# Enhancing visual scene categorization in people with macular degeneration through perceptual learning

Cynthia Faurite[1*], Célia Michaud[2], Pauline Olivier[1], Mathilde Gallice[3], Christophe Chiquet[3], Benoit R. Cottereau[2], & Carole Peyrin[1]

*cynthia.faurite@univ-grenoble-alpes.fr

1. Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, LPNC, Grenoble, France
2. Centre de Recherche Cerveau et Cognition, Université Toulouse III–Paul Sabatier, CNRS, Toulouse, France
3. Department of Ophthalmology, Grenoble Alpes University Hospital, Grenoble, France

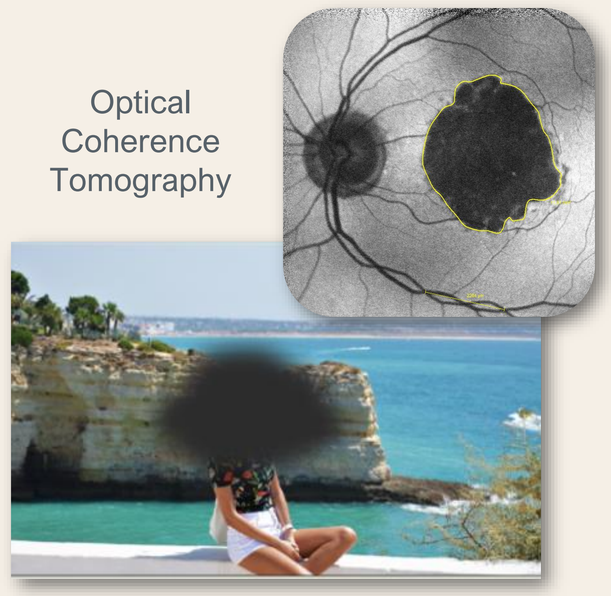
Funding: ANR-21-CE28-0021
Ethics Agreement: CPP Sud Méditerranée IV (2022-A00957-36)

## Introduction

Macular degeneration (MD) is characterized by a central vision loss caused by the destruction of macular photoreceptors (Cohen & Souied, 2014). However, the deficit is not confined to central vision.
Contrast sensitivity measured in the residual vision of patients using sinusoidal gratings has been shown to decrease for high spatial frequencies (HSF) and low spatial frequencies (LSF) at fovea, but also at parafovea (Brown & Lovie-Kitchin, 1987).
Other studies conducted by our team (Musel et al., 2011; Peyrin et al., 2017; Ramanoël et al., 2018) confirmed a deficit in processing HSF in large photographs of scenes in comparison to normally-sighted people, while the processing of LSF was relatively well preserved, allowing effective perception of scenes in parafoveal vision.

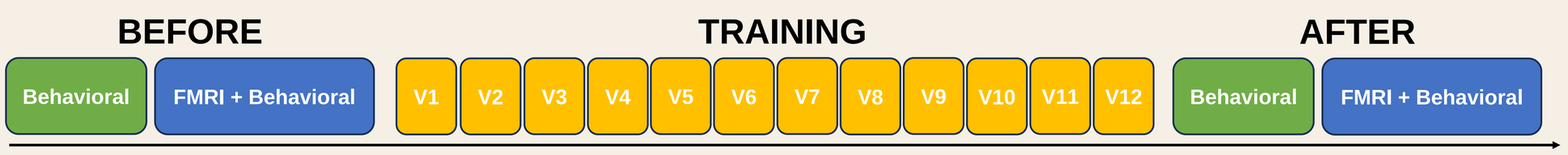
**The present study aims to:**
- **characterize behavioral and cortical reorganization of spatial frequency processing that occur spontaneously in patients**
- **investigate whether perceptual learning could improve patients' performance, thus opening the door to future rehabilitation strategies**

