Incentive-Induced Changes in Neural Patterns During Task-Switching

Adam C. Savine[1], Jordan A. Taylor[2], and Todd S. Braver[1]

[1] Department of Psychology, Washington University - St. Louis, St. Louis, MO, United States of America [2] Department of Psychology, University of California- Berkeley, CA, United States of America

Introduction: It is becoming increasingly appreciated that the mechanisms by which humans exert control over thoughts and actions will need to be understood in terms of motivational as well as cognitive processes. Our objective was to investigate the neural effects of incentive motivation on both cognitive control and perceptual processing. Specifically, we examined manipulations of reward incentive during task-switching to determine whether such manipulations modulated activity not only the brain cognitive control network (e.g., dorsal frontoparietal regions) but also in task-specific perceptual regions (e.g., fusiform face area [FFA] and visual word-form area [VWFA]).

Methods: Healthy participants performed two separate sessions in which face discrimination and word syllable identification tasks were performed in either single-task or task-switching blocks. Task-switching blocks utilized a 2:1 random task-cuing paradigm. In the first session, blocks were performed under no-incentive (baseline) conditions. In the second session, task blocks involved randomly interleaved incentive and no-incentive trials (which were pre-cued prior to task onset). Functional magnetic resonance imaging (fMRI) was employed to measure behavioral and neural responses to the task cues, stimuli, and feedback (participants learned the task outside of the scanner). The experimental design combined a mixed blocked / event-related approach (??ref: Visscher) with partial trial methods (??ref: Ollinger 2001), to enable isolation of both tonic / sustained activation associated with task-switching and incentive blocks, as well as cue-specific preparatory event-related responses.

Results: Behaviorally, incentives attenuated the robust switch costs reported in the task switching literature, demonstrating that incentive motivation does enhance performance on cognitive control tasks. Additionally, the enhancement of performance included both tonic and phasic components (incentive context and incentive cue effects, respectively). In the fMRI analysis, task-specific activation associated with face and word processing was identified in FFA and VWFA, respectively. The Incentive – Non-incentive contrast revealed increased sustained lateral PFC and inferior frontal gyrus (IFG) activity on the mixed task blocks (where cognitive control was necessary) associated with improved performance. The improved performance in single task blocks was associated with greater sustained orbitofrontal cortex and limbic regions, but not lateral PFC activity, which is consistent with the result that there are benefits of incentive on single blocks yet not to the degree of the benefit on mixed blocks. Analyses of event-related activation patterns also enabled differentiation of incentive-related modulation of task-specific regions from those related to cognitive control.

Conclusions: We have shown here that motivation does indeed lead to better task-switching performance not only through enhancement of the activations in regions implicated in reward processing, but through enhancement of activations in cognitive control regions. Our work identifies both the need to consider motivational factors when conducting neural investigations of cognitive processes, as well as a potential need to dissociate attentional from motivational benefits on human task performance. Our study also informs future studies by highlighting how the hybrid blocked / event-related design can be paired with the partial trial approach to reveal more detailed information about the temporal dynamics of brain activity during cognitive control.

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