Spatial attention processing priorities modulate distributed spatial representations in the occipital visual cortex

PhD thesis on the ***4th of july*** at 2pm in the Neurocampus amphitheatre

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Visual selective attention (VSA) is a cognitive function that biases the perceptual processing of visual inputs on the basis of their behavioral relevance. The brain correlates of VSA have mostly been studied in terms of biases of the spatial representations in the occipital cortex, or the functional responses of attention controlling networks in the frontoparietal cortex (FPAN). These two main research fields made use of disparate paradigms and led to contradictory findings, precluding their integration into a unified framework. An emerging theoretical account, the priority maps framework, attempts to reconcile these contradictory findings into a unified view. It posits that an attentional gating is observable within spatial maps in the brain, as a function of the behavioral relevance of items in the visual field and their spatial location, arising from computations both at the occipital and the FPAN levels. However, so far, this account has received poor experimental support. Across three fMRI studies, we tested how multiple spatially-distributed attentional signals bias the spatially-specific responses in the occipital cortex and explored the mechanisms governing these bias. In all studies, we used a visual display containing four items, including one target, placed each in one of the four screen quadrants.

Across experiments, we manipulated the configuration of the visual display by incorporating salience (all experiments), goal-directed endogenous cues (Experiment 1), statistical regularities (Experiment 2) and reward (Experiment 3). The main analyses sought to characterize how the different gating signals affect the activity of distributed spatial representations in the visual cortex and whether/how they interact within these representations. For this we constructed a 2D index (spatial bias vector) that, using the activity of multiple quadrant-specific occipital regions, provides us with a measure of the strength and direction of the overall attentional gating. We carried out these analyses in three separate occipital Brodmann areas (BA17, BA18, BA19) in order to capture the contribution of the attentional signals throughout the visual hierarchy. We explored the mechanisms governing the observed spatially-specific patterns of activity in the occipital cortex using interregional connectivity analyses between the parietal and the occipital cortex and performing whole-brain analyses. We showed that, across the three experiments, all attentional signals impacted the response patterns of spatially-specific activity in the occipital cortex. However, these signals had specific signatures that could be explained in terms of top-down signaling involving the FPAN (Experiment 1), but also local interactions within the occipital cortex (all experiments). This work sheds new light on the specification of the mechanisms and constraints that govern the selection of relevant information in conditions entailing a multitude of competing signals, emphasizing for the first time the key contribution of spatial representations in the occipital visual cortex.

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