Time course of the hemispheric specialization in spatial frequency processing

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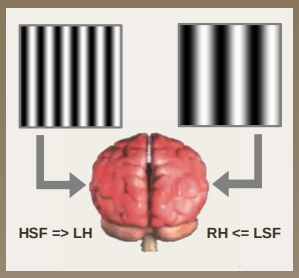


Hemispheric specialization for spatial frequency processing

According to the functional hemispheric hypothesis of spatial frequency processing (Sergent, 1982), **the right hemisphere (RH) is predominantly involved in low spatial frequency (LSF) analysis, while the left hemisphere (LH) in high spatial frequency (HSF) analysis**. However, the hemispheric specialization for spatial frequency processing had been inferred from data obtained by using the hierarchical form paradigm, *without any explicit spatial frequencies manipulation* per se.

In a recent behavioral and neuroimaging study, we have shown a classical hemispheric specialization for spatial frequency processing in natural scene recognition, by altering the picture frequency spectrum (Peyrin et al., 2003).

Research aims: Dynamic of the hemispheric specialization

However, as suggested by the "Visual-Spatial-Frequency" model of cerebral asymmetry (Grabowska and Nowicka, 1996), the hemispheric specialization should be rather considered as a **dynamic system**, wherein the superiority of one hemisphere on the other one could change according to cognitive constraints.

In the present study, conducted on healthy subjects, we have investigated the dynamic of the hemispheric specialization as a function of temporal constraints.

Experiment

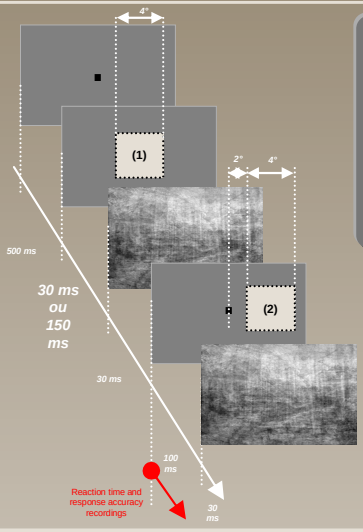
Participants: 16 right-handed students (8 males and 8 females).

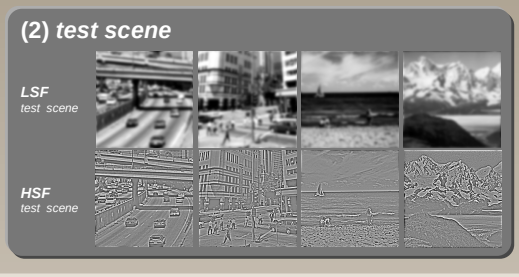
Stimuli: 4 natural scenes. Each of them belongs to a different perceptual / semantic category (highway, city, beach, mountain).

Task and procedure: Matching between a priming scene and a test scene. Subjects were instructed to press a button, with the index of each hand when priming and test scenes were the same (Go/NoGo response).

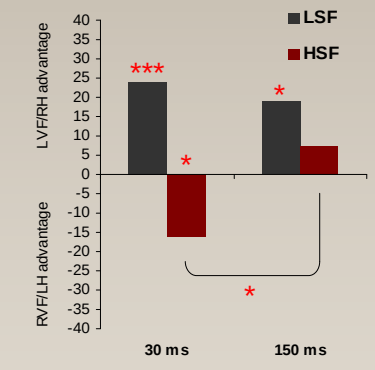
Priming scene:
- Normal scenes (N),
- Central presentation,
- Exposure time : **30** and **150 ms** in two different trial blocks. Each subject performed the experiment under both conditions, at one week interval. The order of conditions was counterbalanced across subjects.

Test scene:
- Filtered scenes : **LSF** (cut-off frequency: 4 cycles per degree) or **HSF** (cut-off frequency: 6 cycles per degree),
- Visual divided field presentation (100 ms) in either the left visual field/right hemisphere (**LVF/RH**) or the right visual field/left hemisphere (**RVF/LH**).





Results



$p < .05$ *
$p < .001$ ***

Hemispheric specialization for spatial frequency processing

(a) For 30 ms,
When temporal constraints were strong, our results showed an hemispheric specialization consistent with that previously stated :
- Spatial frequency * Hemisphere interaction was significant [F(1,14) = 25.29; p < .001]
- Matching between LSF test scenes and N priming scenes was significantly faster in LVF/RH than in RVF/LH [F(1,14) = 24.44; p < .001]
- Matching between LSF test scenes and N priming scenes was significantly faster in RVF/LH than in LVF/RH [F(1,14) = 5.65; p < .05]

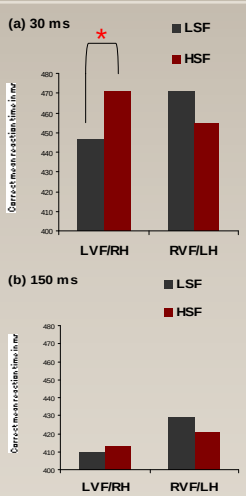
(b) For 150 ms,
Conversely, when temporal constraints were reduced, our results showed a LVF/RH advantage whatever the spatial frequency components of the test scene :
- No Spatial frequency * Hemisphere interaction [F(1,14) = 2.30; p = .15]
- Matching between LSF test scenes and N priming scenes was significantly faster in LVF/RH than in RVF/LH [F(1,14) = 7.51; p < .05]
- Matching between LSF test scenes and N priming scenes was faster in LVF/RH than in RVF/LH, although this difference did not reach significance [F(1,14) = 1.12, p = .31]

Moreover, the significant Hemisphere * Presentation Time interaction was significant only for HSF processing [F(1,14) = 7.37; p < .05], suggesting a hemispheric superiority inversion processing with time.

Spatial frequency processing time according to visual field/hemisphere of presentation

(a) For 30 ms,
- in the LVF/RH, matching between test scenes and N priming scenes was significantly faster for LSF than HSF [F(1,14) = 8,31; p < .05]
- In the RVF/LH, matching between test scenes and N priming scenes was faster for HSF than LSF, near the significativity [F(1,14) = 3,69; p = .07]

(b) For 150 ms,
- LSF and HSF scene test matching were not significantly different neither in the LVF/RH, nor in the RVF/LH



Discussion

Our results showed (i) the classic hemispheric specialization for spatial frequency processing (i.e. a LVF/RH superiority in LFs processing and a RVF/LH superiority in HFs processing) when temporal constraints were strong, and (ii) a LVF/RH advantage whatever the spatial frequency components of the test scene when temporal constraints were reduced.

This temporal dynamic of the hemispheric specialization could reflect:

a) Either a shift in the nature of information processed by the visual system. According to Guyader et al. (submitted), when temporal constraints are strong, scene categorization seems only based on the amplitude spectrum (*vs.* phase). So, in such a case, both hemispheres are working in parallel, each one extracting what it can from the image amplitude spectrum. This extraction depends on the specific abilities for spatial frequency processing of each hemisphere. When temporal constraints are reduced, the task becomes more spatial (phase), fitting better the spatial aptitude of the right hemisphere.

b) Or the setting up of an inhibition process from the right to the left hemisphere in priming scene processing: When temporal constraints are strong, an inter-between hemispheric inhibition has no time to be effective and hemisphere are working in parallel, in relation to its spatial frequency aptitudes.

These two hypotheses are currently examined.

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