Common and Unique Neural Regions Activated During Simple Hand Movements: Implications for Understanding Plasticity After Peripheral Nerve Damage

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Introduction: Can different motor movements of the hand can be mapped onto specific regions of the brain? Rigorous fMRI studies of common and unique neural representations of multiple movements of the fingers, toes and other body parts are lacking (Sanes & Schiebert, 2001). This study takes the first step to investigate the common and unique neural representations of four different hand movements in the same individuals (grasp, index finger flexion and extension, finger spread and thumb raise).

Materials and Methods: Participants: 3 healthy, right, handed adult male subjects (age M=32.3, SD 4.7) were recruited from the surrounding community. None of them had any history of central or peripheral nerve damage. **Task:** The motor tasks included (a grasp task, index finger flexion and extension, finger spread and a thumb lateral raise). Participants wore MRI compatible sensor gloves designed for computer applications in virtual reality. Sensors along the fingers measure finger flexure and the orientation (pitch and roll) of the user's hand. The gloves gave feedback to allow the control of a small black dot that must rise to make contact with a larger dot. Trials were 2 seconds long. Each session had 75 trials with a variable delay. One session per hand movement was repeated for both the right and the left hand alone. All subjects underwent training prior to the scanning session. **fMRI parameters and data analysis:** A T1-weighted spoiled GRASS (SPGR) sequence (TI/TE/FA = 450 ms/3.0 ms/12°, FOV = 24 cm, number of slices = 180, slice thickness = 1.0 mm) obtained a high-resolution whole-brain volume. Standard T2*-weighted echo planar images (EPI) were acquired sagitally using the following parameters TR/TE/FA = 2000 ms/25 ms/77°, with axial slice size of FOV = 24.0 cm, matrix = 96 x 96, slice thickness = 2.5 mm. Images preprocessed and analyzed using SPM8. Images were time slice corrected, realigned and coregistered to each participant's anatomy. Task trial onsets were used as regressors in a go/no-go fashion. Individual participant's contrast images used a threshold of p=.001 with a cluster threshold of 50 voxels. The contrasts of interest were each task versus a passive baseline, a conjunction of all tasks, and each task regressing out the all the other tasks.

Results: The right grasp uniquely activated a small region of the left sensory cortex and regions in superior parietal cortex. Unique activation from the left grasp included regions of the premotor and motor cortex on the right side (Figure 1). Left index finger movement activated a small dorsal region of the sensory and motor cortex. Right index finger activated the left superior parietal cortex. Spreading the fingers of the left hand produced activations in the right supramarginal gyrus. Right handed spread activated left sensory, motor and superior parietal gyrus. It also activated a small right sided region of sensory and motor cortex. There were no reliable unique regions associated with the thumb movement. Conjunction analyses show that the four hand tasks with the right hand recruit common regions in the dorsal medial prefrontal cortex, left premotor, motor and superior parietal cortex (Figure 2). Additionally they also recruit a region of left premotor cortex and superior parietal cortex. The common regions activated by the four left hand tasks were right sided premotor, motor and superior parietal regions. On the ipsilateral side, there were activations in both the premotor cortex as well as the superior parietal cortex.

Conclusion and Discussion: This study shows that there are several key regions that are common to these tasks. However, there are also regions that are uniquely activated by them. Understanding how certain hand tasks that map onto unique neural regions will allow investigators to study neural plasticity following peripheral nerve damage and other disorders of the nervous system. It is hoped that this information will improve diagnosis and aid in refining treatment methods for these debilitating cases.

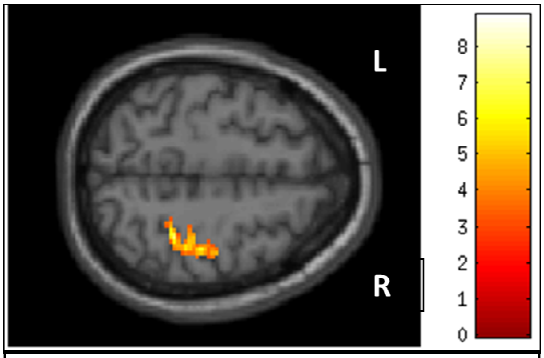

Figure 1. Left Grasp > All Others, p <.001, k=50

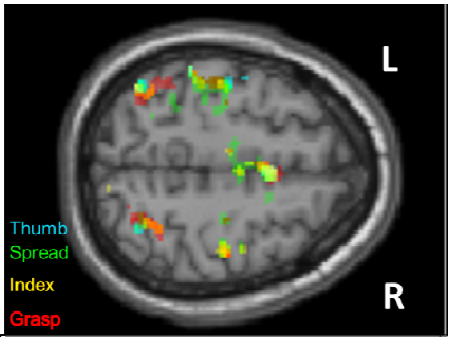

Figure 2. Common regions for right handed tasks p<.001, k=50.