

Cognitive Control of coherent motion perception: functional MRI studies of response selection

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Abstract

Executive control is a human ability that allows to overcome automatic stimulus-response mappings and to act appropriate in the context of a task where the selection of relevant stimuli and the suppression of interfering information are crucial. The first study aimed at characterizing the neural correlates of conflict resolution in two variations of the Simon effect. Two different Simon tasks were introduced where subjects had to identify shapes on the basis of form-from-motion perception (FFM) within a randomly moving dot field, while (1) motion direction (motion-based Simon task) or (2) stimulus location (location-based Simon task) had to be ignored. Behavioral data revealed that both types of Simon tasks induced highly significant interference effects. Using event-related fMRI we could demonstrate that both tasks share a common cluster of activated brain regions during conflict resolution (pre-supplementary motor area (pre-SMA), superior parietal lobule (SPL), and cuneus) but also show task-specific activation patterns (left superior temporal cortex in the motion-based, and the left fusiform gyrus in the location-based Simon task). Although motion-based and location-based Simon tasks are conceptually very similar (Type-3 stimulus response ensembles according to the taxonomy of Kornblum & Stevens (2002)) conflict resolution in both tasks results in the activation of different task-specific regions probably related to the different sources of task-irrelevant information.

The second experiment aimed at investigating the influence of the degree of interfering information on error processing. The ability to detect errors is a crucial prerequisite for the appropriate adjustment of behavior to future situations. By means of fMRI, we provide evidence for the existence of different error-related networks within the human brain. While errors related to incompatible trials were mainly associated with activation of the rostral anterior cingulate cortex (rACC) and the precuneus / posterior cingulate, errors related to trials without pre-response conflict showed specific activation in right inferior parietal cortex. Despite this functional dissociation of brain networks, conjunction analysis revealed common clusters of activation in the medial wall (dorsal anterior cingulate cortex (dACC) and medial superior frontal cortex (msFC)), and bilateral inferior frontal gyrus / insula, consistent with earlier reports of error-related BOLD-signal increases. The results support the view that despite of an overlapping core system of error processing, additional brain areas come into play depending on the existence or absence of cognitive conflict. In order to address the question which brain areas

are involved in the detection and processing of two simultaneously operating sources of interference derived from a spatial incompatibility task, we used fMRI to directly contrast neural activity related to a double conflict situation to single incompatibility conditions. Results show signal increase of left dorsolateral prefrontal cortex when monitoring simultaneously presented conflict. There was no additional activity in the medial prefrontal cortex or anterior cingulate cortex although these regions are expected to play an important role in all types of conflict monitoring. Further analyses also suggest a major role for the basal ganglia during error detection and resolution.