Leftward Movement in Severe Neglect

Shizuko Sato¹,², Sumio Ishiai², Keiko Seki³, Yasumasa Koyama² and Hidehiro Mizusawa¹

¹Department of Neurology, Faculty of Medicine, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8519, ²Department of Rehabilitation, Tokyo Metropolitan Institute for Neuroscience, 2–6 Musashidai, Fuchu, Tokyo 183-8526 and ³Faculty of Health Science, Kobe University School of Medicine, 7-10-2 Tomogaoka, Suma, Kobe, Hyogo 654-0142, Japan

Abstract

The difficulty that patients with unilateral spatial neglect (USN) have in exploring into the contralesional space may be explained by motor or attentional disorder. We experienced a patient with severe USN following cerebral infarction in the right postrolandic region, who showed a strong resistance to leftward movement. We devised two sets of tasks using a whiteboard. In the first experiment, the patient showed great difficulty in tracing a line from the right endpoint to the left endpoint. The examiner barely made him start further tracing even by pushing the hand leftward. By contrast, he quickly erased a whole line leftward with an eraser pen. In the second experiment, he was required to erase a line with or without an attention-attracting stimulus at the right endpoint. Not only the leftward extent, but also the velocity of erasing, were decreased when there was a stimulus at the right endpoint. The results of the two experiments suggest that the ability of leftward movement itself was preserved and overattention to the right-sided stimuli impaired his leftward movement. We consider that use of the line-tracing and line-erasing tasks may contribute to a better understanding of interaction of attentional and motor factors in severe USN.

Introduction

Patients with unilateral spatial neglect (USN) show difficulty in exploring into the contralesional space. This difficulty may be explained by motor or attentional disorder. Motor aspects of USN were studied by Heilman et al. (1987), and the term ‘directional hypokinesia’ was introduced to mean an inability to initiate and execute a movement in or toward the contralateral hemispace. As regards attentional disorder, impaired disengagement of attention from the right side (Posner et al., 1987), or overattention to the object on the right side (Mark et al., 1988; Ladavas et al., 1993), may affect leftward exploration.

We experienced a patient who showed severe left USN when exploring stimuli on the left side. In addition, when the examiner tried to move the patient’s right arm leftward, he showed so great a resistance that his neglect seemed at first impression to be caused by leftward motor disorder or directional hypokinesia. There was, however, another possibility: that the resistance resulted from his strong attentional bias or overattention to the right part of the stimuli. To assess which factor was the main cause of the difficulty in leftward movement, we devised line-tracing and line-erasing tasks using a whiteboard. Mattingley et al. (1992) classified impaired leftward movement found in neglect into directional hypokinesia or initiation failure, directional bradykinesia or slowness in execution, and directional hypometria or insufficient extent. This classification was based on the observed movement and did not discriminate motor from attentional deficit. In the comparison between performances on the line-tracing and line-erasing tasks, we intended to clarify the interaction between attentional and motor factors, focusing on the execution and extent of leftward movement. In this paper, we use the term ‘directional hypokinesia’ according to the definition of Heilman et al. (1987) to indicate motor aspects in the mechanism of USN.

Case report

An 84-year-old right-handed man developed left-sided weakness and left hemianopia following cerebral infarction. Five months later, he was admitted to our hospital for rehabilitation. On admission, he was alert and orientation for time and space was good. He showed mild left hemiparesis and left hemianopia. A brain MRI showed cerebral infarction in the right occipital lobe, the medial part of the right temporal lobe, and the posterior limb of the right internal capsule and its adjacent part of the corona radiata. ¹²³I single photon emission computed tomography (SPECT) revealed an area of decreased cerebral blood flow in the right parietal and occipital lobes.

The patient showed severe left USN. He copied only the...
right half of the figure of a daisy (Heilman et al., 1985). In the line-cancellation test (Albert, 1973; Ishiai et al., 1990), he crossed out the right-most five of the 30 lines. When asked to bisect lines 200 mm long, he marked about 70 mm to the right of the true centre. He showed so great a difficulty in exploring toward the left hemispace that he was unable to find the left endpoint of the line when asked to do so. We then ordered him to trace a line 200 mm long, starting from the right endpoint to reach the left endpoint. The movement of his right arm was very slow and he always stopped when he had traced only about the right one-third of the line. The examiner held his right arm and tried to move it leftward, telling him that the line extended more to the left side. However, the patient showed so great a resistance to leftward movement that the examiner barely made him start further tracing.

