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Interactions between central and peripheral vision rely on the retinotopic processing of spatial frequencies

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Introduction

The ability to perceive visual scenes is based on reciprocal interactions between central and peripheral vision during an ocular fixation. Such interactions are commonly investigated through the semantic congruence effect (Lukavsky, 2019; Trouilloud et al., 2022). The aim of this study was to investigate if the congruence effects between central and peripheral vision rely on bottom-up retinotopic processing of spatial frequencies or on top-down predictive processes based on a spatial frequencies processing.

Method

Participants

Eighteen right-handed students from University Grenoble Alpes (17 women, 19.05 ± 0.94 years old) with normal or corrected-to-normal vision.

Stimuli and Procedure

Stimuli were composed of a central disk and a peripheral ring that could be either semantically congruent (belonging to the same scene image) or incongruent (belonging to different scene images from different categories) presented for 100 ms.

All participants underwent two counterbalanced sessions: In one session, they had to categorize the central disk (target) while ignoring the peripheral ring (distractor). In the other one, they had to categorize the peripheral ring (target) while ignoring the central disk (distractor).

The target was nonfiltered. The distractor was filtered, either in low-spatial frequencies (LSF) or in high-spatial frequencies (HSF).

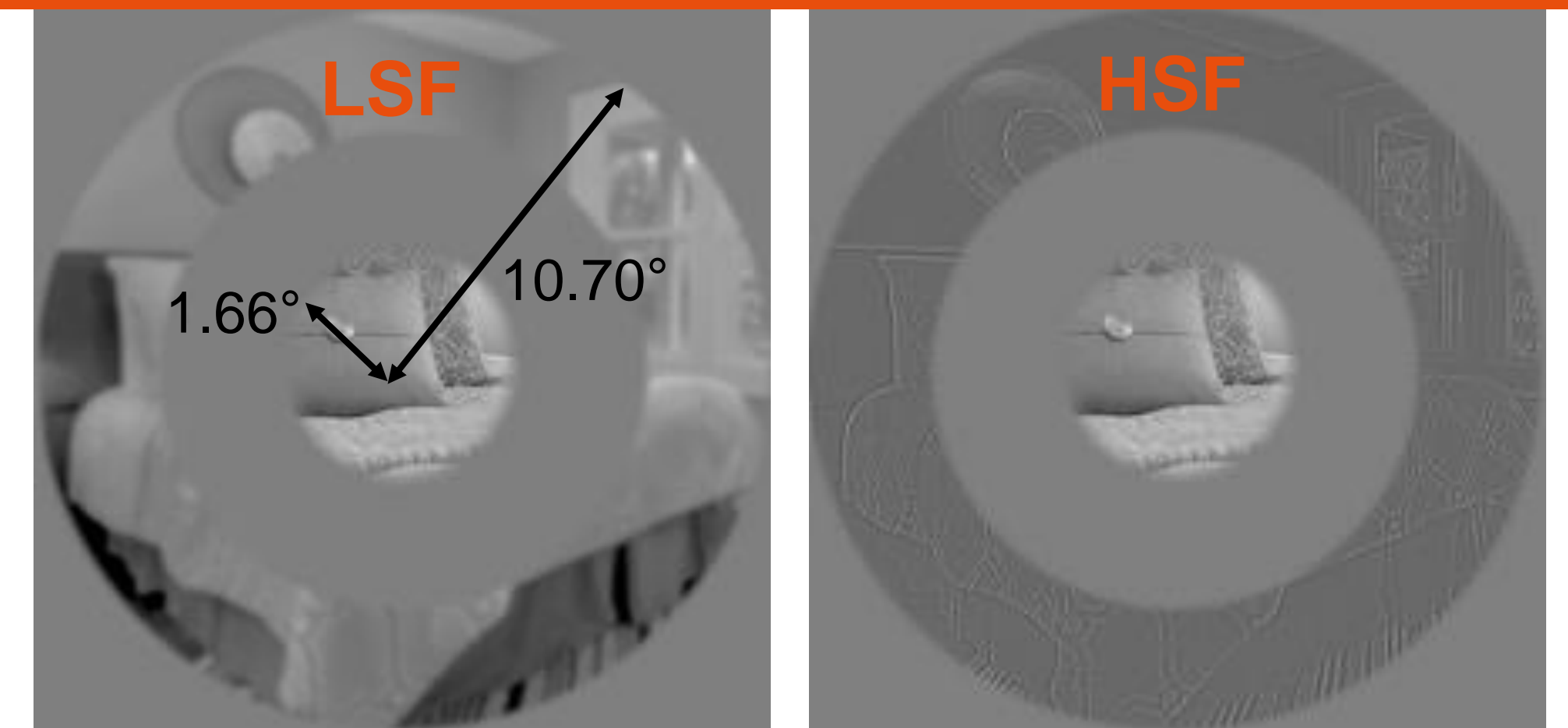
Participants were instructed to fixate the center of the screen and to categorize the target as an indoor or an outdoor scene.

We recorded the accuracy of the response, the reaction time (in ms), and the position of the eyes.

