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

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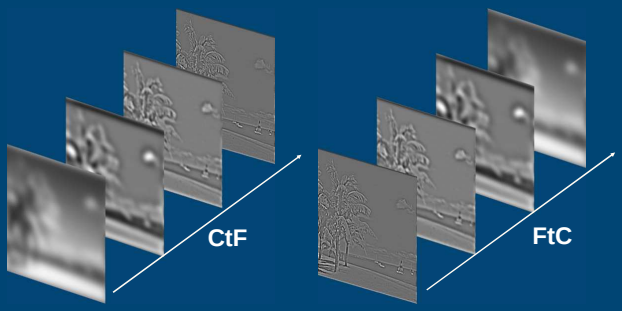
Background

Natural scene perception

Models of visual scene recognition [1, 2] suggest that visual analysis of scenes is mainly based on a parallel extraction of different elementary visual attributes at different spatial scales/spatial frequencies (SF), with a coarse-to-fine processing (CtF) design: A rapid extraction of low spatial frequency (LFS) information may provide an initial perceptual parsing of the scene, subsequently refined by slow but more detailed high spatial frequency (HFS) information.

However, the sequence of SF could be flexible, a fine-to-coarse (FtC) processing being sometimes preferred to a CtF processing depending of the task demands [3].



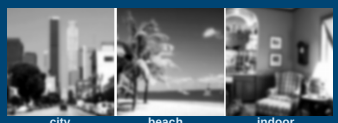
Aim

We investigated the cerebral regions involved in the storage of SF information during CtF and FtC processing of a visual scene. For this purpose, we investigated brain areas showing scene repetition effects during these different sequences of SF analysis.

Method

Participants: 14 healthy right handed male volunteers

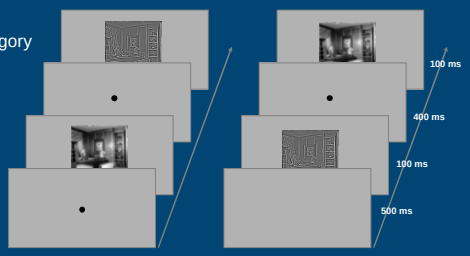
Stimuli: Low spatial frequency (LSF) scenes / High spatial frequency (HSF) scenes



Sequence:

LtH = Low-to-High SF **HtL** = High-to-Low SF

- « **Repeated** » sequences
the same exemplar from the same category
- « **Different** » sequence
two exemplars of different categories



Scene-matching task:
Participants had to decide whether or not 2 successive images of natural scenes were from the same category (city, beach or indoor)

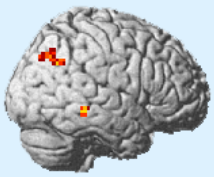
fMRI acquisition

- Event-related fMRI paradigm
- 1.5 T whole-body INTERA system (Philips Medical Systems), echo-planar imaging (EPI)
- Whole brain volume, 30 slices, 4 mm thick, TR = 2.5 sec
- Data analyzed using SPM2, two-stage random-effect analyses

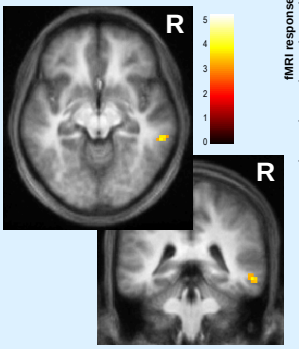
To assess the neural substrates involved in the coding of SF information, we compared fMRI responses to different scenes with those to repeated scenes for each SF sequence (LtH and HtL).
We predicted that repetition effects should involve cerebral regions essential for complex visual stimuli recognition (e.g. inferotemporal cortex [4]).

Results

LtH sequences

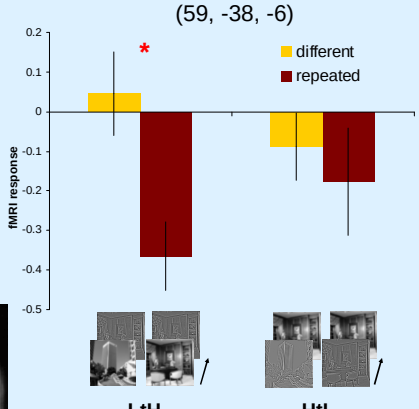


[LtH different > LtH repetaed]



59*x* -38*y* -6*z*, T = 3.82, p < .005

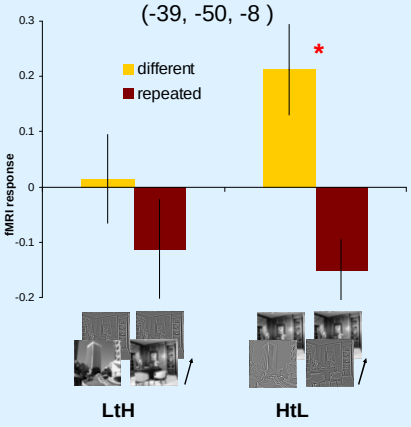
Right middle temporal cortex
(59, -38, -6)



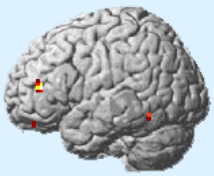
Decreased activation in the right middle temporal cortex when scenes were repeated in LtH sequences

HtL sequences

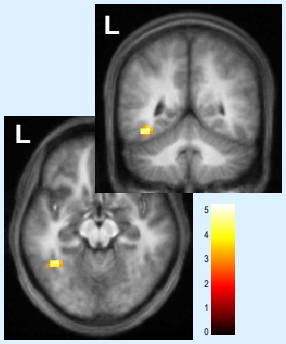
Left occipito-temporal cortex
(-39, -50, -8)



Decreased activation in the left occipito-temporal cortex/fusiform gyrus when scenes were repeated in HtL sequences



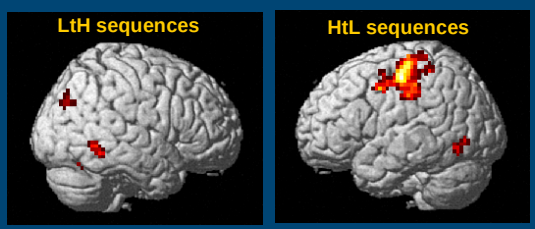
[HtL different > HtL repeated]



-39*x* -50*y* -8*z*, T = 5.75, p < .001

Conclusion

The present study suggests that the right middle 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 [5] and in the coarse-to-fine/fine-to-coarse analysis of natural visual scenes [6].



References
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[6] Peyrin et al., 2005, NeuroImage, 28, 464-473.