Neural correlates of spatial frequency processing: A neuropsychological approach

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* ERTInt 1062 TREAT VISION
TECHNOLOGIE ET RECHERCHE POUR L'ELABORATION D'APPLICATIONS THERAPEUTIQUES DANS LE DOMAINE DE LA VISION

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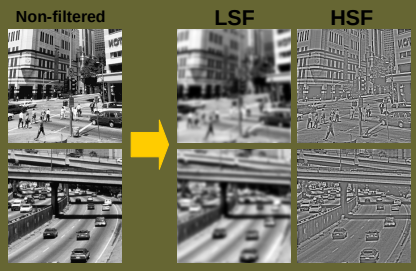
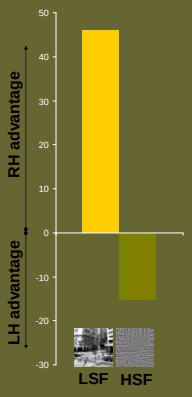
The hemispheric specialization hypothesis

Studies on functional hemispheric asymmetries [1] have suggested that the right vs. left hemisphere should be predominantly involved in low spatial frequency (LSF) vs. high spatial frequency (HSF) analysis, respectively.

We investigated in healthy males, the hemispheric specialization for spatial frequency processing in natural scene perception, by altering the picture frequency spectrum [2].



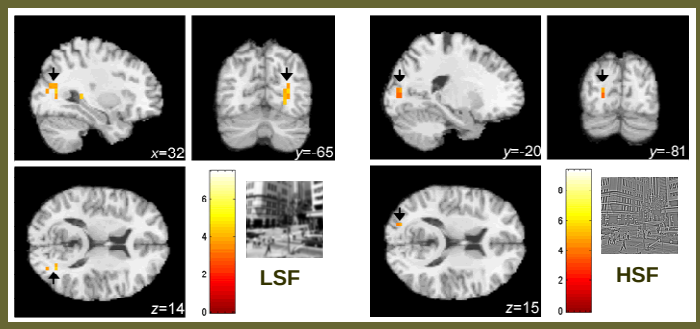


In a divided visual field experiment, we have demonstrated a left visual field/right hemisphere (LVF/RH) dominance during the processing of LSF scenes, whereas a right visual field/left hemisphere (RVF/LH) dominance was observed for the processing of HSF scenes.

It is thought that gender may affect the pattern of visual filed/hemisphere dominance [3,4]: A large number of studies have showed that patterns of functional cerebral asymmetry are more pronounced in men than women.

Besides the question of the hemispheric specialization for SF, an additional question remains, which concerns the intra-hemispheric region where this specialization may occur.

Using LSF and HSF filtered natural scenes in an event-related fMRI study, we recently demonstrated the functional specialization of the right occipito-temporal junction for LSF scenes and of the left occipital cortex for HSF scenes [5].



Studies on unilateral brain-injured patients also constitute an important source of information concerning the neural substrates involved in this hemispheric specialization. In this way, studies on patients suffering from left or right occipito-temporal cortex lesion should allow us to thoroughly investigate the role played by this specific cortical region in SF processing.

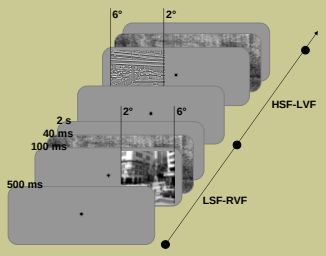
Experiment 1 aims to further investigate the hemispheric specialization by directly testing the sex effect on spatial frequency processing.

Method

Participants: 24 healthy right handed volunteers (12 men, 12 women).

Stimuli: 2 natural scenes (a city and a highway) filtered in LSF (<4 cpd) and HSF (>6 cpd).

Procedure: Participants have to press a response key if the target scene (either the city or the highway) is present (Go/NoGo response).
Stimuli were displayed for 100 ms either in LVF/RH or the RVF/LH.



