The Role of Middle Temporal and Medial Prefrontal Cortex in Representational Momentum: a fMRI Study

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Introduction Our mental representation of a visual object's location could be distorted by motion cues, and shifts a little forward to the implied motion direction. Such memory distortion has been referred to as representational momentum (RM) (1). Although RM effect plays an important role in bridging the gap between perception and action, the neural mechanism mediating this effect remains largely unclear (2). In one hand, some studies (3, 4) suggested that the motion perception area, the middle temple (MT) area, played a key role in mediating RM effects. On the other hand, our recent fMRI study (5) using the classical RM paradigm found that the comparison between RM and non-RM control tasks exhibited additional activation in the prefrontal cortex (PFC) but no additional activity in MT area, which suggested the more important role of high-level prefrontal area in mediating RM effect. In the present study, we used fMRI to further examine the role of MT and PFC areas in the RM and non-RM control tasks compared to a fixation baseline.

Methods Thirteen subjects (mean age 24.8 years, eight males) were scanned in a Siemens 3T Trio scanner when they performing the classical RM and non-RM (NRM) control tasks in addition to the fixation baseline. The RM task stimuli were consisted of three inducing rectangles at different orientations which implied a consistent rotation, followed by a probe at one of 5 orientations (-6, -3, 0, 3, 6 degrees) relative to the last inducing rectangle. In the NRM task (NRM), the order of the first two inducing rectangles was reversed so that no consistent direction of rotation was implied. In both tasks, subjects were asked to judge whether the probe rectangle's orientation was the same as or different from the orientation of the last inducing rectangle. Functional data was acquired using a single-shot, T2*-weighted EPI sequence (TR: 2s, TE: 30ms; FOV: $22\times22cm^2$, Matrix: 64×64, Flip angle: 60^o; 19 axial slices with a thickness of 4mm and an inter-slice gap of 1mm). Imaging data was analyzed by SPM5.

Results Behavioral data Consisted with previous studies (1, 5), behavior results revealed larger forward representational shift in RM condition than NRM control condition ($p = 0.03$, Fig2A). Compared to the fixation baseline, both RM and non-RM tasks induced significant activations in MT (both $p < 0.01$), but there were no difference between the RM and NRM tasks ($p > 0.6$, Fig2B). This finding suggests that MT is part of the neural network mediating the RM task but is not directly associated with the RM effect, which is reflected by the difference between RM and non-RM tasks. In contrast, RM task exhibited significant activation in the medial prefrontal cortex (MPFC) than NRM task (Fig.1), which replicated our previous results (5). By comparing RM and non-RM tasks to the fixation baseline, we found that this MPFC activation difference was due to significant more MPFC deactivation in the NRM task (Fig2B) ($p = 0.002$). In addition, in the RM condition, the amplitude of representation shift was negatively predicted by the activation level in MPFC ($r = -0.59$, $p = 0.03$, Fig2D), but not by the activation level in MT ($r = -0.37$, $p = 0.2$, Fig2C).

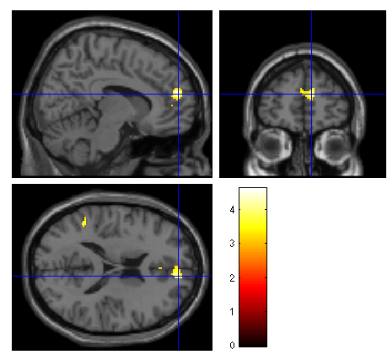

Fig1. MFC activation from RM vs. NRM.

Conclusions The present findings support the view that high-level prefrontal cortex rather than the low-level motion perception MT area plays the key role in mediating RM effect. Considering the important role of MPFC in inhibition control (6), the negative correlation between MPFC activity and amplitude of representational shift may suggest a role of "mental brake" of MPFC in mediating RM effect.

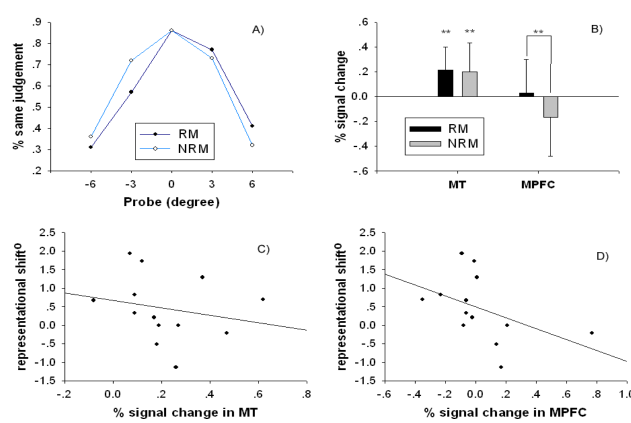

Fig2. Top: Behavioral data (A) and MT, MFC BOLD signal changes (B) in the RM and NRM tasks. Bottom: Activity in MPFC (D) but not MT (C) predicted the amplitude of representational shift in the RM task.

References

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