Functional Deficits in the Extrastriate Body Area During Observation of Sports-Related Actions in Schizophrenia

Hidehiko Takahashi1–3, Motoichiro Kato4, Takeshi Sassa5, Tomohisa Shibuya5,6, Michihiko Koeda7, Noriaki Yahata8, Masato Matsuura3, Kunihiko Asai5, Tetsuya Suhara2, and Yoshiro Okubo7

2Department of Molecular Neuroimaging, Molecular Imaging Center, National Institute of Radiological Sciences, 9-1, 4-chome, Anagawa, Inage-ku, Chiba 263-8555, Japan; 3Department of Life Sciences and Bio-informatics, Graduate School of Health Sciences, Tokyo Medical and Dental University, 1-5-45 Yushima Bunkyo-ku, Tokyo 113-8549, Japan; 4Department of Neuropsychiatry, Keio University School of Medicine, 35 Shinanomachi, Shinjuku-ku, Tokyo 160-8582, Japan; 5Department of Psychiatry, Asai Hospital, 38-1 Katoku Togane 283-8650, Japan; 6Department of Human Sciences, Toyo Gakuen University, 1-26-3, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan; 7Department of Neuropsychiatry and 8Department of Pharmacology, Nippon Medical School, 1-1-5, Sendagi, Bunkyo-ku, Tokyo 113-8603, Japan

Exercise and sports are increasingly being implemented in the management of schizophrenia. The process of action perception is as important as that of motor execution for learning and acquiring new skills. Recent studies have suggested that body-selective extrastriate body area (EBA) in the posterior temporal-occipital cortex is involved not only in static visual perception of body parts but also in the planning, imagination, and execution of actions. However, functional abnormality of the EBA in schizophrenia has yet to be investigated. Using functional magnetic resonance imaging (fMRI) with a task designed to activate the EBA by sports-related actions, we aimed to elucidate functional abnormality of the EBA during observation of sports-related actions in patients with schizophrenia. Twelve schizophrenia patients and 12 age-sex–matched control participants participated in the study. Using sports-related motions as visual stimuli, we examined brain activations during observation of context-congruent actions relative to context-incongruent actions by fMRI. Compared with controls, the patients with schizophrenia demonstrated diminished activation in the EBA during observation of sports-related context-congruent actions. Furthermore, the EBA activation in patients was negatively correlated with the severity of negative and general psychopathology symptoms measured by the Positive and Negative Syndrome Scale. Dysfunction of the EBA might reflect a difficulty in representing dynamic aspects of human actions and possibly lead to impairments of simulation, learning, and execution of actions in schizophrenia.

Key words: body/extrastriate body area/schizophrenia/sports/exercise/fMRI

Introduction

With the introduction of atypical antipsychotics, awareness of these comorbid metabolic disturbances in schizophrenia has become considerably increased among many health care professionals and patients.1 For the management of comorbid metabolic disturbances, exercise is one of the most acknowledged interventions.2 At the same time, exercise and sports have been recognized as having a positive impact on the treatment and rehabilitation of schizophrenia.3 However, individuals living with schizophrenia are less physically active than the general population.4,5 Moreover, they generally show psychomotor poverty and clumsiness6 and have an impairment of motor skill learning,7,8 which have been suggested to be linked to a dysfunctional motor execution system including the striatum-frontal-cerebellum.9,10

It is widely documented in psychological and neurocognitive studies that the systems that mediate action perception, imitation, planning, and execution overlap and interact with each other.11,12 These studies have supported the view that when we observe others’ actions, observed action is automatically simulated and matched with internal motor representation and could even be imitated unconsciously (Chameleon effect).12,13 These externally triggered motor representations are then used to understand, learn, and reproduce the observed behavior.14 Therefore, for learning and acquiring new skills, the process of action perception is as important as that of motor execution.

Passive viewing of biological motions has been known to activate the superior temporal sulcus (STS),15 and the STS has been suggested to have a more extended function in social cognition such as detecting intention of
Others. Kim et al. reported that schizophrenia patients were impaired in the perception of biological motion, and they predicted that impaired biological motion processing arises from functional deficit in the STS. Although the STS is a central node of processing biological motion, passive viewing of biological motion has consistently activated the posterior temporal-occipital cortex including the body-selective extrastriate body area (EBA) in close proximity to the STS. Originally, the EBA was identified as an area that responds selectively to static human bodies and body parts. In biological motion tasks, low-level visual stimuli such as random moving dots have been used as control task, which make it difficult to clarify whether the EBA is only involved in body-sensitive early visual processing or is participant as a part of a system for inferring the action and intention of others like the STS. However, recent studies have suggested an extended role for the EBA, involving not only static visual perception of body parts but also the planning, imagination, and execution of actions.

