

Effects of Hand-Used on Unilateral Spatial Neglect: A Case Study

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FUJII, T., YAMADORI, A., FUKATSU, R. and SUZUKI, K. *Effects of Hand-Used on Unilateral Spatial Neglect: A Case Study.* Tohoku J. Exp. Med., 1996, **180** (1), 73-81 — It was originally claimed that left hand use on line bisection tasks reduced the extent of left neglect by Halligan and Marshall. However, in a following study, the same research group failed to reproduce this left hand amelioration effect if the left hand was initially placed on the right side, and they claimed that spatio-motor cueing was more important in reducing unilateral neglect than the hand used. The present study concerns with the validity of these two theoretical views on modification of unilateral neglect, i.e., hemispheric activation and spatio-motor cueing. A patient with left unilateral neglect and a slight left hemiparesis participated in three experiments. Under conventional testing condition, line bisection performed with the right hand showed more severe left neglect than when performed with the left hand. These hand effects were modified by changing a starting position of the patient's hand when bisecting horizontal lines. However, under body-fixed condition, effects of hand-used as well as starting position were again significant. The results suggest that not only spatio-motor cueing but also differential hemispheric activation can exert a profound effect on unilateral neglect. — unilateral spatial neglect; line bisection test; hemispheric activation; hemispace; hand

Unilateral spatial neglect (USN) is manifested as a failure to attend to space contralateral to the site of a brain lesion (Heilman et al. 1993). It is more frequent and severe with right-sided lesions. Since most patients with left USN consequent upon lesions of the right hemisphere have left hemiparesis, traditional neglect tasks have been performed with their hand ipsilateral to the lesion side, i.e., right hand (Heilman and Valenstein 1979; Riddoch and Humphreys 1983; Fujii et al. 1991, 1995a).

The line bisection test has been adapted for evaluating USN (Heilman and

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Valenstein 1979; Riddoch and Humphreys 1983; Fujii et al. 1991) and cognitive function in normal subjects (Fujii et al. 1995b). Several investigators have noted that performance on the line bisection task was affected by hand-used in normal subjects (Scarisbrick et al. 1987; Fukatsu et al. 1990). In consistence with these studies, a couple of studies have shown that the extent of left USN ameliorated when a task was executed by the left hand, i.e., the hand opposite to the site of lesion (Joanette et al. 1986; Halligan and Marshall 1989; Halligan et al. 1991).

Thus, Joanette et al. (1986) showed that in a visual search task, where targets had to be manually pointed, patient's performance with the left hand showed less severe left neglect than when performed with the right hand. Halligan and Marshall (1989) found a significant attenuation of left USN when the left hand was used on a star cancellation task and a line bisection task. They attributed this effect to activation of the right hemisphere. In a subsequent study, however, they changed their original interpretation and attributed the effect to spatio-motor cueing (Halligan et al. 1991). Their idea was based upon a finding that the beneficial effect of the left hand disappeared if the subject was required to begin the task with the left hand positioned on the right.

Their failure in reproducing the hand effects is puzzling in the light of recent works by Robertson and North (1992, 1993). They demonstrated that the left hand finger movement of a subject with left USN significantly reduced neglect during a letter cancellation task with the right hand. We must now consider a possibility that changing starting positions of the hand might have changed the midsagittal plane of the patient. Effects of space on USN have also been reported (Heilman and Valenstein 1979). In order to ascertain the effects of hand or cue, or both, it may be necessary to consider the effects of space.

In the present study, we report a replication of Halligan's finding (Halligan et al. 1991) that the hand employed modulated the extent of left neglect and this modulation was further modified by changing starting positions of the patient's hand on a line bisection test (Experiment 1 and 2). We then evaluated patient's performance by taking effects of space into account under body-fixed condition (Experiment 3).

SUBJECT AND METHODS

The subject was a 76-year-old, right-handed man who had suffered a right cerebro-vascular infarction on 30 January 1994. On admission to a nearby hospital, he was found to have a mild disturbance of consciousness and left hemiparesis. On 3 March 1994, he was admitted to the Neurology Service of Miyagi National Hospital. He was able to orient time and place, and persons. His visual field assessed by confrontation testing was normal. Limitation of oculomotor movement was not seen. The other cranial nerves were also intact. He had a mild left hemiparesis. He did not show any sensory disturbance. Motor neglect was not observed. He showed left USN and left tactile and visual

extinction phenomena in bilateral simultaneous stimuli. Fig. 1 shows his performance on line cancellation test with each hand.

