**Introduction**

Restoration of functional use of the paralyzed upper extremity is one of the goals of occupational therapy (OT) in patients with stroke hemiparesis because paralyzed upper extremities often cause difficulty in manipulating tools for everyday items by problems such as sensory disturbance and motor control [1]. In addition, approximately 50% of stroke patients experience sensory disturbance, which negatively affects the functional use of the upper extremities [2].

The functional use of the upper extremities is supported by the corticospinal system [3]. For upper extremity function supported by the corticospinal system depends on the specificity of the task, and the exploration of perceptual information and motor control are important factors for the recovery of upper extremity function [4]. Therefore, the exploration of perceptual information and motor control that depends on the specificity of the task is a hypothesis that improves the functional use of the paralyzed upper extremity. The purpose of this study was to monitor the effects of perceptive exploration activity performed.
Method

Subject
The patient, a male in his 70s, diagnosed with a cerebral infarction in the left middle cerebral artery inferior trunk area participated in this study. This study was initiated on day 127 of the illness. Brunnstrom’s stages were right upper extremity IV, finger V. The paralyzed upper extremity had had sensory disturbance and therefore was not used in activities of daily living (ADLs).

ADLs were required the setting and watching of the environment. The Functional Independence Measure had 81 scores. Eating was performed by adjusting the environment of the dining table and manipulating the spoon of the non-paralyzed upper extremity. The spoon manipulation of the paralyzed upper extremity was not appropriate. He spilled most of the food because of the poor fundamental movement of scooping.

Research Design
In this study, the ABAB trial was conducted after obtaining informed consent from the patient. At baselines A and A’, OT comprised facilitating selective movement of the paralyzed upper extremity and self-care skill training was provided for 40 minutes a day, five days a week. For interventions B and B’, a specific intervention for 10 min was added to OT.

Specific Intervention (Fig. 1a)
Spoon manipulation using the paralyzed upper extremity was found to be difficult for scooping the food, so the task of stirring soybeans was selected. This task is considered as a perceptive exploration activity that scoops changes in the sense of resistance to soybeans as an aggregate, and the movement to scoop is a fundamental movement skill of the hand [5].

In the therapy, the paralyzed upper extremity of the patient was guided, and the hand shaping and soybean movement were adjusted based on the change in the sense of resistance provided by the soybeans as an aggregate.

Outcome Measurements
1) Efficiency of spoon manipulation by the paralyzed upper extremity (Fig. 1b, c)
Measurements of evaluation task were taken in daily sessions, measuring the required time (RT) and the number of errors (NOE) based on the beans spilled from the spoon.
2) Goal Attainment Scaling: GAS
GAS was measured at the end of each phase, and the change in score was calculated [6].
3) Fugl-Meyer Assessment: FMA
The FMA was used to measure movement, sensation, range of motion, and pain in the upper extremity at the end of each phase.

Data analysis
For the analysis, RT and NOE measured in each period were compared by 2 standard deviation (2SD) bands, Kruskal-Wallis H-test for analysis of variance, and Mann-Whitney U-test with Bonferroni correction for multiple comparison and was considered statistically significant.

Fig. 1. a) Reproduction of therapy scene by perceptive exploration activity.
b) Go stones. The surface is smooth, is 2.2 cm in diameter, and has a clear weight.
c) Evaluation task. Because there is no evaluation task for utensils manipulation so far, it was decided independently with reference to previous research in Japan. The setting on the table controlled the distance from the edge in front of the table to the Japanese bowl and the distance from the Japanese bowl to a different bowl to 15 cm. The Japanese bowl containing the Go stone is 13 cm in diameter and 6.8 cm in depth. A different bowl is 9 cm in diameter and 6.8 cm in depth. The evaluation task was to move the Go stones placed in the Japanese bowl to a different bowl placed in front of the former as quickly as possible by manipulating the spoon using the paralyzed upper extremity.
In addition, the correlation coefficient of RT, NOE, and FMA were calculated using the Spearman’s rank correlation coefficient.

**Results**

RT and NOE by 2SD bands showed a decrease in interventions B and B’ (Fig. 2). Table 1 shows the changes in outcomes during each phase. Intervention B’s RT was reduced relative to baseline A ($p = 0.013$), but NOE was not significantly different ($p = 0.124$). A comparison of intervention B and A’ showed an increase in both RT and NOE ($p = 0.026$, $p = 0.031$). A comparison of baseline A’ and intervention B’ showed a decrease in both RT and NOE ($p = 0.013$, $p = 0.016$). GAS improved with interventions B and B’. In addition, the spoon manipulation at the B and B’ stages has smoothly changed the process of scooping food and eating it to the mouth. The FMA showed a gradual improvement in

**Fig. 2** Changes in required time and number of errors in task performance
The correlation coefficient between FMA and RT was -0.6 and NOE was -0.3; hence, a negative correlation was observed.

**Discussion**

The paralyzed upper extremity of the patient before the intervention had sensory disturbance, and therefore spoon manipulation was not practical. One underlying mechanism may be disorders of the central nervous system affecting tool manipulation of upper extremity function, which is associated with motor and sensory function [7].

Therefore, perceptive exploration activity was performed in this study to facilitate the perceptive exploration function of the paralyzed upper extremity. Our observation is consistent with previous studies suggesting perceptive exploration of the hand is an active movement that brings consistency between hand movements and sensations, and reactions based on somatosensory input are the basis for acquiring movement skills [8, 9]. In terms of the corticospinal system in the functional use of the hand, the recruitment of corticospinal neurons is activated during hand movement based on perceptive exploration and regulates fine control of the hand [10]. Therefore, it would be reasonable to assume that our intervention improved spoon manipulation and GAS score.

In addition, from the result of negative correlation between spoon manipulation and FMA, the effect of recovery of the motor function of the upper extremity on spoon manipulation cannot be ruled out. Therefore, it is a future task to verify the function that greatest effect on spoon manipulation.

**Conclusion**

It has been shown that perceptive exploration activity may be effective in improving movement skills in tool manipulation of the paralyzed upper extremity with sensory disturbance.

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