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Ability of Procedural Learning and Gestalt Cognition in Patients with Schizophrenia Assessed by Push-Button Task and Tree-Drawing Test

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We assessed the ability of procedural learning and gestalt cognition in patients with schizophrenia by push-button task and tree-drawing test, respectively. The study subjects were 30 patients with schizophrenia and 35 healthy individuals. The patients fulfilled the diagnostic criteria specified in the International Classification of Diseases, Tenth Revision and healthy individuals were all employees of private psychiatric institutions. We used a scale for measuring work ability and classified the patients into two groups of the same size on the basis of the measurements, and called them high-autonomy group and low-autonomy group. In the push-button task, we used an apparatus with 18 buttons whose lighting was controlled by computer, and the lighting order was determined to make the path of lighting form two types of gestalt. Complete push of 18 buttons defined a trial, and we assessed the ability of procedural learning by reduction in reaction time with trial. In the tree-drawing test, we classified the drawing into 3 types, i.e., positive, negative and normal, on the basis of the gestalt of the tree drawn. In each of the two types of gestalt and their combination, the reaction time at respective trials significantly (p<0.0001) decreased in the order of low-autonomy group, high-autonomy group and healthy group, and the reaction time in the respective 3 groups significantly (p<0.0001) decreased with repetition of trials. However, no significant difference was observed among 3 groups in the degree of decrease with trial (p>0.14). The frequency of positive drawing was highest in low-autonomy group and monotonically decreased in high-autonomy group and healthy group, while the reverse order held in the frequency of normal drawing, and the frequency of negative drawing was highest in high-autonomy group. The correlation between the group and the tree-drawing type was significant (p<0.0001). The present study suggests the usefulness of push-button task and tree-drawing test for assessing recovery process in schizophrenia.

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Introduction

Improvement of cognitive function, including learning ability and representation function, is the key to enabling patients with schizophrenia to live independently. It is suggested that poor cognitive function in patients with schizophrenia is responsible for impairment in living including daily activities, personal relations and work.[1,2]

In respect of work, impaired cognitive function manifests as impairment in executing work which necessitates assistance in the planning and executing procedures. It is known that, in the psychiatric clinical setting, patients with schizophrenia frequently exhibit behavior characterized by delayed accomplishment of task due to being unable to understand the whole of the task and to prepare for execution.[3] However, there are reports suggesting that impairment in execution of work is not always observed in patients with schizophrenia and that learning is maintained in such patients.[4,5] This indicates the necessity to assess the ability of patients with schizophrenia to process information related to learning from the viewpoint of work execution.

In respect of representation function, our study using the tree-drawing test,[6,7] which is easy to administer and burdens the examinee little, suggested responsibility of impairment at the physiological level for impairment in gestalt composition in patients with schizophrenia.[8] Utena and his colleagues, measuring the representation function of patients with schizophrenia by tree-drawing test, suggested impairment in cognitive function related with both collapsed gestalt

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and symptoms such as hallucination and delusion.[9-12]

The above-mentioned recent reports indicate the necessity to investigate, in patients with schizophrenia, the relationship between acquisition of learning in work execution and representation which reflects regularity based on procedure. We therefore assessed the ability of procedural learning and gestalt cognition in patients with schizophrenia using push-button task and tree-drawing test.

Subjects and Methods

Subjects

Study subjects were 30 patients with schizophrenia and 35 healthy individuals. The patients with schizophrenia were residents of private psychiatric institutions who fulfilled the diagnostic criteria specified in the International Classification of Diseases, Tenth Revision (ICD-10).[13] All of the patients in the present study participated in rehabilitation programs prescribed by their primary physician. These included skill-acquisition activities for training the patient in areas such as routine activities, including cooking and shopping; social skills; gardening and sports activities for stress reduction and mental and physical discipline; recreation involving activities such music and games; art activities such as creative writing and handicrafts; and group psychotherapy. The healthy individuals were employees of private psychiatric institutions.

The objectives and methods of the study were explained in writing to all subjects, and informed consent was obtained from each subject.

Definition of groups based on work ability

The work ability of the patient group was evaluated using a subscale of the Life Assessment Scale for the Mentally Ill (LASMI) developed by Iwasaki et al.[14] The subscale consists of 10 items for evaluating subject's ability to execute work or to solve problem, and each item is scored 0, 1, 2, 3 or 4 according to subject's behavior observed in the last one month; the lower score indicates the higher ability for the item. We classified the patients into two groups of equal size by the median of the total scores assessed for 10 items and called them low-autonomy and high-autonomy groups.

