Study of Motor Learning by Functional MRI

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Abstract. This work investigated regional effects of motor learning. Subjects practicd simple finger movement tasks for 4 weeks, and were studied using fMRI 3 times (at 0, 14, 28 days). Our results show that motor and sensory areas (SMA, M1 and S1) are involved with learning for the finger movement tasks. The temporal response pattern of these brain areas during learning is complex, with the size of all areas increasing initially and reducing to pre-training levels as skill is attained.

Introduction. Functional magnetic resonance imaging (fMRI) is an important neuroimaging tool in neuroscience. Functional MRI has been used in to study which subjects learn motor sequence by many researches, but the results are inconsistent. Some results show that training decreases activity in many brain areas. Other results show that training increases activity of some brain areas. Our study of long-term motor learning shows that activity of both motor and sensory areas (SMA, M1 and S1) is variable during training. The size of activations associated with these areas increases initially and then returns to normal as the movement task is learned.

Methods. Ten right-handed.healthy subjects, 18-45 years old, were scanned in this study. Each subject was asked to practice a specific finger sequence movement task[1] with their left hand for 4 weeks, and video recording validated practice. Each subject underwent a fMRI study at 0, 14 and 28 days after training. Subjects were asked to keep still and to do finger tapping as a block-design study during the scan. Functional MRI studies were acquired on a GE/Elscint 2T MRI scanner using a gradient echo echo-planar image (EPI) pulse sequence. Scan parameters are TR=2000ms, TE=45ms, flip angle =90 degree. The image parameters are: matrix size=128x72, FOV=3.2mmx2.9mm, slice thickness=6.0mm. Sixteen continuous slices and 240 multiple images were acquired. Functional MRI data were processed using in-house software. Matching convex features of the Talairach brain[3] spatially normalized all subjects' brain volumes. Intra- and inter- subject's movement correction were performed. A cluster analysis method was used to create the SPI image[2]. A threshold of t=2.5 was used to isolate significant areas which were overlaid onto an average anatomical MRI for the group.

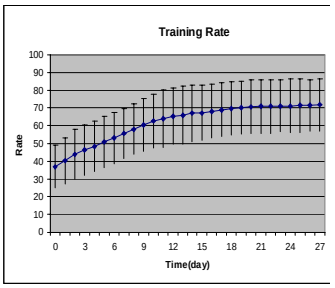
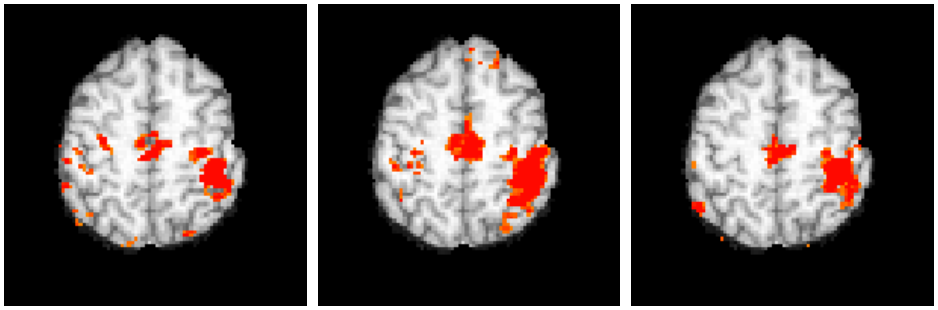


Figure 1. behavioral data

Results. The results of group analysis are presented. Figure 1 is the behavioral data. It shows that subject's skill improved rapidly at the beginning, and reached a plateau at about 20 days. Figure 2 is the significant activation maps from the three functional MRI scans. Figure 3 shows the volume of activated brain regions. The volume of activation for SMA, M1 and S1 is variable during the training. The activated volumes for SMA, M1 and S1 were significantly larger after 14 days of training. After 28 days training, the activity volume of SMA, M1 and S1 returned to the pre-training level. Activation of prefrontal cortex was also observed at the beginning of training, but it fell below significant levels with the training.



A. With 0 day training B. With 14 days training C. With 28 days training

Figure 2. Significant activation maps from function MRI Images

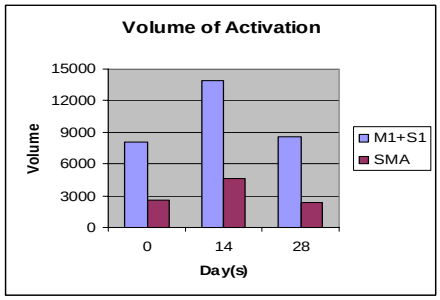


Figure 3. Volume of activation

Discussion. This study shows that while acquiring a motor skill through practice the activation pattern of task associated areas changes. Activated areas increased in volume after two weeks of training, when behavioral measures indicated a high rate of skill change. However, after four weeks training when behavioral measures indicated a plateau in skill level, and the activated volume of task associated brain areas returned to pre-practice levels. We expect that brain activation volume was initially large due to increased effort in attaining a new movement skill and that as the task was learned less brain effort and volume of activation was seen. Future studies will investigate the early stages of training with finer temporal sampling, as this is the time when behavioral measures indicate the greatest rate of change in skill.

References.

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