A MRI scan obtained on 21 April 1994 demonstrated a cerebral infarction in the territory of the right middle cerebral artery (Fig. 2). The lesion involved the right frontal lobe, the insula and anterior part of the parietal operculum.

Experiment 1

The purpose of the present experiment was to examine that rightwards displacement of transections on a line bisection task with the right hand might decrease when the left hand was used.

Method. Lines differing in length (80, 120, 160, 200 and 240 mm) were drawn horizontally across the center of a white sheet of A4-size paper, one line per sheet. Each stimulus sheet was placed on a desktop and was always centered on the midsagittal plane of the patient's head and trunk. The patient bisected four sets of twenty lines, two sets (first and fourth) with the right hand and two (second and third) with the left. The order of presentation was counterbalanced across lengths. All stimuli were shown in free vision without restraint on head and body. No feedback was provided on accuracy.

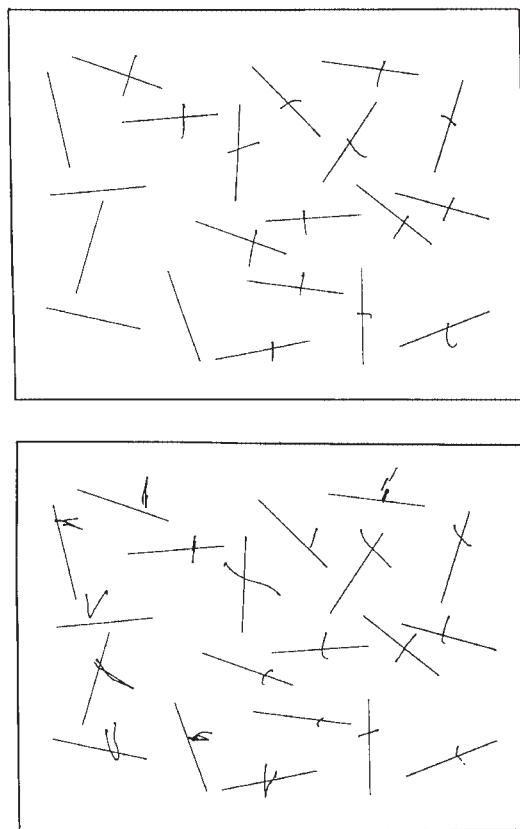


Fig. 1. Performances on the line cancellation task with the right hand (top) and with the left hand (bottom). These figures clearly show an amelioration effect by left hand use.