His verbal intelligence was well preserved as his verbal IQ was 101 on the Wechsler Adult Intelligence Scale – Revised (WAIS-R) (Wechsler, 1990). His performance IQ was 64.

The patient gave informed consent to the following experimental studies.

**Experiment 1**

**Methods**

**Line-tracing task.** We used a whiteboard (450 × 600 mm), a dry erase marking pen, and an eraser pen with a small felt tip (15 × 25 mm) at its end. The examiner sat in front of the patient, across a table, and put the whiteboard flat on the table. A line was drawn with black dry erase ink horizontally on the whiteboard so that it was presented to the patient extending symmetrically into both hemispaces. The patient was asked to draw a line a few millimetres below the presented line from the right endpoint to the left endpoint.

**Line-erasing task.** The patient was presented with a line in the same way as in the line-tracing task. He was asked to erase the line from the right endpoint to the left endpoint with an eraser pen.

No time limit was imposed on each task. We used lines 150, 200 or 250 mm long. The patient was given the two tasks according to an ABBA design. In both tasks, he performed 10 trials for each length in an order randomized across the three lengths. We measured the extent of tracing or erasing to the closest millimetre in each trial. The trials were videotaped to analyse the process of leftward movements. This experiment was carried out 6 months after the onset of cerebral infarction.

**Results**

**Number of successful trials.** Table 1 shows the number of successful trials in which the patient could reach the left endpoint for the line-tracing and line-erasing tasks. He reached the left endpoint in 11 of the 30 line-tracing trials and in all line-erasing trials. The frequency of successful trials was significantly higher in the line-erasing than in the line-tracing task (Fisher’s exact test, $P < 0.01$). The 150 mm lines were most successfully traced in the line-tracing task, but the difference in the number of successful trials was not statistically significant among the three line lengths (Fisher’s exact test).

**Pattern of leftward movement.** We reproduced the video film frame by frame and recorded the position of the tip of pen on the presented line. The position of the pen tip was graphed for each trial from the time of starting leftward movement to the time when it reached the left extreme point. Figure 1 shows a representative pattern of leftward movement in each task. In the line-tracing task, he traced the line at a constant velocity to some point and stopped there for a while. We measured the distance from the right endpoint to this initial stopping point ($L_1$) and the time taken to move this distance ($T_1$). He then traced very slowly by repeatedly adding a small trace and making a short pause. This additional tracing is shown as the staircase configuration of movement pattern in Fig. 1. The total time and extent of tracing were also measured ($T_2$ and $L_2$, respectively). He commented on his performance as follows. He at first stopped tracing at the point which he judged to be the left endpoint, but he noticed a further extent of the line on the left side. He then restarted and traced the line hesitantly because he found the remaining part repeatedly when he added tracing.

In the line-erasing task, he erased the whole extent of each line at a constant velocity. We measured the total time of leftward movement.

**Extent and velocity of leftward movement.** Table 2 shows the means of $L_1$ and $L_2$, and the mean velocity of leftward movement in each task. In the line-tracing task, the velocity for the initial smooth trace ($V_{T_1} = L_1/T_1$) and the velocity for the total extent of tracing ($V_T = L_2/T_2$) were obtained. $V_T$ was slower than $V_{T_1}$, reflecting the stepwise tracing beyond the initial stopping point. We therefore adopted $V_{T_1}$ as the velocity of leftward movement in the line-tracing task. In the line-erasing task, the velocity from the right endpoint to the left endpoint ($V_{E}$) was calculated by dividing the whole length of the line by the total time of leftward movement.

