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Investigating the Reorganization of Spatial Frequency Processing in Maculopathy: A Comparison of Patients and Controls with Matched Artificial Scotoma

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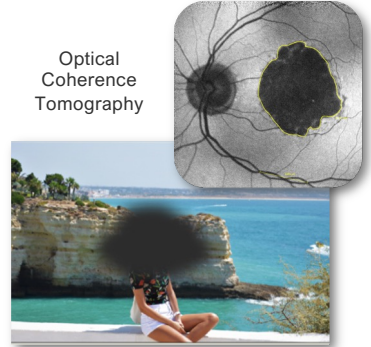
Ethics Agreement: CPP Sud Méditerranée IV (2022-A00957-36)

Introduction

Macular degeneration (MD) is characterized by central vision loss caused by the destruction of macular photoreceptors, which affects visual perception and cognition (Cohen & Souied, 2014).

Studies conducted by our team (Musel et al., 2011; Peyrin et al., 2017; Ramanóel et al., 2018) showed a deficit in processing high spatial frequencies (HSF) in large photographs of scenes in comparison to normally-sighted people, while the processing of low spatial frequencies (LSF) was relatively well preserved, allowing effective perception of scenes in parafoveal vision. This impairment was associated with a reduced brain activity in occipital areas and in the parahippocampal place area (PPA), a key region for scene perception. The differences between patients and age-matched controls may result from functional reorganization compensating for central vision loss in patients, a reduction in the amount of visual stimulation caused by the central scotoma, or a combination of both factors.

The present study aims to investigate how macular degeneration alters spatial frequency processing in the brain by masking the visual field of each control with an artificial scotoma, replicating the scotoma experienced by their matched patient.



Method

Participants

- 7 MD patients (5 Age-related macular degeneration, 2 Stargardt)
- 7 age-matched controls

Behavioral task

Participants had to categorize large scenes filtered either in LSF or in HSF displayed 150 ms.

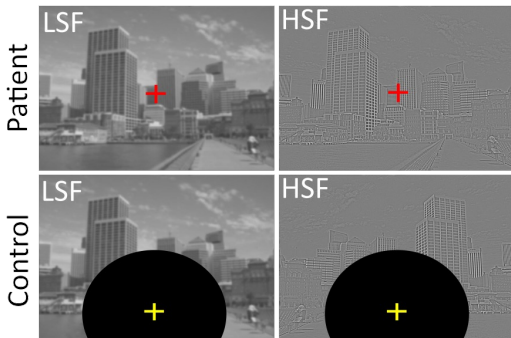
- Patients had to fixate (monocularly with their best eye) the center of the screen (see the red cross on the figure) with their preferred retinal locus (PRL) outside their scotoma.
- Controls had to fixate (monocularly with their best eye) at the position of their age-matched patient's fovea (see the yellow cross). Their central visual field will be masked with an artificial scotoma defined so that visual inputs are identical to those of the age-matched patient.

fMRI acquisition

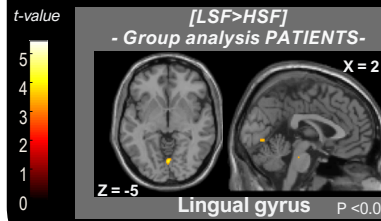
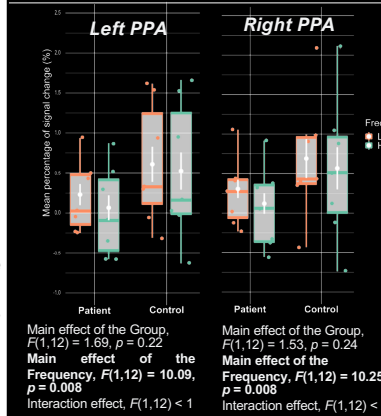
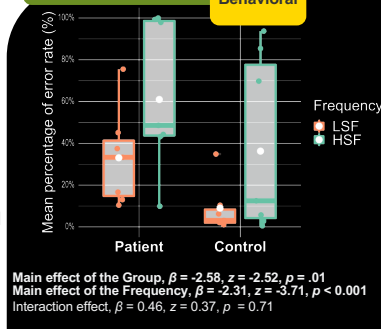
- Whole-body 3 T Philips scanner (Achieva 3.0T TX Philips, Philips Medical Systems)
- Whole brain volume, 44 slices, 2 mm thickness, TR = 2 sec
- 4 functional runs with a block-design fMRI paradigm (6 LSF, 6 HSF and 10 rest blocks)

Hypotheses

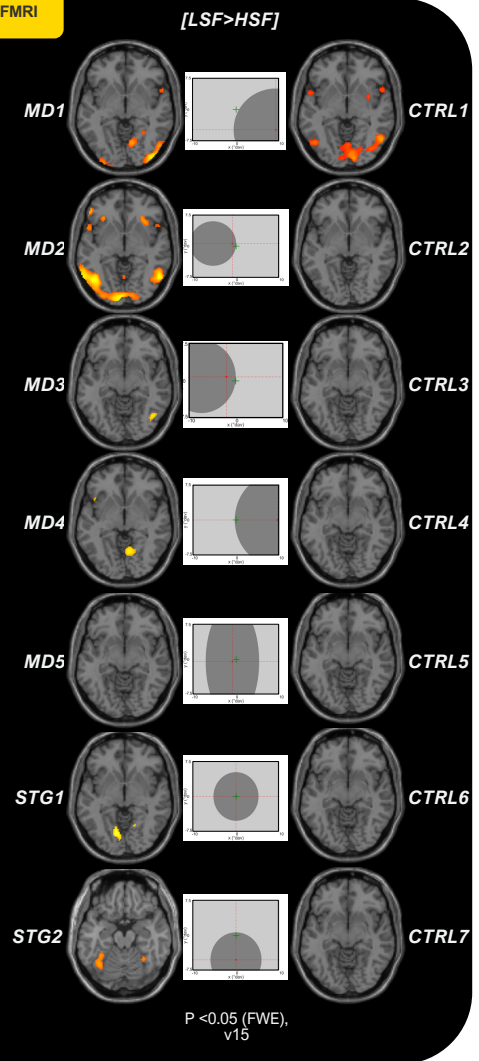
- Deficit for processing spatial frequencies more pronounced for HSF than LSF, for patients only.
- Associated with lower cerebral activity in occipital areas and in the PPA.



Results



fMRI



Conclusion

Results showed less accurate categorization HSF images compared to LSF images for both patients and controls, with a more pronounced HSF deficit in patients despite equalized visual stimulation between the groups.

At the cerebral level, patients exhibited significantly greater activation for LSF than HSF in the occipital cortex, with exploratory analysis highlighting increased activation in the lingual gyrus region associated with peripheral vision. No group differences were found in the PPA, indicating that previously reported differences may result from reduced visual stimulation in patients.

These findings suggest cortical reorganization in the occipital cortex for spatial frequency processing following central vision loss, with LSF being overutilized in peripheral vision at the expense of HSF. Comparing these simulated conditions in controls and patients highlights unique behavioral or neural adaptations to chronic vision loss.

References

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