Chapter 19
Visual-Tactile Bottom-Up and Top-Down Attention

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ABSTRACT

In recent years, there have been many studies on attention. These studies have found that there are two distinct kinds of neural networks employed for visual attention and tactile attention, respectively. This review summarizes the processing mechanism of these attention-related brain networks. One type is the top-down attention related brain structure, which includes the IPs/SPL (intraparietal sulcus/superior parietal lobule)-FEF (frontal eye field). The other is the bottom-up attention related brain structure, which includes the TPJ (temporoparietal junction)-VFC (ventral frontal cortex). Regarding research into tactile attention, in conclusion, the authors found that tactile attention had a similar neural network to that of visual attention in that there was top-down attention to the relevant IPs-FEF and bottom-up attention to the relevant TPJ-VFC.

INTRODUCTION

Attention is a cognitive process. When we pay attention to one aspect of our environment, other things are disregarded. Attention is also a topic within psychology and cognitive neuroscience that is the focus of considerable study. In 1890 William James (James 1890), in his textbook Principles of Psychology, remarked that: "Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought (Scerif 2010)." Then in the 1990s, psychologists began to use PET and later fMRI to image the brain's attentional tasks.

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Attention related researchers have described two different aspects of how our minds select items present in the field of attention. The first aspect is called bottom-up processing, also known as stimulus-driven attention or exogenous attention. This describes aspects of our attentional processing that are thought to be driven by the properties of the objects themselves. These aspects of attention are thought to involve the parietal and temporal cortices, as well as the brainstem (Posner and Petersen 1990). Certain aspects of an object's properties such as motion or a sudden loud noise have the capacity of attracting our attention in a pre-conscious or non-volitional way. We attend to them whether we want to or not want (Theeuwes 1991).

The second aspect is called top-down processing, also known as goal-driven attention, endogenous attention, attentional control or executive attention. This refers to those aspects of attentional orienting which are under the control of a person. The brain is thought to be mediated primarily by the frontal cortex and basal ganglia (Posner and Petersen 1990).

BOTTOM-UP AND TOP-DOWN VISUAL ATTENTION

In a recent attention study (Uncapher, Hutchinson, & Wagner, 2011), subjects were scanned while incidentally encoding a series of visually presented objects in a variant of the Posner cueing paradigm. A triangular arrow cue was preceded on a paper screen by projector, pointing either to the left or the right side of the screen. After the presentation of the target, subjects pressed a button to indicate they had identified a real object, regardless of whether the item appeared in the validly or invalidly cued location (Figure 1).

Recent brain imaging studies using functional magnetic resonance imaging (fMRI) found a frontal-parietal network in top-down attentional control. They used an event-related experimental paradigm and a specially designed visual-spatial attentional-cueing paradigm. In the first 400 ms post cue, attention-directing and control cues elicited similar general cue-processing activity, corresponding to the more lateral subregions of the frontal-parietal network identified by fMRI. These results suggest that voluntary attentional orienting is initiated by medial portions of the frontal cortex, which then recruit medial

Figure 1. Top-down and bottom-up experiment task in the previous study