Functional imaging of observation of action in elite archers using video of Western-style archery task

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Introduction

The core functional role of the mirror neuron system, includes the premotor, inferior parietal lobule, and superior temporal sulcus, is generally assumed to understand others' acts by matching them to the own motor repertoire [1, 2]. Although the mirror neuron system including that of monkey has been extensively studied, no functional imaging data are currently available to gain insight in the possible difference of the mirror system between experts and novices. Therefore, the aim of the present study is to investigate the differences of activation in the mirror neuron system during viewing tool use familiar to experts between expert archers and novice subjects.

Subject and Methods

Subjects: We studied twenty expert archer group (20 females; mean age 28.9(SD:7.33) years; right handed) and twenty-one control subject group (21 females; mean age 26.8(SD:4.46) years; right handed). Archer group was defined as expert archers who play archery more than an average 14.2(SD:3.6) years and control group was defined as healthy participants who are not experienced in archery. After detailed explanation of the study design and potential risks, all subjects gave written informed consent.

Functional MRI: All subjects were imaged on a 3.0T clinical whole body magnet with 8ch head-coil(Excite HD; General Electric Medical, USA). Multi-slice BOLD images with T2*-weighted EPI sequence imaging was performed, the fMRI imaging parameters were as follows: 240 mm field of view, 64x64 matrix size, 31 axial slices, 4 mm slice thickness, repetition time=3000 ms, echo time = 40 ms.

Action observation paradigm: The video stimuli consisted of a posture of archer's shooting process and black screen for baseline trial. The 6 video clips of archery posture were used in this paradigm. Each video clip consisted of 9-s play time and task or control block was repeated for 18-s. The whole paradigm of action observation consisted with three-block with task and control trial (Fig1).

Data Analysis: Statistical parameter map software (SPM2, Wellcome Department of Cognitive Neurology, London, UK) was used to generate activation map. One-sample t-test for within group analysis was performed with each voxel-wise intensity threshold of $P<0.001$(FDR, corrected).

Two-sample t-test for between group analysis was performed with each voxel-wise intensity threshold of $P<0.05$ (FDR, corrected) and applied with random effect model.

Result and Discussion

The goal of this study was to examine the difference in neural correlates of the mirror neuron system involved in action observation of tool use between experts and inexpert control subjects using fMRI. To the best of our knowledge, this is the first study to investigate brain activation among expert archers during viewing videos of Western-style archery. We found that expert archers showed strong activation in the premotor, inferior parietal lobule, superior temporal sulcus while control subjects only showed activation in superior temporal sulcus (Fig. 2, 3, FDR corrected, $P<0.001$).

That is, our results demonstrated that expert archers showed strong activation in the mirror neuron system during viewing videos of Western-style archery relative to inexpert control subjects. One possible explanation for limited neural activations in control subjects is that since the observation of Western-style archery is not familiar scene to controls and thus the mirror neuron system is not fully engaged in control subjects. Between group analysis demonstrated that the major differences in neural correlates were premotor, dorsomedial prefrontal cortex, inferior parietal lobule, superior temporal sulcus, anterior cingulate cortex.(Fig. 4, FDR corrected, $P<0.05$). Taken together, our data consistent with previous reports suggest that human mirror neuron system could contain representations of tool use and expand motor repertoire with tool use experiences.

References

[1] Rizzolatti G, Luppino G, Matelli M. The organization of the cortical motor system: new concepts. Electroencephalogr Clin Neurophysiol. 1998;106(4):283-296.

[2] Iacoboni M, Dapretto M. The mirror neuron system and the consequences of its dysfunction. Nat Rev Neurosci. 2006 Dec;7(12):942-51

Result data

Fig. 1. The sample video clip capture of archer's shooting posture.

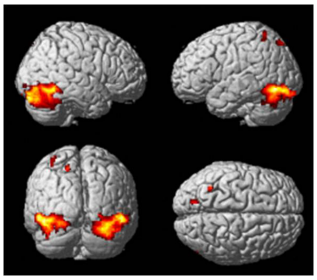

Fig. 2. Brain activation maps for observation of action task in control subject group brain activation.

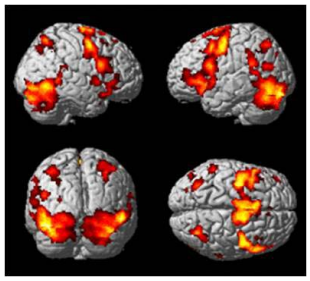

Fig. 3 Brain activation maps for observation of action task in archer group brain activation.

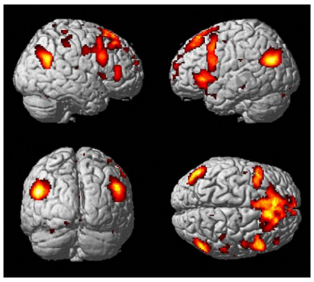

Fig. 4. Two sample t-test map between control subject and expert archer group brain activation.