Peripheral target / Central distractor



Central target / Peripheral distractor



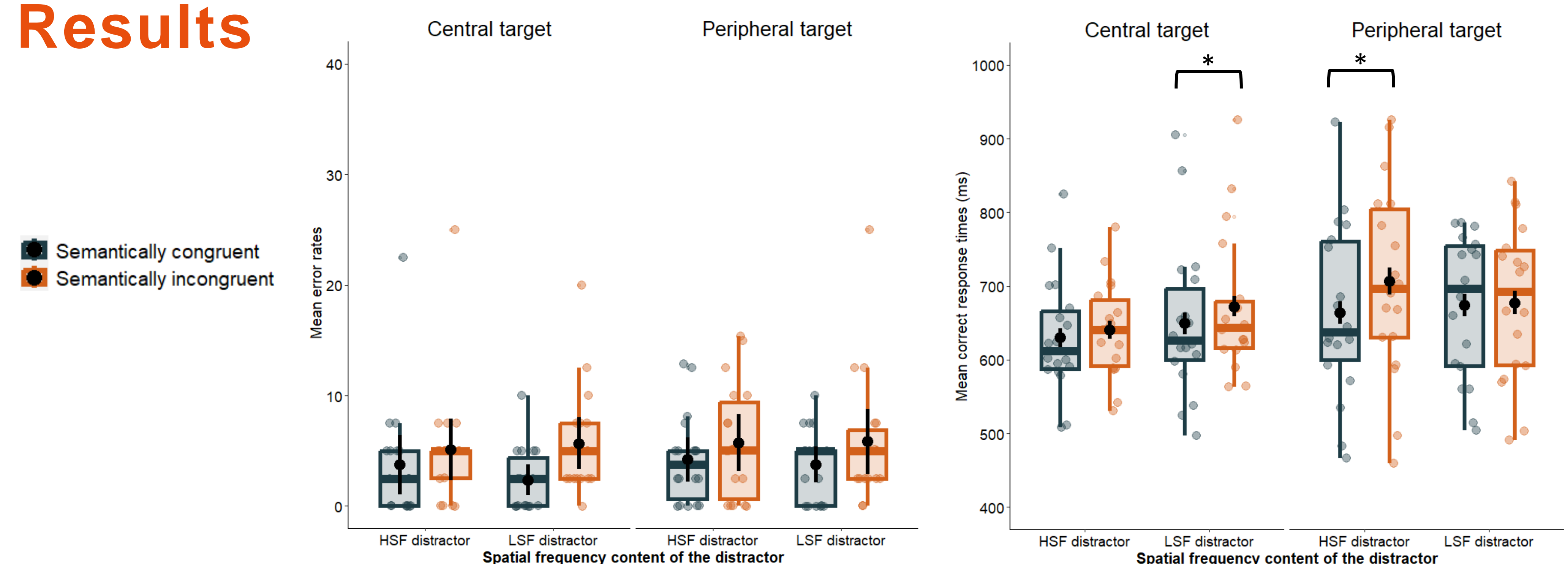
Hypotheses

→ Main congruence effect: higher error rate and longer correct response times when the central disk and the peripheral ring are semantically incongruent than congruent.
Congruence

→ If congruence effects result from top-down predictive processes based on the rapid extraction of LSF: stronger congruence effect from LSF than HSF distractors irrespective of their position in the visual field.
*Congruence*SF Distractor*

→ If congruence effects result from bottom-up processing: A central HSF distractor should induce a greater congruence effect than a central LSF distractor, while a peripheral LSF distractor should induce greater congruence effect than a HSF peripheral distractor.
*Congruence*Target position*SF Distractor*

Results



Data were analyzed using R (R Core Team, 2019) and lme4 package (Version 1.1-31, 2022) to perform linear mixed effect models on error rates and correct response times.

Error rates

→ Main effect of *Congruence*, $\beta = 0.51$, $z = 3.88$, $p < 0.01$.
→ No significant *Congruence*SF distractor* interaction, $\beta = -0.39$, $z = 1.47$, $p = 0.14$.
→ No significant *Congruence*Target position*SF Distractor* interaction, $\beta = 0.50$, $z < 1$.

Correct response times

→ Main effect of *Congruence*, $\beta = 19.73$, $t(5421.75) = 4.23$, $p < 0.001$, $dz = 1.03$.
→ No significant *Congruence*SF distractor* interaction, $\beta = 12.76$, $t(5421.64) = 1.37$, $p = .17$, $dz = 0.35$.
→ Significant *Congruence*Target position*SF Distractor* interaction, $\beta = 47.88$, $t(5421.72) = 2.57$, $p = .01$, $dz = 0.62$.
- For the peripheral target condition, the congruence effect was significant only when the central distractor was filtered in HSF, $\beta = 41.88$, $t(5421) = -4.49$, $p < .01$, $dz = 1.09$.
- For the central target condition, the congruence effect was significant only when the peripheral distractor was filtered in LSF, $\beta = 21.52$, $t(5422) = -2.32$, $p = .02$, $dz = 0.56$.

References

Lukavský J. (2019). Scene categorization in the presence of a distractor. *Journal of vision*, 19(2), 6. <https://doi.org/10.1167/19.2.6>

Trouilloud, A., Rossel, P., Faurite, C., Roux-Sibilon, A., Kauffmann, L., & Peyrin, C. (2022). Influence of physical features from peripheral vision on scene categorization in central vision. *Visual Cognition*, 30(6), 425-442. <https://doi.org/10.1080/13506285.2022.2087814>

Conclusion

→ We found a congruence effect from central vision on peripheral vision only when the central distractor was filtered in HSF and a congruence effect from peripheral vision on central vision only when the peripheral distractor was filtered in LSF. This result suggests that interactions between central and peripheral vision rely on the bottom-up retinotopic processing of spatial frequencies.
→ However, presence of top-down mechanism in peripheral vision cannot be totally ruled out.
→ Clinical implications for patients with macular degeneration: central loss → central-peripheral interactions loss?