Measurement apparatus, study design and procedures

The push-button task set for the subjects in the present study was designed based on the serial reaction time task developed by Nissen et al.,[15] and we used the Board Trainer USN GH-845 (OG Giken, Co. Ltd., Okayama, Japan) which measured 750 mm×1260 mm×21 mm. The apparatus was set upright above the floor and its position was adjusted according to the height of the examinee. The stimulus consisted of 18 cylindrical buttons (25 mm in diameter and 10 mm in height), which were arranged in a grid configuration as shown in Figure 1 A. Lighting of each button was controlled by computer, and 18 buttons were lighted one by one according to the order of numerals indicated in Figure 1 A. The button once lighted remained and was turned off when pressed, and the next button was lighted immediately. The time taken in pushing the lighted button was recorded in 100 msec by computer for each button. Complete push of 18 lighted buttons defines a trial, and the examinee repeated the trial 10 times with a rest of about one minute between the 5th and 6th trials. The lighting order shown in Figure 1 A was determined to make the path of lighting in the push-button task form two gestalts similar to those of the Corsi Block Tapping Test used by Kemps.[16] As shown in Figure 1 B, the lighting order of the first 8 buttons was determined, except for the second one, to light the button most distal from the currently lighted button. The gestalt corresponding to this order was symmetrical. Another gestalt corresponding to the lighting order of the remaining 10 buttons depicted a spiral path (Figure 1 C).

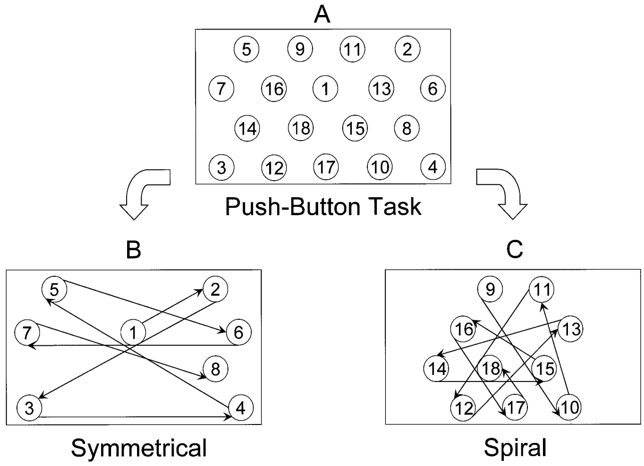

Figure 1. A. Configuration of 18 buttons on the board trainer used in the push-button task and their order of lighting. **B.** The gestalt corresponding to the lighting order of the first 8 buttons (called symmetrical). **C.** The gestalt corresponding to the lighting order of the last 10 buttons (called spiral).

After the tester first demonstrated the push-button task explaining the procedure, the subjects practiced repeatedly until they understand the procedure; the subjects, however, were not informed of anything about the lighting order. The subjects were instructed to find and press the lighted button as quickly as possible, and then started the push-button task using only the dominant hand.

After all subjects finished the push-button task, the tester asked each of them for the impression of the push-button task. Subjects who became aware of the lighting order were asked to verbally describe it.

Gestalt assessment in the tree-drawing test

In the tree-drawing test, subjects were instructed to carefully draw a fruit-bearing tree.[17] The tree-drawing types described by Utena et al.[11] (Figure 2) were used as the criteria for assessing the gestalt of the tree drawn by each subject. The assessment criteria were as follows:

A. Positive drawing: The outline of the tree was poorly defined, with an open trunk and branches, and collapsed morphology (Figure 2 A).

B. Negative drawing: Two or more of the following characteristics-complex line drawing, pronounced symmetry, small drawing occupying less than 25% of the drawing paper, a weak drawing consisting of a single line (Figure 2 B).

C. Normal drawing: Photographic depiction, cartoon-like figure, or expository pictogram that is integrated, including detailed single line drawings. Did not meet the requirements of a positive or negative drawing; the strength/weakness and coarseness of the strokes were not taken into account (Figure 2 C).

