Bottom-up and top-down selection in time

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Chapter 6

Summary / Samenvatting

The visual environment contains a vast amount of information, most of which is irrelevant for our current goals. Still, we need to be able to select those parts that are necessary to act purposefully. This means that the brain faces the difficult task of extracting relevant and discarding irrelevant information. It accomplishes this using a mechanism called selective attention. Selective attention prioritizes some stimuli in the visual field over others, such that they are processed with more resources. Selective attention is assumed to be controlled by two mechanisms: a bottom-up mechanism and a top-down mechanism. Bottom-up selection is stimulus-driven: the bottom-up mechanism prioritizes stimuli that are salient relative to their local surroundings. These stimuli might, for example, have a unique color or orientation, move among static surrounding elements, or differ in size relative to the other stimuli. Top-down selection is goal-driven: the top-down mechanism prioritizes stimuli that are in line with our current behavioral goals. Both bottom-up and top-down selection can be spatial or feature-based. Spatial selection involves the selection of a stimulus at a specific location, for example an object presented at the left side of a display. Feature-based selection involves the selection of a stimulus with a specific feature. A typical example of feature-based selection is the selection of a specific color from other colors that are present in the visual field. The present thesis is concerned with bottom-up and top-down feature-based selective attention. The first chapter introduces the relevant terms and provides the background to the empirical Chapters 2 - 5.

Chapter 2 contains a study of the time course of color- and luminance-based salience effects. In two experiments, we investigated how salience derived from color and luminance differences influences covert visual attention over time. We presented observers with a display consisting of two distinct color (Experiment 1) or luminance singletons (Experiment 2) embedded in a field of homogeneously oriented lines which was masked after six different stimulus-onset-asynchronies. Observers had the task to indicate the location of a probe within the mask. A comparison of reaction times to the probe at the location of the more salient singleton, the less salient singleton and a background location revealed that the relative salience of the singletons affected covert attention only briefly after stimulus onset. The mere presence of a singleton object, however, affected selection for a much longer time span.

Chapter 3 comprises a study of feature-based selection in neglect and extinction patients. In two experiments, we asked a group of patients with extinction and with and without additional neglect to make a direct saccade to one of two differently oriented lines within a field of homogenous background lines. We varied the relative salience of these lines by changing the orientation of the background elements. We measured the endpoint and the saccadic latency of the first saccade after display onset to determine speed-accuracy functions for each condition and participant. Using a multinomial model, we decomposed these functions into the underlying top-down or goal-driven and bottom-up or stimulus-driven components. This analysis revealed that stimulus-driven processing of stimuli in the more severely affected hemi-field was initially present, but reduced in comparison to the less affected hemi-field and in comparison to a control group. Goal-driven processing was overall reduced in the patients. Experiment 2 showed that this pattern of results did not depend on an overall spatial bias toward the less affected hemi-field.

Chapter 4 describes a study of the time course of working memory effects on visual attention. In five experiments, we asked participants to memorize a color, which was either difficult or easy to verbalize. They then searched for an unrelated target in a visual search display and finally completed a memory test. In half of all trials, one of the distractors in the search display had the memorized color. In the other half of all trials, the color of all distractors differed from the memorized color. We varied the time between the to-be-remembered color and the search display, as well as the ease with which the colors could be verbalized. We found that when the to-be-remembered color reappeared in the search display and was difficult to verbalize, response times to the target were longer than when the memorized color did not reappear. This suggests that the memory item attracted the participants' attention and thus delayed the response to the target. However, when the to-be-remembered color was easy to verbalize, the influence of the working memory item on visual search decreased with increasing time between the presentation of the memory item and the search display. Working memory effects on visual search also decreased when the duration of visual encoding was limited by an additional task or when the memory item was presented only briefly. We concluded that for working memory effects on visual attention to be sustained, a sufficiently strong visual representation is necessary.

Chapter 5 contains a study of the costs of attentional set switching. In two experiments, we asked observers to sequentially saccade towards two color-defined targets, one on the left side of the display and the other on the right, each among heterogeneously colored distractors. The targets were either of the same color (no switch condition) or of different colors (attentional set switch condition). Each color was consistently tied to one side, allowing observers to maximally prepare for the switch. We found that saccades were both slower and less accurate in the switch condition than in the no switch condition. Further, whenever one of the distractors had the color associated with the other attentional set, a large proportion of saccades did not end on the target, but on this distractor.

A time course analysis revealed that the preference for the distractor associated with the old set turned into a preference for the target (associated with the new set) after about 250 to 300 ms, which suggests that this is the time required to switch attentional sets.