Results

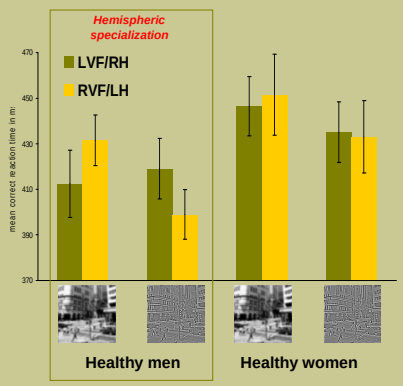
There was a significant Gender x SF content x Visual field interaction ($F1,20 = 12.06$, $MSE = 125.12$, $p < 0.003$).

Healthy men:

- Significant SF content x Visual field interaction ($F1,20 = 35.47$, $MSE = 125.12$, $p < 0.0001$).
- HSF scenes, RTs were significantly faster in the RVF/LH than LVF/RH (399 ms and 419ms respectively, $F1,20 = 7.81$, $MSE = 301.03$, $p < 0.02$).
- LSF scenes, RTs tended to be faster in the LVF/RH than RVF/LH (413 ms and 432 ms respectively, $F1,20 = 3.94$, $MSE = 530.66$, $p = 0.06$).

Healthy women:

- No SF content x Visual field interaction ($F1,20 = 1.09$, $MSE = 125.12$, $p = 0.31$).
- No difference between the LVF/RH and the RVF/LH for both LSF (447 vs. 451 ms, respectively, $F1,20 < 1$) and HSF (435 vs. 433 ms, respectively, $F1,20 < 1$).



Conclusion

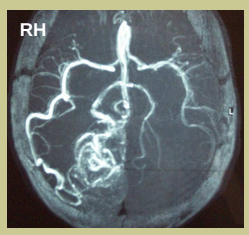
Experiment 1 provides evidence for hemispheric specialization in spatial frequency processing in men (the right hemisphere is predominantly involved in LSF analysis and the left in HSF analysis) but not in women.

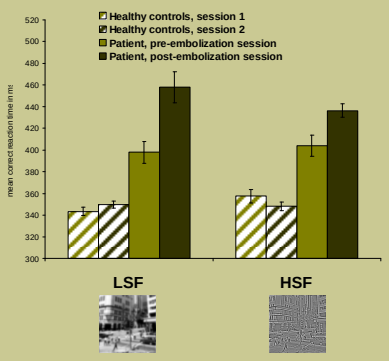
Experiment 2 aims to further investigate the role of the right occipito-temporal cortex in LSF processing with a neurological female patient who had a focal lesion of this region due to an embolization of an arterioveinous malformation, by comparing the performances before and after the surgical intervention.

Method

Participants: The patient (a right-handed women who suffered from a right occipito-temporo-parietal AVM and underwent an embolization of this region) and 5 healthy right-handed control women.

Stimuli and procedure: The patient and control participants performed the same task as in Experiment 1, except that scenes were only presented in the RVF.
The experimental paradigm was presented to the patient 1 week before the embolization (**pre-embolization session**) and 6 months after (**post-embolization session**).
Control participants were also tested two times spaced out 6 months.





Results

Patient:

- Significant Session x SF content ($F1,15 = 5.43$, $MSE = 568.87$, $p < 0.05$).
- **Preembolization session**, RTs did not differ significantly between LSF and HSF scenes (398 ms and 404 ms, respectively; $F1,15 < 1$).
- **Postembolization session**, LSF scenes was processed significantly slower than HSF scenes (458 ms and 436 ms, respectively; $F1,15 = 5.06$, $MSE = 739.92$, $p < 0.05$).

Healthy controls:

- No Session x SF content ($F1,15 = 3.87$, $MSE = 417.72$, $p = 0.07$).

Conclusion

After the right occipito-temporal cortex embolization, LSF processing was more impaired than HSF processing, thus suggesting the major contribution of the right occipito-temporal cortex for LSF analysis.

Conclusion

The neuropsychological approach we adopted to study the neural correlates of SF processing provided two main findings.

(i) Our results bring evidence for hemispheric specialization in SF processing on men. This hemispheric specialization might be more difficult to detect in healthy women because of interfering factors (e.g., fast callosum transfer, hormonal level fluctuations over the menstrual cycle).

(ii) However, the deficit in LSF processing observed in the female patient we tested suggests that the right occipito-temporal cortex is involved in LSF processing even in females, although it is difficult to observe in normal subjects.

References

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