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Abstract of the thesis 'Neuronal mechanisms of feature-based selection in humans'

The human visual system is both flexible and adaptive, with systems that allow it to focus the brain's processing resources onto the most relevant aspects of our visual world. Selective visual attention plays an important role in perception as it determines which aspects of the sensory input will be processed at higher visual levels. Selections can be based not only on the spatial position of an object, but also on non-spatial stimulus features (such motion direction, orientation, and color). However, different models disagree about the manner in which these different selection mechanisms interact. While some studies argue that location-based attention dominates over feature-based selection processes, others demonstrate that the early selection of relevant features can provide location information (at least in a coarse manner) and thereby highlight potential target locations. Until now, however, the evidence bearing the occurrence of such a feature guidance effect has been inconclusive in human neurophysiological investigations.

In the present study, neuronal mechanisms of feature-based attention and their relationship to location-based selection were investigated. Healthy volunteers were instructed to solve complex visual attention tasks while combined electrical and magnetic recordings (EEG, MEG) were non-invasively obtained. The spatial distribution of distractors, which interfere with the target because they contain a task-specific feature, was varied systematically to separate the relevant feature selection process from spatial focusing onto the potential target item. The results showed that the presence of an attended feature led to a modulation of the event-related potentials and event-related magnetic field responses in a time period between 140 and 300 ms after the stimulus presentation. This modulation was completely independent of the target location. The relevant feature effect was found in the inferior-temporal cortex ~40 ms before the onset of the neuronal activity that represents the suppression of distractors (N2pc component, experiment 1). It could not be explained by the stimulus-specific values used in the experiment or by a simple perceptual effect (control experiments 1 and 2). In addition, location precueing was added to the original design to determine the impact of prior location knowledge on the relevant feature effect (experiment 2). Taken together, the presented results provide direct neurophysiological evidence for a neuronal correlate of the coding of relevant features before the operation of spatial focusing in vision. It is important to emphasize that the relevant feature effect reflects an automatic and location-independent selection process. This type of feature-based selection process has been discussed in several models of visual attention. It acts to briefly highlight the most relevant aspects of the internal representation of our visual world. These highlighted aspects can serve as markers that guide the subsequent deployment of spatial attention. In particular, the feature guidance that has been proposed by several models of visual search could depend on such feature-based modulations. To evaluate the relationship of these modulations to location-based attention in greater detail, the discrimination time for the relevant feature was reduced by visual masking (experiment 3). When this was done, no relevant feature effect was found. Thus, the relevant feature effect was clearly strongly dependent on the ongoing

stimulus processing, so that relevant features outside of the spatial focus of attention were only given preferential processing when features were discriminated actively.

Altogether, the present experiments showed that visual attention must coordinate different selection processes on a tight temporal scale of tens of milliseconds, and uses attentional modules in a flexible manner, in order to perform in a manner that best suits the requirements of an individual search task.