Optical Coherence Tomography

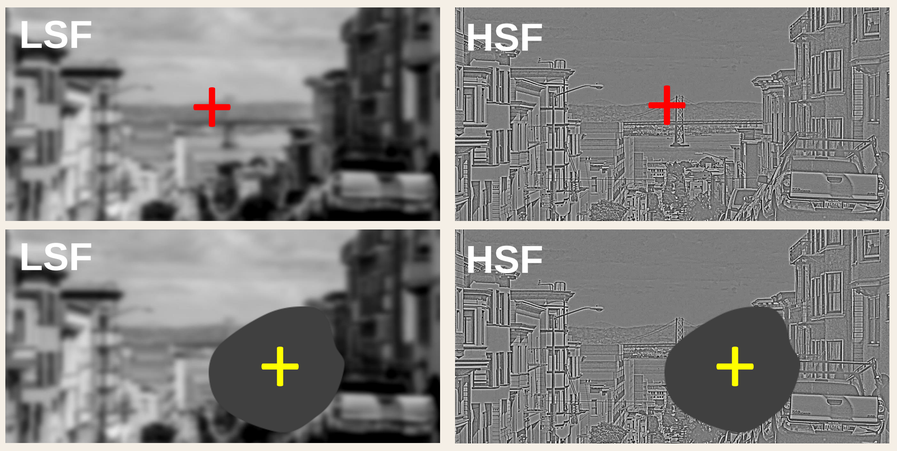


## Method

### Participants
- MD patients (AMD, Stargardt)
- 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)

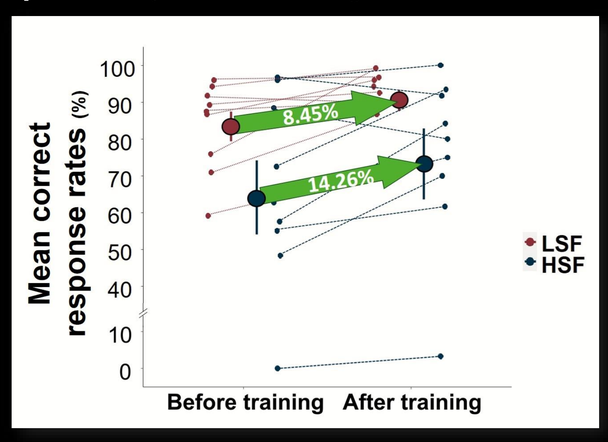
**Training:** Intensive training (12 one-hour sessions spread 4 weeks) based on perceptual learning with different scene images.

### Hypotheses
- **Spontaneous reorganization:** Deficit for processing spatial frequencies, more pronounced for HSF than LSF, and associated with lower cerebral activity.
- **Training effect :** Improved performances, more pronounced for HSF than LSF scenes, and boosted cortical responses in high-level visual areas.

## Preliminary results

**Behavioral**

**9 patients** (5 males; Mean age ± SD: 71.11 ± 8.61 y-o)




Improvement rate: $\left(\frac{PostTraining\ results - PreTraining\ results}{PreTraining\ results}\right) \times 100$