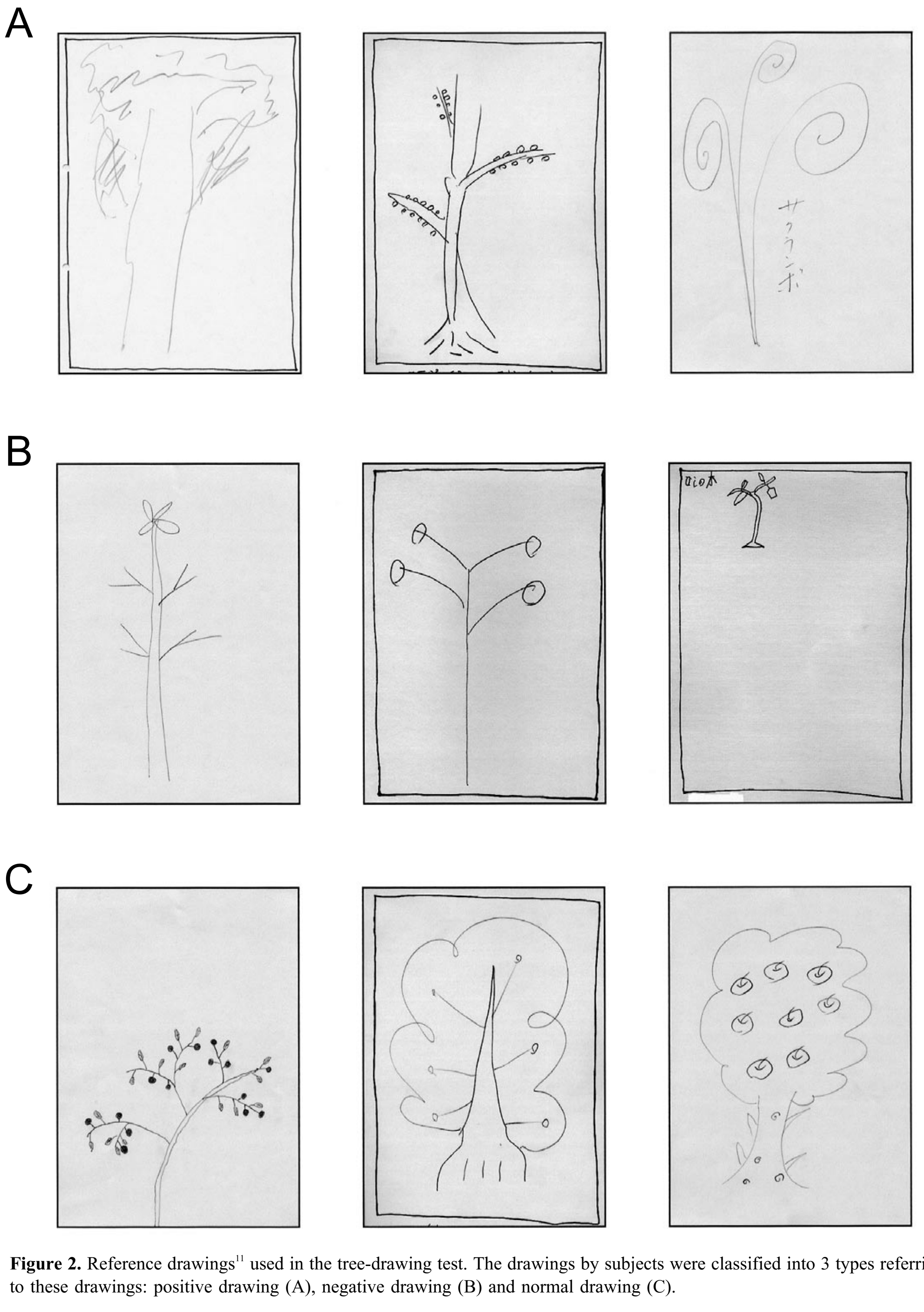

Figure 2. Reference drawings[11] used in the tree-drawing test. The drawings by subjects were classified into 3 types referring to these drawings: positive drawing (A), negative drawing (B) and normal drawing (C).

Statistical analysis

The age and the length of education were compared among three groups using Kruskal-Wallis test, and the clinical characteristics in the two patient groups were compared using Wilcoxon rank-sum test.

To evaluate the difference by group (low-autonomy, high-autonomy and healthy) in the performance of procedural learning, we compared the reaction time in the push-button task among three groups regarding the time recorded in respective trials as repeated measures; we analyzed the time recorded for the symmetrical gestalt, spiral gestalt and their sum, separately using a general linear model including group and trial as main factors with their interaction.

We tested the correlation between the work ability and the tree-drawing type using Fisher's exact test for 3×3 contingency table.

NPAR1WAY, FREQ and GLM in the SAS® system[18] were used for the calculations.

Results

The sex ratio, age and the length of education in the 3 groups including healthy subjects are presented in Table 1 along with clinical characteristics of the patients in the two groups. No items except for the length of education showed a significant difference in groups.

