DISSECTING PROACTIVE CONTROL PROCESSES IN TASK-SWITCHING: A MODEL-BASED NEUROSCIENCE APPROACH

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B Psychology (Hons I)

Submitted in total fulfillment of the requirements for the degree of Doctor of Philosophy

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Abstract

Cognitive control processes support purposeful, goal-directed behaviour in the presence of conflicting demands from our environment. Given advance information, this type of control can be engaged in anticipation of a change in behaviour. The cued-trials task-switching paradigm can temporally dissociate proactive and reactive cognitive control processes involved in switching between sets of abstract task rules. Typically, there is a performance cost for switch relative to repeat trials, which is attributed partly to proactive control processes required to prepare for a switch in task and partly to reactive control processes required to deal with between-task interference. Despite two decades of research into preparatory processes in task-switching, the cognitive processes and neural substrates that support proactive control remain underspecified. This thesis uses a model-based neuroscience approach to define the temporal and spatial characteristics of cognitive processes that contribute to proactive control in task-switching. Using converging evidence from ERPs, a novel multivariate pattern misclassification analysis of EEG data and cognitive modeling, we showed that a switch-specific preparation process is temporally and spatially distinct from more general task preparation for both switch and repeat trials. Consistent with a conflict control mechanism, we show that this switch-specific preparation process is linked to a right inferior frontal source and is related to upward adjustment of response caution in anticipation of more difficult switch trials. We also used fMRI- and DWI-based analyses to examine the neural basis of these cue-related adjustments in response caution, showing that distinct cortico-basal ganglia networks are associated with the ability to flexibly adjust response caution in anticipation of easy or difficult decisions, as well as intrinsic tendencies to set overall response caution high or low. We discuss implications of these findings for our understanding of the organization and timecourse of cognitive control mechanisms.
### Abbreviations

#### Neuroanatomical

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACC</td>
<td>Anterior cingulate cortex</td>
</tr>
<tr>
<td>CPJ</td>
<td>Caudate-putamen junction</td>
</tr>
<tr>
<td>DLPFC</td>
<td>Dorsolateral prefrontal cortex</td>
</tr>
<tr>
<td>IFC</td>
<td>Inferior frontal cortex</td>
</tr>
<tr>
<td>IFG</td>
<td>Inferior frontal gyrus</td>
</tr>
<tr>
<td>IFJ</td>
<td>Inferior frontal junction</td>
</tr>
<tr>
<td>IPL</td>
<td>Inferior parietal lobule</td>
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<tr>
<td>IPS</td>
<td>Intraparietal sulcus</td>
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<tr>
<td>PFC</td>
<td>Prefrontal cortex</td>
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<tr>
<td>PPC</td>
<td>Posterior parietal cortex</td>
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<tr>
<td>Pre-SMA</td>
<td>Pre-supplementary motor area</td>
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<tr>
<td>SPL</td>
<td>Superior parietal lobule</td>
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<td>STN</td>
<td>Subthalamic nucleus</td>
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<td>VLPFC</td>
<td>Ventrolateral prefrontal cortex</td>
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#### Other

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<tr>
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<tbody>
<tr>
<td>BESA</td>
<td>Brain Electrical Source Analysis</td>
</tr>
<tr>
<td>BIS</td>
<td>Barratt Impulsiveness Scale</td>
</tr>
<tr>
<td>BOLD</td>
<td>Blood oxygenation level dependent</td>
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<tr>
<td>CNV</td>
<td>Contingent negative variation</td>
</tr>
<tr>
<td>CSD</td>
<td>Current-source-density</td>
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<tr>
<td>CSI</td>
<td>Cue-stimulus interval</td>
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<tr>
<td>C-T interval</td>
<td>Cue-target interval</td>
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<tr>
<td>dB</td>
<td>Decibel</td>
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<tr>
<td>dHb</td>
<td>Deoxygenated haemoglobin</td>
</tr>
<tr>
<td>DMC</td>
<td>Dual mechanisms of control</td>
</tr>
<tr>
<td>D-Pos</td>
<td>Differential switch positivity</td>
</tr>
<tr>
<td>DWI</td>
<td>Diffusion weighted imaging</td>
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<tr>
<td>EEG</td>
<td>Electroencephalogram</td>
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<tr>
<td>EMG</td>
<td>Electromyogram</td>
</tr>
<tr>
<td>EOG</td>
<td>Electrooculogram</td>
</tr>
<tr>
<td>EPI</td>
<td>Echo planar imaging</td>
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<tr>
<td>ERP</td>
<td>Event-related potential</td>
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<tr>
<td>Hb</td>
<td>Oxygenated haemoglobin</td>
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<tr>
<td>FA</td>
<td>Fractional anisotropy</td>
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<tr>
<td>fMRI</td>
<td>Functional magnetic resonance imaging</td>
</tr>
<tr>
<td>FSL</td>
<td>FMRIB Software Library</td>
</tr>
<tr>
<td>HRF</td>
<td>Haemodynamic response function</td>
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<tr>
<td>LPC</td>
<td>Late positive component</td>
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<tr>
<td>MRI</td>
<td>Magnetic resonance imaging</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>R-C interval</td>
<td>Response-cue interval</td>
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<tr>
<td>ROI</td>
<td>Region of interest</td>
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<tr>
<td>RT</td>
<td>Reaction time</td>
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<tr>
<td>R-T interval</td>
<td>Response-target interval</td>
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<tr>
<td>SPM</td>
<td>Statistical Parametric Mapping</td>
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<td>S-R priming</td>
<td>Stimulus-response priming</td>
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<tr>
<td>TBSS</td>
<td>Tract-Based Spatial Statistics</td>
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<tr>
<td>TMS</td>
<td>Transcranial magnetic stimulation</td>
</tr>
<tr>
<td>T-R mapping</td>
<td>Target-response mapping</td>
</tr>
<tr>
<td>WM</td>
<td>White matter</td>
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