An analysis of variance was applied to the velocity of left-
Table 2. Extent (mm) and velocity (mm/s) of leftward movements

<table>
<thead>
<tr>
<th>Line length (mm)</th>
<th>Line-tracing task</th>
<th>Line-erasing task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L_1$</td>
<td>$L_2$</td>
</tr>
<tr>
<td>150</td>
<td>73.2 (27.8)</td>
<td>135.5 (23.9)</td>
</tr>
<tr>
<td>200</td>
<td>76.8 (27.2)</td>
<td>137.2 (52.4)</td>
</tr>
<tr>
<td>250</td>
<td>107.9 (27.5)</td>
<td>190.0 (51.6)</td>
</tr>
</tbody>
</table>

$L_1$ is the distance from the right endpoint to the initial stopping point, and $L_2$ is the total extent of tracing. $V_{T_1}$ and $V_T$ are the velocities for $L_1$ and $L_2$, respectively, in the line-tracing task. $V_E$ shows the velocity for the whole line extent in the line-erasing task. Values are means with the standard deviation.

Table 3. Profiles of control patients with a right-hemisphere stroke

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Duration after onset (months)</th>
<th>Lesion site</th>
<th>Aetiology</th>
<th>Symptom</th>
<th>MMSE$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>66</td>
<td>Male</td>
<td>4</td>
<td>Thalamus</td>
<td>Haemorrhage</td>
<td>Left hemiparesis</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>76</td>
<td>Male</td>
<td>5</td>
<td>Putamen</td>
<td>Haemorrhage</td>
<td>Left hemiparesis, dysarthria</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>68</td>
<td>Male</td>
<td>1.5</td>
<td>Precentral gyrus, middle frontal gyrus</td>
<td>Infarction</td>
<td>Clumsiness of left hand</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>55</td>
<td>Male</td>
<td>3</td>
<td>Putamen, corona radiata</td>
<td>Infarction</td>
<td>Left hemiparesis</td>
<td>29</td>
</tr>
</tbody>
</table>

$^a$Mini-mental State Examination.

Fig. 1. Representative pattern of leftward movement in the tracing or erasing of a 200 mm line. In the line-tracing task, $L_1$ indicates the distance from the right endpoint to the initial stopping point and $T_1$ indicates the time taken to move this distance. $L_2$ and $T_2$ indicate the total extent and time of tracing, respectively.

Table 2. Extent (mm) and velocity (mm/s) of leftward movements.

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$L_1$ is the distance from the right endpoint to the initial stopping point, and $L_2$ is the total extent of tracing. $V_{T_1}$ and $V_T$ are the velocities for $L_1$ and $L_2$, respectively, in the line-tracing task. $V_E$ shows the velocity for the whole line extent in the line-erasing task. Values are means with the standard deviation.

ward movement with two main factors (task and line length). Task showed a significant main effect: $V_E$ was significantly higher than $V_{T_1}$ ($F[1, 54] = 192.77; P < 0.0001$). As for line length, there was no significant main effect. Task $\times$ length interaction was not significant.

Discussion

In the line-erasing task, not only the frequency of successful trials, but also the velocity, was significantly higher than in the line-tracing task. In other words, the patient with severe neglect could execute leftward movement flawlessly when he erased the line from the right endpoint. The results suggest that the tracing difficulty may be due to a strong attentional bias or overattention to the right part of the line. There is, however, another possibility: that the line-tracing task required a more complex response than the line-erasing task and induced the difficulty in leftward tracing.

Experiment 2

This experiment was aimed at examining whether leftward movement was affected by the right-sided stimulus when line erasing was commonly used as the response. The patient underwent this experiment 1 month after Experiment 1.

Methods

Right-cue condition. The patient was presented with a line with a red spot 5 mm in diameter at the right endpoint. The examiner explained to the patient that the red spot was not erasable and asked him to erase the line from the right endpoint.
**Table 5. Extent (mm) and velocity (mm/s) of leftward movements for the patient with severe neglect**

<table>
<thead>
<tr>
<th>Line length (mm)</th>
<th>Right-cue condition</th>
<th>No-cue condition</th>
<th>Statistical significance$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>147.7 (14.3)</td>
<td>150.0 (0.0)</td>
<td>$P &lt; 0.01$</td>
</tr>
<tr>
<td>200</td>
<td>160.8 (39.6)</td>
<td>200.0 (0.0)</td>
<td>$P &lt; 0.01$</td>
</tr>
<tr>
<td>250</td>
<td>172.3 (38.0)</td>
<td>239.2 (34.2)</td>
<td>$P &lt; 0.01$</td>
</tr>
</tbody>
</table>

$^a$Fisher’s exact test.

Values are means with the standard deviation.