The performance by group and trial in the push-button task is presented in Figure 3 for symmetrical gestalt (upper panel) and spiral gestalt (lower panel), respectively, and in Figure 4 for the two gestalts combined. In each of the two types of gestalt, i.e., symmetrical and spiral, and their combination, the reaction time at respective trials significantly (p<0.0001) decreased in the order of low-autonomy group, high-autonomy group and healthy group. Similarly, the reaction time in the respective three groups decreased with repetition

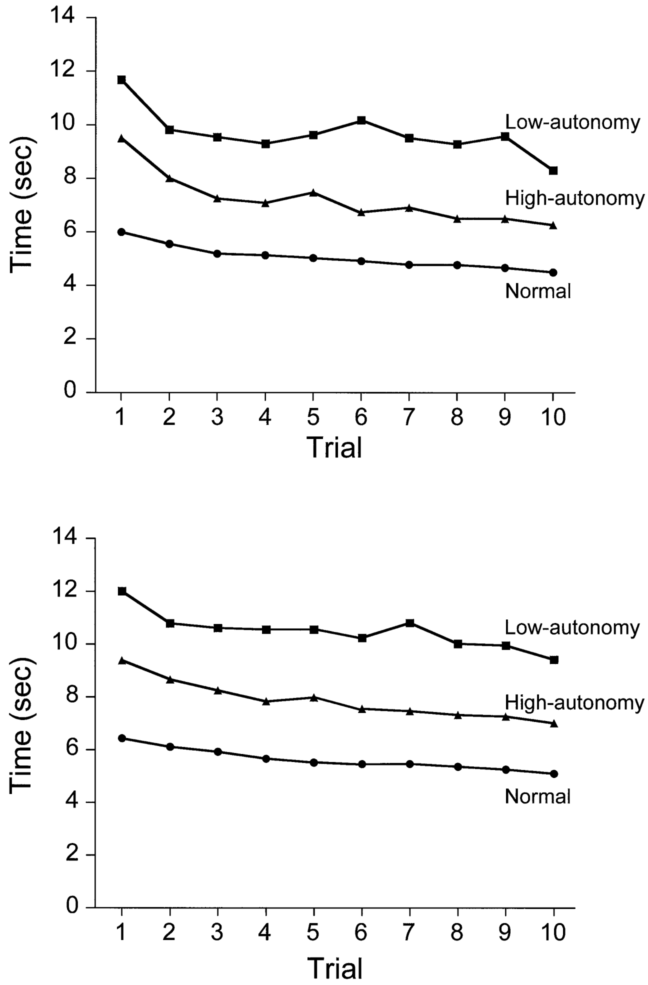

Figure 3. Reaction time (in second) by group of subjects and trial in the push-button task for symmetrical gestalt (upper panel) and spiral gestalt (lower panel).

Table 1. Clinical and other characteristics of subjects by group

Item	Group			p-value
	Low-autonomy (n=15)	High-autonomy (n=15)	Normal (n=35)	
Gender (male/female)	10/5	12/3	24/11	0.7631[c]
Age (years)	53 (28-58)[a]	49 (40-57)	48 (37-60)	0.5682[d]
Length of education (years)	9.0 (8.7-12.0)	12.0 (9.0-16.5)	14.0 (12.0-16.0)	0.0001[d]
Age at onset (years)	21.0 (13.0-57.0)	27.0 (14.0-40.0)	NA[b]	0.8781[e]
Duration of disease (years)	22.0 (1.0-38.0)	20.0 (12.0-43.1)	NA	0.7512[e]
Length of hospitalization (years)	9.5 (1.0-30.7)	6.0 (2.0-17.3)	NA	0.2616[e]
Chlorpromazine equivalent (mg)	531.0 (104.6-1400.0)	798.0 (13.3-1950.0)	NA	0.1160[e]

[a] Median (Minimum-Maximum in parentheses).
[b] Not available.
[c] Fisher's exact test.
[d] Kruskal-Wallis test.
[e] Wilcoxon rank-sum test.

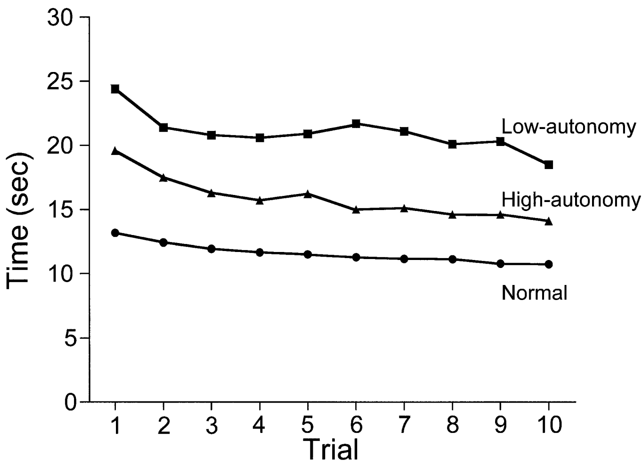

Figure 4. Reaction time (in second) by group of subjects and trial in the push-button task for combination of the two gestalts.

of trials (p<0.0001); however, no significant difference was observed among three groups in the degree of decrease with trial (p>0.14).

