral areas encoding spatial frequency information during coarse-to-fine and fine-to-coarse analysis of natural visual scenes

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Introduction. Recent models of visual recognition [1,2] have suggested that the visual analysis is mainly based on spatial frequency (SF) processing of the image with a preferential coarse-to-fine (i.e. low-to-high SF) processing sequence. A rapid extraction of low-spatial frequency (LSF) information may thus provide an initial perceptual parsing of a visual scene, subsequently refined by slow but more detailed high-spatial frequency (HSF) information. However, the sequence of SF analysis could be flexible, a fine-to-coarse (i.e. high-to-low SF) processing sequence being sometimes preferred to a low-to-high SF-sequence depending on task demands. In the present event-related fMRI experiment, we aimed to assess the cerebral regions involved in the storage of SF information during coarse-to-fine and fine-to-coarse processing sequences of a visual scene. For this purpose, we investigated brain areas showing scene repetition effects during these different sequences of SF analysis.

Methods. 14 participants performed a matching task between two scene images (either low- or high-pass filtered) displayed in either a low-to-high sequence (LtH, i.e. low-pass scene presented first and high-pass scene second) or a reverse high-to-low sequence (HtL). In half of the trials, the two successive scenes in the sequence were the same exemplar from the same category but with inverse SF-content ("repeated" condition), while in the other half of trials, the two successive scenes were of different categories ("different" condition). Participants had to decide whether the two successive scenes belonged to the same category. To assess the neural substrates involved in the coding of SF information, we compared fMRI responses to repeated scenes with those to different scenes for each SF sequence (LtH and HtL). We predicted that repetition effects should involve cerebral regions essential for complex visual stimuli recognition (e.g. inferotemporal cortex [3]).

Results. Behavioral results showed significant scene repetition effects. Reactions times were faster for repeated than different scenes for both LtH and HtL sequences. FMRI results showed a main effect of scene repetition in several regions of the temporal cortex. The right inferior temporal cortex (59, -38, -6; $P < 0.0001$ uncorrected) showed a significant decrease when scenes were repeated in LtH sequences (Fig 1), whereas the left occipito-temporal cortex (-39, -50, -8; $P < 0.002$ uncorrected) showed a significant repetition decrease for HtL sequences (Fig 2).

Conclusion. The present study suggests that the right inferior temporal cortex may encode and maintain LSF information in scenes for coarse-to-fine recognition while the left occipito-temporal cortex may maintain HSF information for fine-to-coarse recognition. These results are consistent with the right/left hemisphere predominance in LSF/HSF information processing [4] and in the coarse-to-fine/fine-to-coarse analysis of natural visual scenes [5].

References

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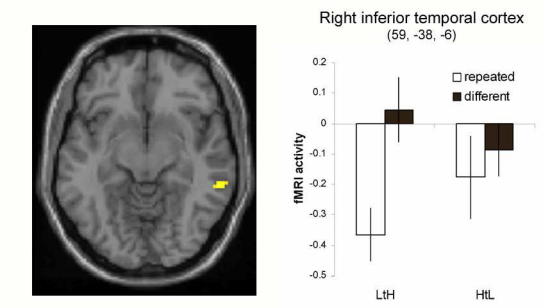

Fig 1. Cerebral regions showing scene repetition effects during LtH preocessing sequences

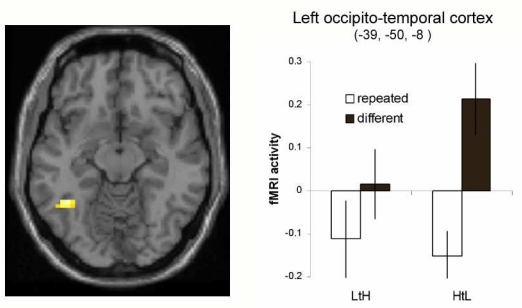

Fig 2. Cerebral regions showing scene repetition effects during HtL preocessing sequences