Prior disturbance increases activation  
in the right inferior frontal gyrus (IFG) during competition

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Introduction

Interpersonal interaction is defined as an individual’s “simultaneous  
or sequential actions that affect the immediate and future outcomes of  
the other individuals involved in the situation” (Johnson and Johnson,  
2005). Studies of interpersonal interaction are classified into concurrent  
interaction and turn-based interaction. Ample studies have examined  
neural mechanisms of bodily synchrony underlying concurrent  
interaction such as finger-movement imitation, and demonstrated that  
the right frontal cortices are critical for concurrent cooperation (not  
for concurrent competition). However, bodily synchrony is not necessary  
for turn-based actions. Instead, mental synchrony between two persons  
is required to understand the partner’s intention in turn-based  
interactions such as predicting tactical move at chess.

Previous studies have revealed that understanding other person’s  
actions and intentions relies on prior experience to hold representations  
of one’s own experience and that of others. The right inferior frontal  
gyrus (IFG) is involved in understanding of others’ intention and  
empathy with others’ emotion. The present study aimed to examine  
how prior experience of role-playing affects an individual’s right IFG  
activation during turn-based cooperation and competition.

Method

Participants Twenty students (16 males, 4 females, age: 19.2 ± 1.2  
years) in Nagoya University participated for course credit.

Materials and task We used a computerized turn-taking game as in  
Decety et al. (2004). Pairs of participants were assigned to either one of  
two roles in the game: a Builder taking the initial move to copy a  
disk-pattern on a monitor and a Partner taking the second move to aid  
the Builder in his/her goal in a cooperative game or to obstruct it in a  
competitive game.

The experiment consisted of two sessions. Each session was  
composed of eight cooperative and eight competitive games. One  
participant played the game as a Builder (B) in the session 1 and  
changed the role to the Partner (P) in the session 2, i.e., one player was  
B-P and the other player was P-B vice versa.

Apparatus A multichannel NIRS unit (FOIRE-3000/16; Shimadzu,  
Japan) was used to simultaneously measure the Builder-Partner pairs’  
concentration changes of oxy-Hb (Coxy-Hb) in the bilateral IFG.

Data analysis A linear baseline correction was conducted using the  
mean value of Coxy-Hb during the 2 s before each task. The z-scores  
were then calculated using the mean value and the standard deviation  
during the baseline period.

Results and discussion

We conducted a two-way ANOVA [Role (B-P vs. P-B) × Session (1 vs.  
2)] in the cooperation and the competition condition, respectively. Figure 1  
shows the mean Coxy-Hb of each participant group in the two conditions.

In the cooperation condition, both the left and the right IFG showed no  
significant main effects of Role and Session, and no significant interactions.

In the competition condition, there were no significant main effects of  
Role and Session, but significant interactions [F(1,13) = 4.70, p < 0.05, ηp²  
= 0.27; F(1,13) = 6.11, p < 0.05, ηp² = 0.32] in the bilateral IFG. The  
post-hoc analyses (Bonferroni’ procedure) revealed that in the left IFG  
there was no significant difference between two roles (i.e., Builder vs.  
Disturber) of the same player in the session 1 and the session 2. The  
Disturber shows significantly higher activation than the Builder in the  
session 1 [F(1,13) = 7.66, p < 0.05, ηp² = 0.37], but not in the session 2.

Importantly, in the right IFG, B-P showed significantly higher activation  
when (s)he played as the role of Disturber in the session 2 than when (s)he  
played as the role of Builder in the session 1 [F(1,8) = 5.53, p < 0.05, ηp²  
= 0.41], but P-B did not. There was no significant difference between  
the Builder and the Disturber in both the sessions 1 and 2.

These results suggest that prior experience of being disturbed allows one  
to disturb others more skillfully. That is, B-P had the experience of being  
disturbed while attempting to build. Thus, B-P could draw from that  
experience to more tactically disturb in the subsequent competition with  
P-B. The better understanding of the Builder’s position increased the right  
IFG activation of B-P when (s)he was meant to disturb in the session 2.

Fig. 1. Mean Coxy-Hb of each participant group in the cooperation and  
competition conditions. Error bars represent standard deviation. Numbers  
in the parentheses indicate the number of the Builder and the Partner  
(Cooperator or Disturber) in the corresponding session, respectively. *  
indicates p < 0.05.