**No-cue condition.** The patient performed the line-erasing task in the same way as Experiment 1.

The order of the two conditions was balanced using an ABBA design. In each condition, the patient performed 10 trials for each length in an order randomized across the three lengths.

Four control patients with a right-hemisphere stroke were also examined in the no-cue condition. They showed no USN in the screening tests for neglect and the activities of daily living. Table 3 shows their profiles.

**Results**

**Number of successful trials.** Table 4 shows the number of successful trials in the right-cue and no-cue conditions. He reached the left endpoint in 12 of the 30 trials with a right cue and in 29 of the 30 trials with no cue. The frequency of successful trials was significantly higher in the no-cue condition than in the right-cue condition (Fisher’s exact test, $P < 0.01$). In the right-cue condition, the number of successful trials was significantly greater for the 150 mm lines than for the 250 mm lines (Fisher’s exact test, $P < 0.05$).

**Extent and velocity of leftward movement.** Table 5 shows the mean extent and velocity of leftward movement in the right-cue and no-cue conditions. In each condition of this experiment, the velocity was nearly constant throughout the extent of erasing. We therefore calculated the velocity for the total extent of erasing in both tasks.

An analysis of variance was applied to the velocity of leftward movement with two main factors (condition and line length). Condition showed a significant main effect: The mean velocity was slower in the right-cue condition than in the no-cue condition ($F[1, 54] = 17.08; \ P < 0.0001$). As for line length, there was no significant main effect. Condition $\times$ length interaction was not significant.

The possibility remains that the difference in velocity resulted from the shorter extent of erasing in the right-cue condition than in the no-cue condition. We compared the results of successful trials between the two conditions. The mean velocity was again greater in the no-cue condition using 150 and 200 mm lines ($F[1, 27] = 4.99; \ P < 0.05$).

Table 6 shows the mean velocity in the no-cue condition for the four right-hemisphere controls. The result shows that when the right cue was absent, our neglect patient could erase a line at a speed within the range of the right-hemisphere controls without neglect.

**Discussion**

In this experiment, we used line erasing commonly as the response. The patient with severe left USN showed decreased leftward extent and velocity of erasing when there was an attention-attracting stimulus on the right side. The result suggests that overattention to the right-sided stimulus impaired the leftward movement. In addition, the speed of leftward movement itself was preserved when compared with that of the right-hemisphere controls without neglect.

In the no-cue condition, no hesitant motion and stopping were observed, and the velocity of leftward movement was increased, compared with the results of the line-tracing task in Experiment 1. This better performance might result from some improvement of neglect during the interval between the two experiments, although severe neglect was still observed in the screening tests.

**General discussion**

The patient with severe USN performed the line-tracing task that required leftward movement of the right arm. The extent of tracing movement was limited to the right part of the line and its execution was slowed. When the examiner tried to move the patient’s arm leftward, he showed a strong resistance to leftward movement. However, he could move the arm leftward without difficulty when performing the line-erasing task. The results show that the ability of leftward movement of the arm itself was preserved. We therefore conclude that overattention to the right-sided stimuli impaired his leftward movement.
According to Tegnér and Levander (1991), Bisiach et al. (1990) and Bottini et al. (1992), directional hypokinesia may play a part in USN of patients with lesions that involve the frontal lobe, while attentional deficit may predominate in those who have lesions confined to the postrolandic area. In our case, SPECT revealed an area of decreased cerebral blood flow in the right postrolandic area, which suggests that the parietal lobe of our case had a functional deficit. The results of the present study are therefore compatible with the hypothesis concerning lesion site and mechanisms of neglect.

The premotor theory of spatial attention by Rizzolatti and Gallese (1988) posited that the setting of a motor plan should produce a shift of attention toward the direction in which the motor plan will be executed. Ishiai et al. (1994) showed that the patients with left USN could extend a horizontal line leftward almost correctly to double its original length. They considered that the patients could compare the lengths of the right and left segments of a line as the execution of a leftward movement enabled the patients to shift attention sufficiently to the left side. Our patient with severe left USN, however, could not maintain leftward movement in the condition with attention-attracting stimuli on the right side even when he started the required movement. In patients with severe neglect, an intention or initiation of leftward movement cannot induce effective shift of attention to the left side.

