University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

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"The Role of Frontal Beta Oscillations in Learning and Memory"

Department of Psychology

Friday, August 7, 2015
1:00PM
Cornett Building
Room A228

Supervisory Committee:
Dr. Clay Holroyd, Department of Psychology, University of Victoria (Supervisor)
Dr. Adam Krawitz, Department of Psychology, UVic (Member)
Dr. Roderick Edwards, Department of Mathematics & Statistics, UVic (Outside Member)

External Examiner:
Dr. James Cavanagh, Department of Psychology, University of New Mexico

Chair of Oral Examination:
Prof. Michael McGuire, Department of Electrical & Computer Engineering, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Several theoretical frameworks have implicated the dorsolateral prefrontal cortex (DLPFC) and the anterior cingulate cortex (ACC) in cognitive functions related to learning, decision making, and working memory. However, the particulars about how these functions are carried out are still ambiguous. This thesis investigates whether beta oscillations, a ~20-30 Hz signal in the human electroencephalogram distributed over frontal areas of the scalp, can provide insight into these neurocognitive functions. Increased beta power has been consistently observed following presentation of reward feedback stimuli in a variety of reinforcement learning paradigms such as gambling, probabilistic learning, and time-estimation tasks. This beta oscillatory activity has been proposed to underlie learning from rewards through synchronization of prefrontal cortical regions or by mediating cross-talk between cognitive processes underlying attention, motivation, and memory, but these ideas have not been empirically tested. I hypothesized that frontal beta reflects the activation of neural ensembles in the DLPFC and ACC related to recent actions or action sequences, that bias the activity of other brain areas that are responsible for task execution in order to enhance task performance. Over trials, this process would result in the transfer of task performance from frontal brain areas to other neural systems that can execute behavior relatively automatically. This hypothesis is based partly on existing theoretical frameworks about the functions of DLPFC and ACC. I tested this hypothesis in a series of four experiments. First, I showed that, in line with my hypothesis, frontal beta oscillations do not code for a reward prediction error signal – an important signal in neural theories of reinforcement learning. Second, I showed that reward feedback stimuli compared to error feedback stimuli elicited greater beta power by the DLPFC. Third, I showed greater beta power elicited by feedback stimuli following a sequence of actions compared to just a single action, and that this contrast was associated with the ACC activity. Fourth, I found that frontal beta to reward feedback is reduced when actions preceding the error feedback are useful for desired task performance i.e., they carry task-related information and further, that higher post-feedback beta power was associated with faster recall of the stimuli associated with feedback irrespective of feedback valence. These findings indicate that frontal beta oscillations reflect a mechanism related to boosting the active representation of information related to actions or sequences of actions preceding the feedback irrespective of feedback valence. Further, they show that a general theory about the functional significance of frontal beta oscillations cannot be explained according to reinforcement learning paradigms, but rather point to a more common account that explains this neural signature through processes governed by the PFC and ACC.