In addition, we have shown that sports-related context-congruent actions produced greater activation in the EBA, along with the STS, than context-incongruent actions. Compared with frontal or limbic areas, the posterior temporal-occipital or temporal-parietal cortex has received relatively little attention in the field of schizophrenia research, and functional abnormality of the EBA in schizophrenia has yet to be investigated. We hypothesized that patients with schizophrenia would show diminished activation in the EBA, along with the STS, in response to sports-related context-congruent actions.

**Methods**

**Participants** Twelve patients with schizophrenia (6 men and 6 women, mean age: 31.8 ± 7.2 [SD] years) were studied. Diagnoses were based on the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Axis I Disorders. All patients were attending the day hospital unit of Asai Hospital. Exclusion criteria were current or past substance abuse and a history of alcohol-related problems, mood disorder, or organic brain disease. The mean illness duration was 9.8 ± 6.9 years. All patients received antipsychotics (mean chlorpromazine equivalent daily dosage = 641.6 ± 471.2 mg). Clinical symptoms were assessed by the Positive and Negative Syndrome Scale (PANSS) for schizophrenia. Mean total scores of PANSS and subscale (positive scale, negative scale, and general psychopathology scale) were 69.8 ± 13.6, 14.3 ± 4.0, 19.7 ± 4.7, and 35.8 ± 6.4, respectively. The ratings were reviewed by trained senior psychiatrists, H.T. and T.S., after the patient interviews, and disagreements were resolved by consensus; consensus ratings were used in this study. Twelve age-sex–matched normal controls (6 men and 6 women, mean age 29.4 ± 4.5 years) were recruited from the surrounding community. The candidates were carefully screened, and standardized interviews were conducted by H.T. and T.S.. They did not meet criteria for any psychiatric disorders. None of the controls were taking alcohol or medication at the time, nor did they have a history of psychiatric disorder, significant physical illness, neurological disorder, or alcohol or drug dependence. All subjects were right-handed, and they all underwent a magnetic resonance imaging (MRI) to rule out cerebral anatomic abnormalities. All subjects had achieved an educational level of high school or higher. All of them had the experience of playing basketball in elementary school or junior high school, but they had little opportunity, if any, to play basketball thereafter. After complete explanation of the study, written informed consent was obtained from all participants, and the study was approved by the Ethics Committee of Asai Hospital.

**Materials**

We employed the same visual stimuli as in the previous report where healthy volunteers were studied. The stimuli were designed to activate the EBA by sports-related actions. Two types of video clips were provided (basketball-related motions [BRM] and basketball-unrelated motions [BUM]). Examples of the video clips are shown in figure 1. BRM consisted of 3 types of scenes (player shooting a free throw, player dribbling, 2 players performing man-to-man defense/defense). BUM also consisted of 3 types of scenes (player rolling a basketball, player carrying a basketball, and one person crossing in front of another without interaction). In order to make BRM and BUM as similar as possible, all players in the video clips performed in front of a basket hoop on a basketball court, and the number of persons, objects, motion direction, and speed were matched, ie, rolling a basketball, carrying a basketball, and crossing in front of another without interaction corresponded to shooting a free throw, dribbling, and man-to-man defense.
respectively. The video clips were projected via computer onto a screen mounted on a head coil. The subjects were instructed to pay attention to the video clips and to press a selection button with the right index finger when they watched the free throw scene and the basketball-rolling scene, indicating that they had paid attention to them. The experimental design consisted of 5 blocks for each of the 2 conditions (BRM and BUM) interleaved with 20-second rest periods. During the rest condition, participants viewed a crosshair pattern projected to the center of the screen. In the BRM and BUM 24-second blocks, 3 scenes were presented twice for 4 seconds each.

Image Acquisition

Images were acquired with a 1.5-T Signa system (General Electric, Milwaukee, WI). Functional images of 115 volumes were acquired with T2*-weighted gradient echo planar imaging sequences sensitive to blood oxygenation level–dependent contrast. Each volume consisted of 40 transaxial contiguous slices with a slice thickness of 3 mm to cover almost the whole brain (flip angle, 90°; echo time (TE), 50 ms; repetition time (TR), 4 sec; matrix, 64 × 64; field of view, 24 × 24 cm). High-resolution, T1-weighted anatomic images were acquired for anatomic comparison (124 contiguous axial slices; 3D Spoiled-Grass sequence; slice thickness, 1.5 mm; TE, 9 ms; TR, 22 ms; flip angle, 30°; matrix, 256 × 192; field of view, 25 × 25 cm).

