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Functional reorganization of spatial frequency processing induced by central vision loss in patients with macular degeneration

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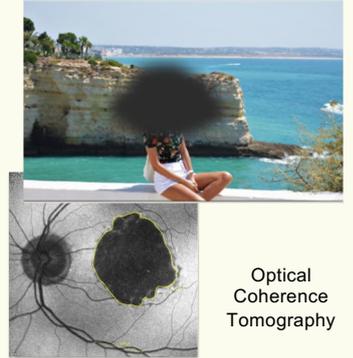
Context, positioning, and objective

Macular degeneration (AMD) is characterized by a central vision loss caused by the destruction of macular photoreceptors (Cohen & Souied, 2014).

Some studies have investigated the visual abilities of AMD patients in their residual vision. Contrast sensitivity measured using sinusoidal gratings has been shown to decrease for high and low spatial frequencies both at fovea and parafovea suggesting that deficits are not confined to central vision (Brown & Lovie-Kitchin, 1987). Other studies confirmed 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 (Musel et al., 2011; Peyrin et al., 2017; Ramanoël et al., 2018).

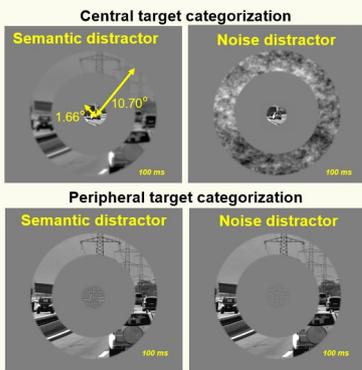
The present project aims to:

- 1 – deepen the understanding of disorders in the processing of spatial frequencies in peripheral vision induced by a loss of central vision by studying the interaction between central and peripheral vision in normally sighted people (Axis 1; see also Faurite et al. 2024).
- 2 – characterize the reorganization of spatial frequency processing that occurs spontaneously in patients and study whether this reorganization can be reinforced by perceptual learning, thus opening the door to future rehabilitation strategies (Axis 2).



Optical Coherence Tomography

Axis 1 : Role of spatial frequencies in the interaction between central vision and peripheral vision in people with normal vision



Method

Participants: 20 students from UGA (17 women; 19.7 ± 1.59 years) with normal or corrected-to-normal vision.

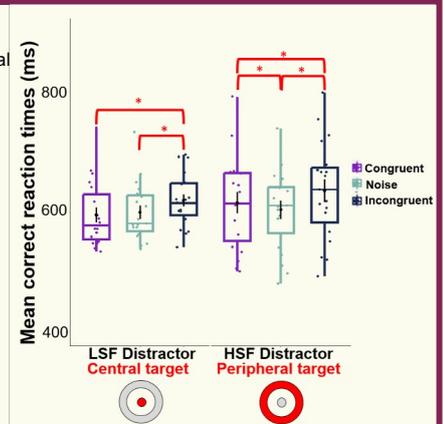
Stimuli: a central disk and a peripheral ring displayed 100 ms.

Participants performed two sessions. They had to categorize (as an indoor or outdoor scene) a nonfiltered central target while ignoring a LSF peripheral distractor stimulus or to categorize a non-filtered peripheral target while ignoring a HSF central distractor stimulus. The order of sessions was counterbalanced between participants.

The distractor contained, either a semantic information (congruent or incongruent) or a 1/f noise stimulus without semantic information.

Hypotheses

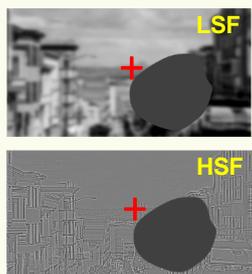
If semantic information in distractors is integrated in a top-down manner, performance of categorization of the target would be better when the distractor is semantically congruent than when it has no semantic information (noise). In addition, performance would be worse when the distractor is semantically incongruent than the noise.



Results and Conclusion

Participants were faster to categorize the peripheral target when the central HSF distractor was a noise than when it was a semantic distractor (congruent or incongruent) \Rightarrow **Semantic congruence effects from central to peripheral vision** would reflect bottom-up processes, based on the accumulation of HSF information. Participants were faster to categorize the central target when the peripheral LSF distractor was a noise than when it was semantically incongruent. Even if non significant, results show that participants were faster to categorize the central target when the peripheral LSF distractor was congruent than when it was a noise \Rightarrow **Semantic congruence effects from peripheral to central vision** would reflect top-down mechanisms, that rely on the rapid processing and integration of LSF. These results suggest that patients with AMD should still be able to categorize scenes in their residual (peripheral) vision without central vision.

Axis 2: Enhancing visual scene categorization in people with age-related macular degeneration through perceptual learning



Method

Four AMD patients participated in an intensive training (12 one-hour sessions spread 4 weeks). They had to categorize large scenes filtered either in LSF or in HSF displayed 150 ms. They fixate the red cross with their preferred retinal locus (PRL) outside their scotoma.

Hypotheses

Patients would have better performance for categorizing LSF scenes than HSF scenes in their peripheral residual vision. We expect that perceptual learning improve HSF scene categorization.

Conclusion

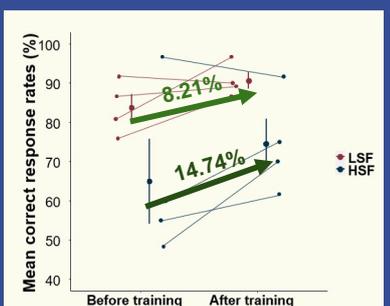
Results showed an improvement on both HSF and LSF processing of scenes when comparing pre- and post-training results. Moreover, the improvement is higher for HSF scenes than LSF scenes. These results are preliminary and have to be confirmed with more patients but they suggest that **perceptual learning could be an efficient tool to improve AMD patients' scene perception in their peripheral vision.**

Preliminary results

We compared pre- and post-training performance by calculating an improvement rate:

$$\left(\frac{\text{PostTraining results} - \text{PreTraining results}}{\text{PreTraining results}} \right) \times 100$$

Results revealed an average rate improvement of 14.74% (standard error: 6.59%) in processing HSF filtered scenes and of 8.21% (standard error: 4.22%) in processing LSF filtered scenes.



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