The Neural correlates of Biomechanical Constraints In Hand Laterality
Judgment Task Performed from Other Person’s Perspective:

A Near-Infrared Spectroscopy Study

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key words : Hand laterality judgment task, Biomechanical constraints, Other person’s perspective

Introduction

In the present study, we measured activation of prefrontal cortex (PFC) to investigate whether the HLJ (hand laterality judgment) task performed from a first-person perspective (1PP) as well as a third-person perspective (3PP) shows the biomechanical constraint (BC) effect. We hypothesized that there should be a hand and orientation interaction in the 1PP condition (Sekiyama, 1982), i.e., the brain activation for the left hand in the 1PP condition increases from 90° to 270°, while the brain activation for the right hand increases from 270° to 90°. Namely, we hypothesized the brain activation for 3PP condition should be reversed with 1PP condition.

Methods

Participants: One hundred right-handers were assigned to either 1PP (N = 63) or 3PP group (N = 37).

Materials: We used two tasks: a HLJ task and a character rotation task. In the HLJ task, two types of hand drawings (i.e., the back of the left or right hand with all five fingers raised) were presented in one of three different orientations (0°, 90°, and 270°). In the character rotation task, two capital characters (i.e., G and P) were displayed in the normal or the mirror-reversed form in the same three orientations. At last, six images for the HLJ task and 12 images for the character rotation task were created, respectively. Each participant performed a total of 96 trials (HLJ task: 48 trials; Character task: 48 trials) during the experiment.

Procedure: Each trial consisted of a fixation period (800 ms) displaying a black cross on a white monitor, followed by a hand or character stimulus. The stimulus was presented until participants pressed a response key. The response was given with their feet: they pressed the “left” pedal with the left foot for the “left” hand or normal character, and pressed the “right” pedal with the right foot for the “right” hand or mirror character. The inter trial interval (ITI) was 2 s. Participants judged whether a rotated hand picture was their own or the other’s (1PP vs. 3PP groups) left or right hand, respectively.

Data analysis: Using their error rates in the HLJ task, the two groups were subdivided into Error sub-Group (EG) and No Error sub-Groups (NEG) (Beste et al., 2010). In the 1PP group, twenty-two participants (error rate: 3.50%) were divided into the EG and forty-one participants (error rate: 0) were divided into the NEG; and in the 3PP group, eleven participants (error rate: 4.36%) were divided into the EG and twenty-six participants (error rate: 0) were divided into the NEG.

NIRS data acquisition: A 2-channel NIRS unit (Pocket NIRS, Dyna Sense Inc., Japan) was used to measure PFC activity.

Results

In the HLJ task, the bilateral PFC showed a main effect of Hand (Left PFC: F(1,21) = 7.94, p < 0.05; Right PFC: F(1,21) = 8.32, p < 0.05) in the EG in the 1PP condition. However, none of the interactions were significant. In the 3PP condition, none of the main effects were significant in either the EG or the NEG. But the activity of the left PFC showed a significant BC effect (Hand × Orientation interaction: F(1,10) = 6.59, p < 0.05) in the EG. The activity of the right PFC of the EG did not significantly change as a function of BC.

In the character task, there were no significant main effects or interactions in bilateral PFC. Furthermore, in the EG of HLJ task, the activations of left PFC in the 1PP and 3PP conditions were reversed, (Orientation × Group: F(1,31) = 6.03, p < 0.05), when a left hand picture was presented (Figure 1).

Discussion

The NIRS profile of EG in 3PP group showed a significant interaction of Hand × Orientation in their left PFC. Specifically, the left PFC activation of two EGs between 3PP and 1PP groups showed a significant interaction for the presented left hand in the HLJ task indicating that BC interferes with the HLJ performed from the 3PP as well as the 1PP.

Figure 1. Mean Coxy-Hb changes of PFC the left hand of EG

References
