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Abstract

The environment most brain systems of humans and other animals are almost constantly confronted with is complex and continuously changing, with each time step updating a potentially bewildering set of opportunities and demands for action. Far from the controlled, discrete trials used in most neuro- and psychological investigations, behavior outside the lab at Caltech is a seamless and continuous process of monitoring (and error correction) of ongoing action, and of evaluating persistence in the current activity with respect to opportunities to switch tasks as alternatives become available. Prior work on frontopolar and prefrontal task switching, use tasks within the same modality (View a stream of symbols on a screen and perform certain response mappings depending on task rules). However, in these 'task switches' the effector is constant: only the mapping of visual symbols to the specific button changes. In this task, the subjects are choosing what kinds of future action decisions they want to perform, where they can control either which body part will act, or which direction they will orient an instructed body action. An effector choice task presents a single target and the subject selects which effector to use to reach the target (eye or hand). While the techniques available for humans can be less spatially resolved compared to non-human primate neural data, they do allow for experimentation on multiple brain areas with relative ease. Thus, we address a broader network of areas involved in motor decisions. We aim to resolve a current dispute regarding the specific functional roles of brain areas that are often co-activated in studies of decision tasks, dorsal premotor cortex(PMd) and posterior parietal cortex(PPC). In one model, the PPC distinctly drives intentions for action selection, whereas PMd stimulation results in complex multi-joint movements without any awareness of, nor subjective feeling of, willing the elicited movement, thus seems to merely help execute the chosen action.

Tie to Mission:

This proposal supports national security missions by studying the fundamental science associated with the thought and decision process. The proposed study seeks to identify those areas of the brain directly responsible for changes in cortex during decision making for action in the absence of external reward. Successful experiments would enhance our ability to relate thought to action, which, in turn, would enable enhanced detection systems, aid the warfighter and be a step towards self-controlled prosthetics/robotics.

Previous Accomplishments:

In the past year, we have successfully implemented accurate eye tracking in the Siemens 3T TIM MRI environment using an ISCAN system that feeds realtime eye behavior to custom task programs written in Matlab. Each subject in the pilot study has undergone 4 MRI sessions: high resolution anatomy; a retinotopic mapping task to determine functional visual areas in the cortex of each subject; a topographic mapping task to determine functional motor action planning areas in parietal and prefrontal cortical areas; a novel choice task. In the novel choice task, we have demonstrated hemodynamic changes in frontopolar cortex during task-choice that is also sustained during blocks of action-choice compared to blocks where the action-choice type was instructed. That is, frontopolar cortex is crucial to deliberating task switching as well as maintenance of evaluating the outcome of task choice. \par

Work Proposed:

During the upcoming year we have the following specific aims:
1. Demonstrate further specificity of top-down (prefrontal to parietal) activation for effector choices as compared to a bottom-up (parietal to prefrontal) activation during spatial choices. Quantify the effective connectivity of brain regions of interest during different action choice conditions using dynamic causal modeling.
2. Use TMS and the Brainsight frameless stereotactic targeting system as well as the subject-specific regions of interest (ROIs) determined from their fMRI data to determine TMS target positions. Investigate the timing of the neural contribution of these ROIs to choice behavior and more importantly, probe the causality of the measured connectivity relationships.
3. Determine the feasibility of decoding these task and action choices from the fMRI data both offline and realtime (ie. during the decision making process, while the subject is in the MRI scanner).
4. Develop a computational model for of the kinds of processes these different neural regions are performing as indicated by the fMRI and TMS data.
5. Introduce external reward parameter into the task and measure corresponding changes in neural and behavioral data using fMRI and TMS.

Outcome:

This work is incomplete and finished. The PI changed advisors twice, was removed from the PhD Program and has not furthered her work. The project is terminated.

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