Subjects' impression of the push-button task indicated that none became aware of any pattern in the spiral gestalt, while they became aware of symmetrical gestalt in part. However, even in the latter case, they could point to only a few buttons such as those lighted first, second or last, and none could describe the lighting order completely.

Table 2 presents the distribution of the types in tree-drawing test by group. The frequency of positive drawing was highest in low-autonomy group and monotonically decreased in high-autonomy group and healthy group, while the reverse order held in the frequency of normal drawing, and the frequency of negative drawing was highest in high-autonomy group. The correlation between the group and the tree-drawing type was significant (p<0.0001).

Table 2. Frequency of drawing types in 3 groups of subjects observed in the tree-drawing test

Group	Drawing type			Total
	Positive	Negative	Normal	
Low-autonomy	9 (60.0)[a]	4 (26.7)	2 (13.3)	15
High-autonomy	3 (20.0)	7 (46.7)	5 (33.3)	15
Normal	3 (8.6)	6 (17.1)	26 (74.3)	35

[a] Parenthetic entries refer to the percentage of subjects in respective groups.

Discussion

Improvement of performance without acquisition knowledge which can be worded is called implicit learning. Implicit learning is a phenomenon that the subject learns without conscious access to or verbalization of the knowledge required to complete a task.[19] Nissen et al.[15] reported that implicit learning is characterized by the fact that learning effect is reflected to the results of performance such as a reduction in reaction time, while not reflected to the results of verbal reporting.

The results of the push-button task in the present study, demonstrating that a significant decrease in reaction time with trial was observed in the patients with schizophrenia while none of them could describe the lighting order completely, support the previous studies[4,5] reporting the preservation of procedural learning in patients with schizophrenia. The results indicate motor control effect that enabled the examinee to react while searching for and attending to the location of the lighted button.

In the push-button task of the present study, we used two types of gestalt, symmetrical and spiral, expecting a difference in implicit learning effect between the respective types of gestalt for each group; previous studies[20] suggested impairment in patients with schizophrenia in organizing perception. However, contrary to our expectation, no such difference was observed for each group. This may be due to that the two gestalts did not differ much in their patterns and hence motor function predominated over perceptive system in reducing the reaction time in the push-button task of the present study.

The positive drawing, most frequently observed in patients of the low-autonomy in the tree-drawing test, was of distorted gestalt. Our recent study[8] suggested that difference in morphological characteristics of the drawings among schizophrenia subtypes may reflect physiological difference in brain function that differs from the levels of mental phenomena measured with questionnaire. Based on the findings that ruler-catching time was slower by 25 to 45 msec in patients with schizophrenia who drew trees of distorted gestalt than in healthy individuals, Utena and his colleagues[11,12] suggested that distorted morphology in the tree-drawing test may indicate impairment in information-processing function related to successive time perception before and after movement and perception. In other words, the gestalt distortion in the tree-drawing may suggest the failure in organizing elements of the tree due to impairment in information processing such as to draw a tree retaining the image of the tree pictured in mind and compare the drawing with the image of the tree kept in memory.

In a report on implicit motor learning as indicated by serial reaction time, Forkstam et al.[21] described the role of subcortical structures in encoding procedural information. A study, which used functional magnetic resonance imaging to examine the brain regions activated by conceptualization of the image, found that the activated regions included not only the parietal lobe and bilateral motor areas but also a broad region of the brain extending from the midbrain to the cerebellum.[22] Analysis of visual event-related potentials in the task of gestalt recognition suggested impairment in patients with schizophrenia in integrating information input into the frontal and prefrontal area.[23] Moreover, imaging studies of brain function in schizophrenia have shown that impairment in communication between the mesocortical system and mesolimbic system is strongly associated with psychiatric symptoms and pathologies.[24,25]

Although the present study could not clarify the role of the local regions of the brain in relation to procedural learning and gestalt recognition, it suggested impairment in brain function in patients with schizophrenia in integrating procedural learning and representation. The present study therefore suggests the usefulness of push-button task and tree-drawing test for assessing recovery process in schizophrenia.

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