A comparison between gestures with real and imagined objects: an fMRI investigation

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Introduction

Patients with apraxia often fail to pantomime the use of objects on command despite that they can use real objects properly in a natural situation. To investigate the mechanism for this dissociation between pantomime and real object-use, we compared activation in object-use gestures with and without real objects in healthy volunteers. One reason for the dissociation may be that real objects constraint the range of possible movements, while pantomiming requires actors themselves to form or recall concepts of objects [1]. Previous fMRI studies of tool-use pantomimes (without real objects) confirmed a traditional view that the left parietal lobe is important for the concepts of object-use [2-3]. Thus we specifically compared activation in the parietal areas during the real object-use with the imagined object-use (pantomime).

Materials and Methods

Subjects were ten normal volunteers (male/female = 6/4, age 21-38, all right-handed, all gave written informed consent). All imaging was performed on a 3T MR scanner (GE Signa VH/i 3.0T). A gradient recalled echo spiral sequence [4] was used for the functional studies (TE/TR/FA = 30/5000/70, FOV 22 cm, 72*72 reconstructed into 128*128, 4 mm thick interleaved, 30 axial slices, 54 frames). Four on-off style block-designed fMRI series were conducted (30 sec per block, 9 blocks, total 4 min 30 sec). Four experiments were conducted in separate fMRI series; right-hand object-use gesturing with having a Real object (rt-R), that without a real object but an Image to have it (rt-I), left-hand object-use gesturing with a real object (lt-R), and that without a real object (lt-I). To minimize motion artifacts, a clustered volume acquisition technique (2 sec for image acquisition with 3 sec silence during the 5 sec TR) was applied as follows. Six non-magnetic daily used objects (e.g. spoon made of wood), which are ordinarily used with the right hand, were prepared. Names of the objects were displayed on a LCD display one by one at every 5 sec during the image acquisition time (2 sec) in the task blocks. In rt-R and lt-R, the indicated object was put just beside the subjects' hand during the 2 sec. Subjects then took it and gestured as if using the object during the 3-sec silent period. In rt-I and lt-I, subjects pantomimed the use of the object during the 3 sec. The Data were analyzed using SPM2 (http://www.fil.ion.ucl.ac.uk/spm/). A random effect model was applied for a group analysis ($p < 0.001$, uncorrected).

Results and Discussion

All experiments induced similar activation except for the left primary motor area (M1) for rt-R/rt-I and the right M1 for lt-R/lt-I (Fig. 1, upper row). Activation around the left intraparietal sulcus, specifically in the supramarginal gyrus (SMG), during all experiments (Fig. 1, lower row) strongly suggested that the previous fMRI for tool-use pantomimes without having real objects [2-3] fairly represented the actual tool-use performances. Activation around the intraparietal sulcus was specifically prominent during the rt-R condition (Fig. 1, lower row, leftmost). Statistical comparisons demonstrated more extensive activation in the right SMG during rt-R than rt-I, although this difference was not found between lt-R and lt-I (Fig. 1, yellow arrowhead). Somatosensory feedbacks by manipulating real objects might enhance BOLD signals but if so, the same enhancement would result in the lt-R condition. The right as well as the left SMG is often activated during motor tasks such as imitation of actions [5]. The bilateral SMG may play an important role in forming object-use concepts. Extensive activation in the right superior parietal lobule during both rt-R and lt-R (Fig. 1, white arrowhead) may be explained by the somatosensory feedbacks.

Conclusions

We can conclude that object-use gestures with real objects and those with imagined objects employed essentially the same brain areas including the left inferior parietal lobule. Familiar real objects manipulated by the preferred (right) hand might employ the bilateral supramarginal areas for supporting the proper formation of the object-use concepts.

References

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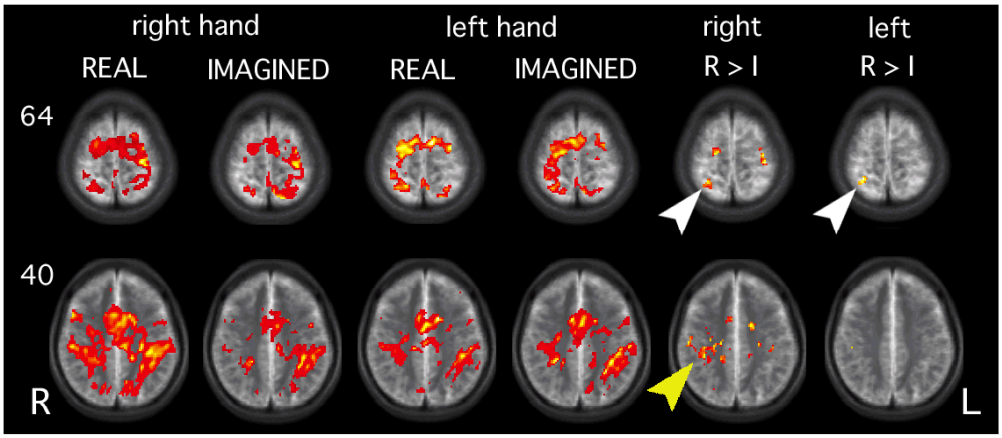

Fig. 1. Statistical parametric maps generated by a random effect model ($n = 10$, $p < 0.001$ uncorrected). The "64" and "40" indicate z-coordinates of Talairach brain atlas.