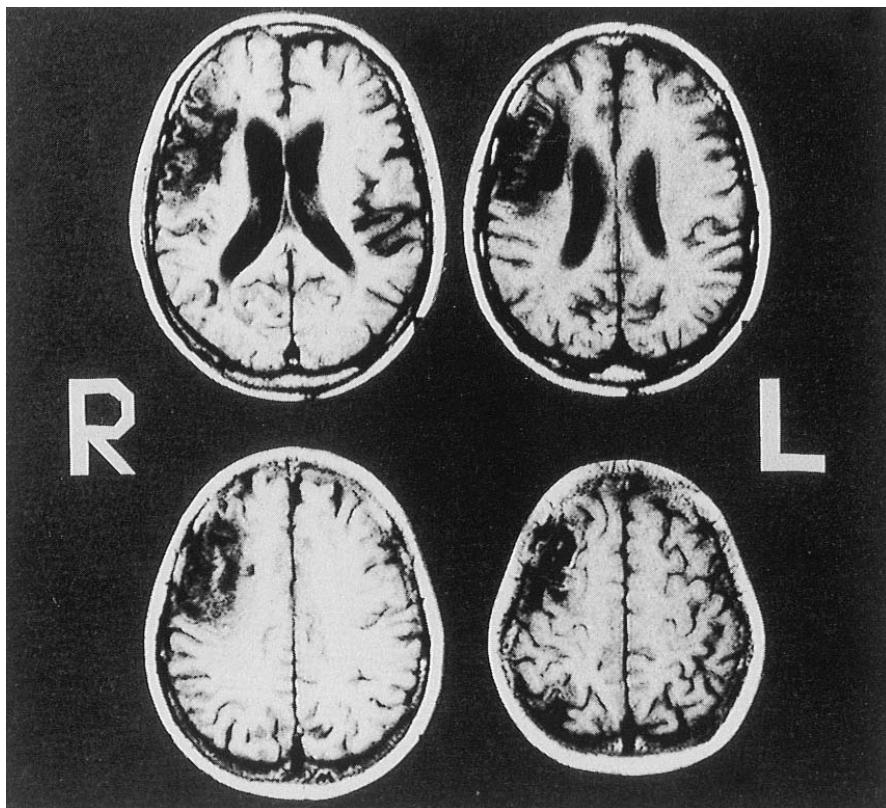


Fig. 2. MRI scan obtained on 21 April 1994, showing infarction of the right middle cerebral artery territory.

Experiment 2

The aim of this experiment was to reproduce the result demonstrated by Halligan et al. (1991) that effects of hand-used disappeared when the starting position of the hand (cueing) was taken into account.

Method. Horizontal lines differing in length (as previously described) were prepared. Each stimulus sheet was placed on a desk top and was always centered on the midsagittal plane of the patient's head and trunk. Like the Halligan's method (Halligan et al. 1991), four conditions were included: two natural conditions (right hand placed at the right end of a stimulus line and left hand placed at the left end of a stimulus line), two unnatural conditions (relationships with hand-used and hand position were reversed). The patient bisected four sets of ten lines, two sets (first and fourth) with the right hand and two (second and third) with the left hand. Hand positions were randomized in each set and the order of presentation was counterbalanced across lengths. All stimuli were shown in free vision without restraint on head and body. No feedback was provided on accuracy.

Experiment 3

Experiment 3 was conducted to investigate the effects of hand-used, hand

position and hemispace. To prevent the shift of patient's midsagittal plane due to his hand position, the patient's body was restrained by another experimenter.

Method. Unless otherwise stated, the method was the same as the experiment 2. Along with conditions for hand-used and hand position, condition for space was introduced: right and left hemispace (on right hemispace condition, papers were placed in such a way that the left end was located about 5 cm to the right of the patient's body midline and on left hemispace condition, the papers were placed reversely). The patient bisected eight sets of ten lines, four sets (first, fourth, fifth and eighth) with the right hand and four (second, third, sixth and seventh) with the left hand. Hand positions were randomized in each set and the order of presentation was counterbalanced across lengths. The patient bisected the first two and last two sets in right hemispace, the remainder in left hemispace. All stimuli were shown in free vision and free head movement. Another experimenter restrained the patient from changing the body direction by holding his body.

RESULTS

Experiment 1

Transection accuracy was measured to the closest mm, and expressed as positive (+) for rightwards displacements and negative (-) for leftwards displacements. Fig. 3 shows the mean error scores as a function of hand-used in mm.

The results of two-way analysis of variance revealed statistically significant main effects of hand-used ($F=9.84$, $df=1, 63$; $p<0.01$) and line length ($F=4.76$, $df=4, 63$; $p<0.01$). Left hand performances were further leftward ($M=4.17$, $SD=5.18$) than right hand performances ($M=8.55$, $SD=9.12$).

Experiment 2

The results were collected in the same way as in experiment 1. Fig. 4 shows the mean error scores as a function of hand-used and hand position (cueing) in

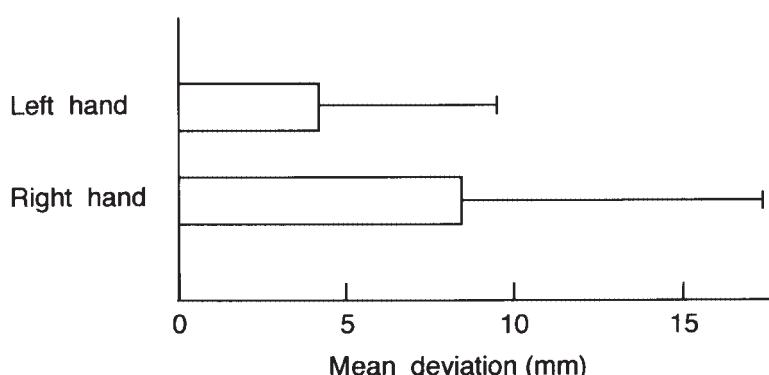


Fig. 3. Mean deviation (in mm) of transections from the objective midpoint for each hand in experiment 1. Rightward deviation is coded as positive, leftward as negative.