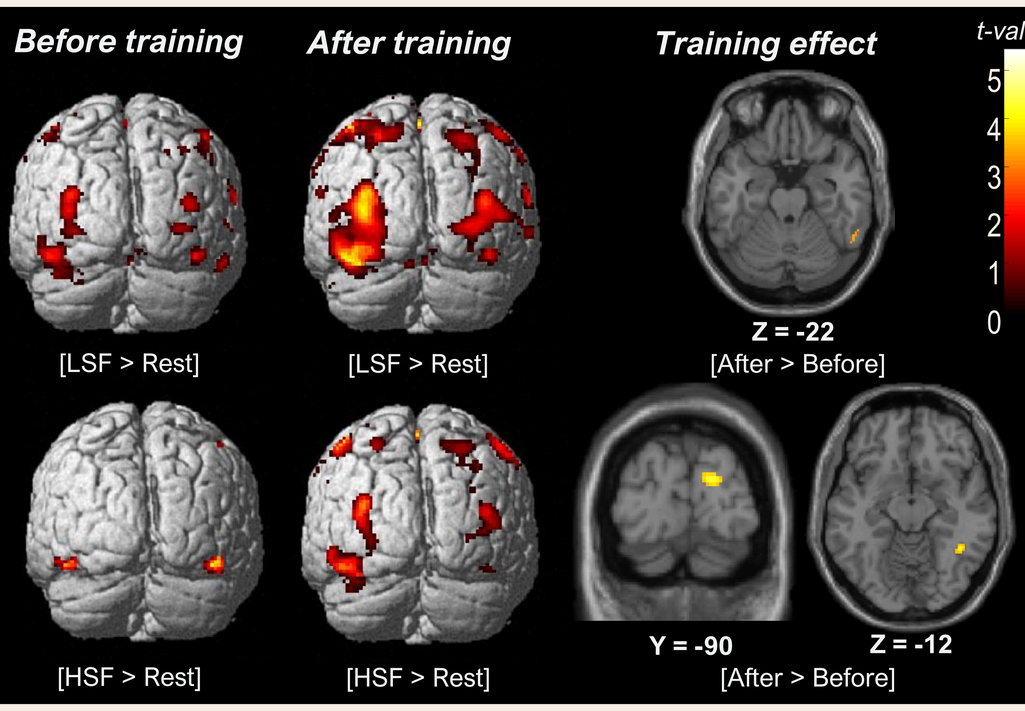
- HSF rate improvement: **14.26%** (standard error: 7.50%)
- LSF rate improvement: **8.45%** (standard error: 3.96%)

**FMRI + Behavioral**

**Patient MD1, male, 73 y-o**

Mean percentage of correct response:

| | Before | After |
|---|---|---|
| LSF | 63.54% | 91.67% |
| HSF | 32.29% | 64.58% |




## Conclusion

Before training, behavioral performance was lower for HSF than LSF scenes. Consistently, the activation of the occipito-temporal cortex was lower for HSF than LSF.
Comparison of pre- and post-training behavioral performance showed an improvement on both HSF and LSF processing of scenes. Consistently, comparison of pre- and post-training activations revealed activation increase of the occipito-temporal cortex, for both HSF and LSF scenes.
These results are preliminary and must be confirmed with more patients and controls participants the we currently tested, but they suggest that **perceptual learning could be an efficient tool to improve MD patients' scene perception in their peripheral vision and enhance cortical reorganization in these regions.**

## References

Brown, B., & Lovie-Kitchin, J. (1987). Contrast sensitivity in central and paracentral retina in age related maculopathy. Clinical and Experimental Optometry, 70(5), 145-148. https://doi.org/10.1111/j.1444-0938.1987.tb04234.x

Cohen, S.-Y., & Souied, E. (2014). Rétine : Vol. 7. Dégénérescence maculaire liée à l'âge. Lavoisier.

Musel, B., Hera, R., Chokron, S., Alleysson, D., Chiquet, C., Romanet, J. P., Guyader, N., & Peyrin, C. (2011). Residual abilities in age-related macular degeneration to process spatial frequencies during natural scene categorization. Visual neuroscience, 28(6), 529–541. https://doi.org/10.1017/S0952523811000435

Peyrin, C., Ramanoël, S., Roux-Sibilon, A., Chokron, S., & Hera, R. (2017). Scene perception in age-related macular degeneration : Effect of spatial frequencies and contrast in residual vision. Vision Research, 130, 36-47. https://doi.org/10.1016/j.visres.2016.11.004

Ramanoël, S., Chokron, S., Hera, R., Kauffmann, L., Chiquet, C., Krainik, A., & Peyrin, C. (2018). Age-related macular degeneration changes the processing of visual scenes in the brain. Visual neuroscience, 35, E006. https://doi.org/10.1017/S0952523817000372