Analysis of Functional Imaging Data

Data analysis was performed with SPM02 (Wellcome Department of Cognitive Neurology, London, UK). All volumes were realigned to the first volume of each session to correct for subject motion and were spatially normalized to the Montreal Neurological Institute template. Functional images were spatially smoothed with a 3D isotropic Gaussian kernel (full width at half maximum of 8 mm). Significant hemodynamic changes for each condition were examined using the general linear model with boxcar functions convolved with a hemodynamic response function. Statistical parametric maps for each contrast of the t statistic were calculated on a voxel-by-voxel basis.

To examine possible group differences in response to BUM (baseline), we conducted a 2-sample t test of BUM contrast. To assess the specific condition effect, we used the contrasts of BRM minus BUM. A random-effects model was implemented for group analysis. A 1-sample t test was applied to determine group activation for the contrasts of BRM minus BUM. Between-group comparison of BRM minus BUM contrast was performed with a 2-sample t test. We used SPM’s small volume correction to correct for multiple testing in regions about which we had a priori hypotheses. These a priori volumes of interest (VOIs) included the EBA (inferior temporal cortex) and STS (superior temporal cortex). VOIs were defined by standardized VOI templates implemented in brain atlas software. Significant differences surviving this correction at $P < .05$ were determined as were activations outside regions of interest surviving a threshold of $P < .001$, uncorrected, with an extent threshold of 10 contiguous voxels.

We conducted regression analyses to demonstrate a link between regional brain activities with the patients’ demographics. Using the demographic data (age, duration of illness, chlorpromazine equivalent daily dosage, and PANSS scores) for each subject as covariates, regression analyses with the BRM minus BUM contrasts and the covariates were performed at the second level. The same threshold as used in the between-group comparison was applied. To confine the regions where significant group differences were observed, we created masks of group differences of the BRM minus BUM contrast from the 2-sample t test (threshold at $P < .05$, uncorrected), and these masks were applied inclusively. Using the effect sizes, representing the percent signal changes, of the BRM minus BUM contrasts at the peak coordinates uncovered in the regression analyses, we plotted the functional MRI (fMRI) signal changes and PANSS scores.

Results

Behavioral Data

All patients and controls paid attention to the video clips and pressed the button appropriately (accuracy was virtually 100%).

fMRI Results

In the control group, BRM minus BUM condition produced activations in the bilateral posterior temporal-occipital cortex including the bilateral EBA ($x = 58, y = -60, z = 2$; $t = 4.86$), middle temporal ($x = 54, y = -66, z = -12; t = 8.38$), right STS ($x = 56, y = -22, z = -2; t = 6.58$), bilateral premotor cortex ($x = -48, y = -4, z = 40; t = 4.94$), and bilateral inferior parietal lobules ($x = -34, y = -50, z = 54; t = 7.25$) (coordinates and $t$ score refer to the peak of each brain region). In the patient group, BRM minus BUM condition produced activations in the left lingual gyrus ($x = -6, y = 92, z = 0; t = 6.52$), right prefrontal cortex ($x = 36, y = 52, z = 14; t = 5.66$), and right premotor cortex ($x = 36, y = -2, z = 54; t = 4.52$).

A 2-sample $t$ test revealed no significant differences (threshold at $P < .001$, uncorrected) in the activations by BUM between controls and patients. Group comparison of the BRM minus BUM contrast showed that patients demonstrated significantly less activation in the bilateral EBA, bilateral parahippocampal gyrus, right STS, right temporal pole, right lingual gyrus, and globus pallidus (table 1 and figure 2). The activations in a priori regions (EBA and STS) survived a threshold of $P < .05$.
corrected for multiple comparisons across a small VOI. No significantly greater activation was identified in patients in the group comparison of the BRM minus BUM contrast.

