Cortical regions involved in proactive control of task-set

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature:…….

Abstract

This thesis is about what happens in the brain when people switch between tasks. Each task requires a particular assembly of cognitive processes, an orientation of attention and set of rules relating action to input — a "task-set". The research reported used a task-cueing paradigm to study preparatory control of task-set. On each trial a stimulus (a coloured shape) was preceded by a verbal task-cue specifying which task to do (judge the shape or the colour of the stimulus). Reaction time and error rate increase on trials when the task changes relative to trials on which it does not. When the cue stimulus interval (CSI) is increased, this "switch cost" is reduced, indexing a process of task-set reconfiguration in which top-down control is employed to reconfigure the task-set parameters. Effective reconfiguration may also be indicated by a reduction in the "response congruence effect" — poorer performance on stimuli mapped to different responses for the two tasks than for stimuli mapped to the same response. I present six experiments using transcranial magnetic stimulation (TMS), a technique for interfering briefly and harmlessly with neuronal activity in a small region of cortex, to address the question of which brain regions contribute to anticipatory control of task-set as indexed by these behavioural measures.

To help guide the selection of candidate brain regions, I first present a review and meta-analysis of neuroimaging studies of task-switching in the literature. Many fMRI studies, comparing brain activation on task-switch and -repeat trials have been published. Some have also tried to isolate activations related specifically to pro-active control of task-set. The activations reported are quite inconsistent over studies. I used a quantitative meta-analysis technique to identify which brain regions are most consistently found by studies reporting switch minus repeat contrasts and which may be specifically important for preparation on switch trials.

The experiments examined the effect of stimulating several regions during the long cue-stimulus interval of a task-cueing paradigm, relative to control conditions. A first pair of experiments suggests an important role in proactive task-set control for two regions in dorsal medial frontal cortex, the supplementary motor area (SMA) and an area known as pre-SMA, though the former region appeared to contribute to reducing the switch cost while the latter appeared to reduce the effects of response congruence. In a further three experiments, I examined the role of the right intra-parietal sulcus (rIPS); this appears to play a crucial role in preparation for a task-switch but not post-stimulus task-set reconfiguration. In a final

experiment, I used TMS guided by fMRI activations in the same participants to study the effects of stimulation over the left inferior frontal junction (IFJ). The results indicate that a region just anterior to the left IFJ is specifically important for preparing for a switch trial. I discuss the roles that may be played by these three regions in task-set control.

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