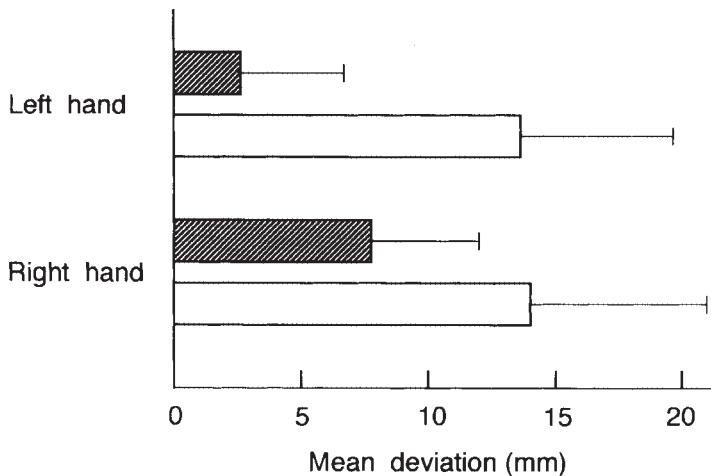


Fig. 4. Mean deviation (in mm) of transections from the objective midpoint as a function of hand-used and hand position in experiment 2. Rightward deviation is coded as positive, leftward as negative. Hatched columns=left cue; open columns=right cue.

mm.

A repeated measures analysis of variance revealed a significant main effect for hand position ($F=25.46$, $df=1, 27$; $p<0.01$) (right starting position: $M=13.75$, $SD=6.37$, left starting position: $M=5.15$, $SD=4.68$). There was no significant effect of hand-used ($F=2.51$, $df=1, 27$; ns) (right hand-used: $M=10.8$, $SD=6.41$, left hand-used: $M=8.10$, $SD=7.52$) and no significant interaction between these two factors.

Experiment 3

The results were collected in the same way as in experiment 1. Fig. 5 shows the mean error scores as a function of hand-used, hand position (cueing) and hemispace in mm.

A repeated measures analysis of variance revealed significant main effects for all three factors (hand-used: $F=11.94$, $df=1, 63$; $p<0.01$, hand position: $F=17.53$, $df=1, 63$; $p<0.01$, hemispace: $F=165.0$, $df=1, 63$; $p<0.01$) and a significant interaction between hand-used and hand position ($F=4.47$, $df=1, 63$; $p<0.05$). There was greater rightward deviation of transections by the right hand-use ($M=8.08$, $SD=9.92$) compared to the left hand-use ($M=3.83$, $SD=10.24$). Relative to the left starting condition ($M=3.38$, $SD=10.78$), there was greater rightward deviation of transections in the right starting condition ($M=8.53$, $SD=9.09$). With respect to hemispace, there was greater rightward deviation of transections in left hemispace condition ($M=13.85$, $SD=6.48$) than in right hemispace condition ($M=-1.9$, $SD=6.52$). Interaction between hand-used and hand position showed that transections were more leftward when the left hand is positioned on the left side than when the right hand was on the left side and the left hand was on the right side.

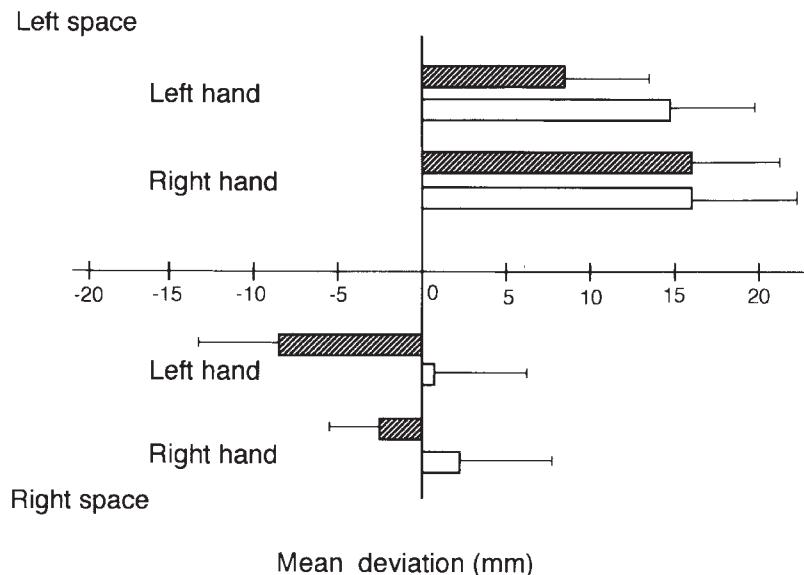


Fig. 5. Mean deviation (in mm) of transections from the objective midpoint as a function of hand-used, hand position and hemispace in experiment 3. Rightward deviation is coded as positive, leftward as negative. Hatched columns = left cue; open columns = right cue.