Regression analysis revealed negative linear correlations between the negative scale score of PANSS and the degree of activation in the left EBA ($x = -58$, $y = -58$, $z = -6$; $t = 7.01$) in BRM minus BUM contrast (figure 3). Scores of the general psychopathology scale were also negatively correlated with the degree of activation in the left EBA ($x = -58$, $y = -56$, $z = -6$; $t = 5.81$) (figure 3). These correlations in a priori regions (EBA) survived a threshold of $P < .05$ corrected for multiple comparisons across a small volume of interest. There was no correlation between the positive scale score and regional brain activation. Regression analysis revealed that none of age, duration of illness, or chlorpromazine equivalent daily dosage had a relation with regional brain activation.

### Discussion

This study demonstrated that patients with schizophrenia showed diminished brain activations during observation of context-congruent actions in the EBA, along with the STS. The coordinates of the EBA were in good agreement with the previous literature (reviewed in Arzy et al.

The STS is located at a convergence zone for multimodal signals including limbic information, and it has been suggested to be involved not only in the perception of biological motion but also in a more extended function of social cognition such as understating others’ intention. Dysfunctional STS might contribute to a difficulty in understanding intentional actions and behavior of agents in schizophrenia.

The novel finding in this study was that the patients showed diminished EBA activation in response to context-congruent actions despite the fact that the patients comprehended explicit information of body movement (and basketball rules) similar to controls. This implies that the patients might not have processed implicit information carried by body movements as much as controls, but it is very difficult to quantify such implicit information and complex EBA function in a limited MRI environment and in a limited time period. Interestingly, PANSS score, instead of performance during fMRI scans, was directly linked to EBA activation in patients. That is, the less EBA activation was, the more severe the symptoms (negative and general psychopathology) in the patients were. The EBA was first identified as an area that responds selectively to static human bodies. Recent
studies have suggested that the EBA is also directly involved in representing the dynamic aspects of human motions as part of a system for inferring the intention of others.32 Jackson et al22 reported that, compared with observation of actions, EBA activation was enhanced during imitation. Furthermore, the motivation to act has been shown to modulate EBA activity.33 These studies proposed an extended role for the EBA, involving the planning, execution, and imagination of actions. Our previous report that using the current task in healthy volunteers was in favor of this view,23 suggesting that the EBA might contribute to the understanding of actions and intention of others through the mechanism of observed action being automatically represented and simulated.14,32

Empirical studies have shown that schizophrenia patients have difficulty in representing motor actions internally.34,35 The diminished EBA activation in patients suggests that internal representation of the dynamic aspects of human motions is impaired. Motor representation is associated with understanding and rehearsing observed behavior.14 In fact, recent studies demonstrated that motor representation is highly involved in skill learning and motor rehabilitation.36,37 Consequently, the deficit in the EBA in schizophrenia could lead to difficulties in learning and reproducing new skills in addition to impairment in understanding others’ actions.

The present study has several limitations. First, we examined only patients with chronic schizophrenia with long-term antipsychotic medication because our primary interest was the possible role of sports participation/observation in the management of chronic schizophrenia and comorbid metabolic disturbances partly due to antipsychotic medication. Medication possibly affects neural activation, but regression analysis revealed that chlorpromazine equivalent daily dosage has no relation with regional brain activation, and expression of dopamine D2 receptors in the posterior temporal-occipital cortex is extremely low.38 Second, our task was not a behaviorally/cognitively demanding task leading to lack of dispersion in behavioral data (100% accuracy for both control and patient groups). Using a behaviorally/cognitively demanding task would require us to include only patients with psychiatric symptoms and cognitive impairments mild enough to undergo the imaging procedure and comply with the demanding task. However, the target patients of rehabilitation and management of comorbid metabolic disturbances in a day hospital have considerable behavioral and cognitive disturbances, which make it difficult to obtain reliable self-reported data of complex and subtle functions. Therefore, we employed the current task, aiming to examine patients with chronic schizophrenia in a real-world setting. From these limitations, it must be emphasized that any generalization of our findings to patients with first episode or nondeficit patients needs to be approached with caution.

In conclusion, chronic schizophrenia patients demonstrated diminished activation in the EBA in response to sports-related actions. Dysfunction of the EBA might reflect impairment of representation of dynamic aspects of human actions and might lead to impairments in simulation, learning, and execution of actions in schizophrenia. Furthermore, these impairments might lead to difficulty in understanding others’ actions, interpersonal communication, body awareness, and overall physical activity manifested as negative symptoms and general psychopathology symptoms. The results of this study seem to have some important clinical implications for the management of chronic schizophrenia and merit further investigation in terms of the role of sports participation/observation in the rehabilitation for chronic schizophrenia and their effects on EBA function.

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