Dissecting visual attention

DOI:
10.26481/dis.20240229tw

Appendix

Summary

The primary purpose of this thesis was to obtain a deeper understanding of visual attention bias and attention effects of alerting and orienting. Using a multimodal approach including meta-analysis, magnetic resonance imaging (MRI), drift diffusion model (DDM), and electroencephalography (EEG), we addressed specific aspects of these attentional phenomena in three parts.

Part I: Attentional Bias

Attentional bias was explored through meta-analyses of Transcranial Magnetic Stimulation (TMS) effects. In Chapter 2, we focused on the inhibitory/disruptive effects of TMS on the left and right parietal cortex, specifically examining performance on line bisection and landmark tasks revealing attentional bias shifts and evaluating potential hemisphere asymmetries. The results provided strong support for hemispheric asymmetry of TMS effects on attentional bias with TMS effects only being present after right parietal TMS but not left parietal TMS. This pattern of results mimics the lateralization reported in hemineglect patients. However, this work is limited in informing us about why the right hemisphere plays a more important role than left hemisphere. Chapter 3 tried to tackle this problem by assessing the inhibitory/disruptive effects of TMS on the left and right parietal cortex, this time examining performance on a visual detection task that separates the role of the left and right hemifield. This allows for the isolated experimental assessment of the left versus right hemispheric contribution to stimulus detection in the contra- versus ipsilateral hemifield. These analyses aimed to elucidate mechanisms of hemisphere asymmetry and inform visuospatial attention theories. This study rejected the critical prediction of ipsilateral enhancement that is a cornerstone of Kinsbourne's opponent processor model (1977). Moreover, the presence of contralateral impairment effects was in general agreement with Heilman's hemispatial theory (Heilman & Abell, 1980).

Part II: TMS Localization Methods

Next, we focused on TMS target localization methods guided by MRI. Chapter 4 explored and compared various MRI-guided approaches for localizing TMS targets in the Dorsal Attention Network (DAN) and Ventral Attention Network (VAN). We found that individual task-based

localization generally works well but not consistently for all individuals or brain regions. Aggregating task data across participants yields the best approximation of individual targets when individual localization failed and is thus a good alternative approach in such situations. Additionally, the other alternatives like resting state and the overlap of resting-state and tractography had mixed success across brain regions, with individual data sometimes deviating more from individual task-based targets than group average data.

Part III: Alerting and Orienting Effects

Lastly, we delved into the cognitive mechanisms underlying alerting and orienting effects in visuospatial attention. Chapter 5 employed an online exogenous cueing task combined with a DDM to investigate these cognitive mechanisms. This study revealed that DDM could be a useful tool to understand cognitive processes of alerting and orienting effect. The alerting effect could be attributed to the rapid capture of attention by the exogenous cues, initiating a faster motor response preparation. And the orienting effect can be attributed to rapidly shift attention towards the cues location and managed to initiate the visual attention process more swiftly, as indicated by the shorter early visual preprocessing time. In Chapter 6, an endogenous cueing task was employed to explore similar mechanisms while also assessing alerting and orienting hemifield lateralization potentially influenced by hemispheric asymmetry. We not only found motor response preparation but also drift rate varies in alerting effect, indicating the adjustment of the rate of gathering evidence based on expectations and goals. The orienting effect also had a shorter early visual preprocessing time. Surprisingly, the lateralization of alerting and orienting was not found, neither on the behavioral level nor in model parameter (or cognitive processes) level. Chapter 7 extended this by utilizing EEG signals during the same endogenous cueing task to establish links between neural dynamics and cognitive processes associated with alerting and orienting effects. It revealed that only posterior P2 amplitude reflects motor response preparation processes in alerting effect but nothing was found for the orienting effect. This connection highlights the intricate relationship between neural activation and attentional processes in alerting situations. It also demonstrates that combining modeling with electrophysiological signals is a promising approach to help understand cognitive and neural processing mechanisms.

References

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