Rizzolatti and Gallese (1988) also stated that an attraction of attention to a stimulus may activate a movement toward the same direction as the attended stimulus. Tegnér and Levander (1991) and Bisiach et al. (1990) tried to separate premotor factors from perceptual factors in USN. Tegnér and Levander used a 90° angle mirror and Bisiach et al. devised an apparatus with a pulley to dissociate the horizontal line of visual attention and that of hand movement. They intended that attention should be directed to the direction opposite to that of the movement. Mattingley et al. (1994, 1998) pointed out that these experiments might provide only the empirical evidence relevant to the directions of ‘input’ versus ‘output’ factors in neglect. Incongruent conditions in such tasks give rise to unnatural visual–proprioceptive and visual–kinetic correspondences. Any apparent dissociation between congruent and incongruent conditions may therefore reflect the susceptibility of brain-damaged patients. They claimed that natural visuomotor correspondences in the device are necessary to verify whether perceptual or motor dysfunction affects performance of neglect patients.

Mijovic (1991) reported that she failed to detect directional hypokinesia regardless of the severity of clinically assessed neglect and lesion site. In the reversed visual condition, her task required leftward movement of the arm when the attention-attracting target was located in the right space. As the target was brought to the central point by moving the arm leftward, attention was also shifted in the same direction. The ability of leftward movement was estimated appropriately because the direction of attentional shift coincided with that of arm movement. In our tasks, attention was also expected to shift in the same direction as the movement of the arm.

The presence of the right-sided stimulus, however, reduced the extent and velocity of leftward movement. We therefore consider that, in patients with severe left USN, leftward movement cannot be estimated appropriately when there is an attention-attracting stimulus on the right side. It seems necessary to remove right-sided stimuli, and to couple the direction of attentional shift and that of arm movement, to clarify motor aspects of severe USN.

Ládavas et al. (1993) and Mark et al. (1988) reported that the removal of attention-attracting stimuli on the right side improved exploration to the left side in patients with left USN caused mainly by perceptual factors. In our line-erasing task, no stimulus or line was visible to the right of the eraser which was moved leftward with the hand of the patient. The tasks of Mark et al. and Ládavas et al., and the line-erasing task, are appropriate to estimate leftward exploration or movement of patients with severe neglect because they are required to remove the stimuli that capture their attention. The line-tracing task and the line-erasing task with or without a right cue have an advantage to analyse the temporal process of leftward movement of the arm. We consider that combination of these tasks may contribute to better understanding of attentional and motor factors of neglect, as it may quantify the effect of the attention-attracting stimulus on leftward movement.

Acknowledgements

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References

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### Leftward movement in severe neglect

**S. Sato, S. Ishiai, K. Seki, Y. Koyama and H. Mizusawa**

**Abstract**

The difficulty that patients with unilateral spatial neglect (USN) have in exploring into the contralesional space may be explained by motor or attentional disorder. We experienced a patient with severe USN following cerebral infarction in the right postrolandic region, who showed a strong resistance to leftward movement. We devised two sets of tasks using a whiteboard. In the first experiment, the patient showed great difficulty in tracing a line from the right endpoint to the left endpoint. The examiner barely made him start further tracing even by pushing the hand leftward. By contrast, he quickly erased a whole line leftward with an eraser pen. In the second experiment, he was required to erase a line with or without an attention-attracting stimulus at the right endpoint. Not only the leftward extent, but also the velocity of erasing, were decreased when there was a stimulus at the right endpoint. The results of the two experiments suggest that the ability of leftward movement itself was preserved and overattention to the right-sided stimuli impaired his leftward movement. We consider that use of the line-tracing and line-erasing tasks may contribute to a better understanding of interaction of attentional and motor factors in severe USN.

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Neurocase 2000; 6: 45–50

**Neurocase Reference Number:**

O182

**Primary diagnosis of interest**

Unilateral spatial neglect

**Author's designation of case**

None

**Key theoretical issue**

- Premotor theory

**Key words:** unilateral spatial neglect; leftward movement; attention; directional hypokinesia

**Scan, EEG and related measures**

MRI, SPECT

**Standardized assessment**

Test battery for neglect, WAIS-R

**Other assessment**

Line-tracing and line-erasing tasks

**Lesion location**

- Right postrolandic lesion

**Lesion type**

Cerebral infarction

**Language**

English