DISCUSSION

The results of the experiment 1 showed that line bisection performed with the left hand showed less severe left neglect than when performed with the right hand. The results of the experiment 2 showed that hand position had a striking effect, that is, greater attenuation of left neglect in left starting condition than in right starting condition, but hand-used did not. In the natural condition of the experiment 2, as compared with the results of the experiment 1, performance with the right hand deviated more rightward and performance with the left hand deviated more leftward. Starting position in the natural condition of the experiment 2 might act as spatio-motor cueing, because the patient naturally set his hand with a pen near the body midline on the desk in the experiment 1. In the experiment 3, we introduced spatial condition besides the conditions of hand-used and hand position. The results revealed significant effects for all three factors and a significant interaction between hand-used and hand position.

The experiment 1 and 2 succeeded in replicating the results demonstrated by Halligan et al. (1991). They claimed that the position of the hand in space rather than the hand per se was responsible for the attenuation and enhancement of neglect and thus effects of hand were mainly due to spatio-motor cueing and not to differential activation of the hemisphere which is contralateral to the hand employed. However, we noticed that setting the hand in an unnatural position had slightly changed the midsagittal plane of the patient's body if not restrained. As shown in the present results and the results of previous studies (Heilman and Valenstein 1979), there are significant space effects in which bisection of a line

tends to shift more toward the right in left space than in right space. When the patient uses his left hand and starts with the hand in its unnatural position, his body would slightly deviate toward right and hence the line would fall into leftward space than its natural position. In this condition, effects of hand-used and space would act conversely as to direction. We suspected that the effects of hand *per se* might be countermanded by the effect of space in experiment 2. So we added a spatial condition in experiment 3. In this particular condition, the patient's body was restrained by another experimenter. The results clearly showed the effects of hand-used along with the effects of cueing and space. As shown in the results of experiment 3, the patient showed leftward deviation in right hemispace. Clinically, we have seen such cases with mild left USN who showed leftward deviation in right hemispace. This result may be explained by the different magnitude of the effects of three factors. The greater space effect might overwhelm the effect of hand-used and cueing (see *F* value of the three factors in the experiment 3). This point remains to be proved.

From a theoretical point of view, attenuation of left neglect when the left hand was used is consistent with "hemispheric rivalry hypothesis" proposed by Kinsbourne (1987) or recent "recruitment hypothesis" by Rizzolatti and Camarda (1987). In fact, if other conditions were the same, displacements were always leftward when the left hand was used compared to the right hand in our experiment 3. Robertson and North (1992) reported that left finger movements in left hemispace reduced neglect, but neither right finger movements in left hemispace nor left finger movements in right hemispace did. Therefore, they claimed that "recruitment" and "cueing" hypothesis cannot fully account for their results at least in its simplest form. In our experiment 3, we found significant main effects not only for hand-used but also for cueing and interaction between hand-used and cueing, showing that displacement was more to the left when it was coupled with left side cueing than any other conditions. These results imply that these two hypotheses are not necessarily conflicting or contradictory to each other. Performance would be modified depending on the balance of efficiency of these two factors (hand-used and cueing).

The results of recent works (Coslett et al. 1990; Tegner and Levander 1991) suggested the existence of two types of neglect (premotor and perceptual). Although it was known that sensory cueing to the left could reduce the extent of left neglect (Riddoch and Humphreys 1983; Reuter-Lorenz and Posner 1990), the case reported by Robertson and North (1992) showed no effect of visual cueing. They discussed that the patients with premotor neglect require motor cueing while the patients with perceptual neglect might benefit from visual cueing. However, it was difficult to decide whether hand cueing employed in the present study acted as motor or visual.

In conclusion, differential hemispheric activation as well as spatio-motor cueing and space has a profound effect on unilateral spatial neglect. Further

studies using physiological or functional imaging methods may be helpful to ascertain the effect of differential hemispheric activation on this symptom.

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