CASE REPORT

Neglected-Field Eye Patching Improves Visual Inattention in Hemispatial Neglect: A Case Study

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Objective: Recently, eye patching has been used as a technique for adjusting visual information. However, there are differing opinions regarding the influence of eye patching on visual attention in hemispatial neglect. Studies on eye patching do not usually consider the effects of differences in task difficulty or reaction space. Moreover, to date, no trial has used neglected-field eye patching. We investigated the effect on hemispatial neglect of hemi-visual field eye-patching glasses in a patient with left spatial neglect. **Methods:** The patient was an 86-year-old woman who had suffered a stroke. She had severe left hemiparesis and left spatial neglect. Three types of eye-patching glasses were used: right-field patching, left-field patching, and no patching. The line bisection test, the line crossing test, the star cancellation test, and the letter cancellation test were carried out for the three eye-patching conditions. **Results:** The line bisection test results showed rightward deviations for both left and right patching compared to no patching. For the line crossing test, there were no omission errors for any patching condition. In the star cancellation test, there were small differences between the three patching conditions. However, in the letter cancellation test, the fewest omission errors occurred during left-field patching, with the most notable improvement on the right half of the test paper. **Conclusion:** The results suggest that neglected-field eye patching for hemispatial neglect might improve visual attention, especially the non-spatial aspects.

Key Words: attention network system; eye patching; hemispatial neglect; processing resources for attention; stroke

INTRODUCTION

Patients with hemispatial neglect fail to perceive or respond to stimuli on the contralesional side.¹⁾ In general, left spatial neglect is more severe than right spatial neglect. The basic effect of left spatial neglect is the rightward bias of spatial attention; however, left spatial neglect seems to result in inattention not only in the leftward space but also in the rightward space. Robertson et al.²⁾ reported that patients with left spatial neglect had deficits in spatial and non-spatial attention. Kahneman³⁾ noted that the attention process is performed using limited mental resources. This means that attention processing for simple tasks with little perceptual information is likely to be carried out satisfactorily because such tasks do not require extensive resources. Nonetheless,

for more complex tasks, non-spatial inattention in left spatial neglect may result from a lack of processing resources for attention. Consequently, the reduction in perceptual information by partial restriction of the visual field could improve non-spatial inattention.

Bisiach et al.⁴⁾ reported that patients with left spatial neglect selected well-shaped drawings when making preference judgments, although they were unable to detect left-sided differences in paired drawings. This result indicates that patients with left spatial neglect do perceive the visual information from the neglected space, regardless of their intention. Dorsal and ventral network systems in the human brain are known to be involved in attentional functions.⁵⁾ Broadly speaking, the dorsal network is activated during orientation of attention toward an expected stimulus,

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Fig. 1. MRI images of the patient's brain. These panels show damage in the right frontal, temporal, and parietal lobes, including the middle frontal gyrus, inferior frontal gyrus, precentral gyrus, postcentral gyrus, superior temporal gyrus, and insula.

whereas the ventral network is activated during the detection of an unexpected stimulus. Patients reported by Bisiach *et al.* ignored the leftward space when they selected essential objects from a large amount of unintentionally perceived information.

In previous studies,^{6–14)} eye patching has been used as a technique to adjust visual information. However, there are differing opinions regarding the influence of eye patching on visual attention in hemispatial neglect. These previous studies focused on the rightward bias of spatial attention and did not take into account the amount of processing resources required for attention. Moreover, the studies did not consider the effects of differences in task difficulty or reaction space. To date, no trial has used neglected-field eye patching.

The current study aimed to determine whether manipulations of visual information using hemi-visual field eye-patching glasses influenced the response to visual attention tasks in a patient with left spatial neglect.

MATERIALS AND METHODS

Case Description

An 86-year-old right-handed woman suffered a right cardioembolic cerebral infarction. Magnetic resonance imaging (MRI) showed damage in the right middle frontal gyrus, the inferior frontal gyrus, the precentral gyrus, the postcentral gyrus, the superior temporal gyrus, and the insula. However, the right inferior parietal lobule was intact (**Fig. 1**). The patient had severe left hemiparesis and hemihypoesthesia, along with left spatial neglect without hemianopia. The patient's scores for the behavioral inattention test (BIT, Japanese version)¹⁵⁾ were 121 points for the conventional subtest (cutoff point 131/146) and 63 points for the behavioral subtest (cutoff

point 68/81) (**Table 1**). The patient showed no evidence of cognitive dysfunction in a mini-mental state examination (26 points). Measurements were obtained 5 months after the onset of stroke. This study was carried out in accordance with the code of ethics of the World Medical Association. After the patient and her husband received an explanation of the procedures of this study, she agreed to participate and gave permission for the use of MRI images and data.

Materials

Hemi-visual field eye-patching glasses were made by attaching paper to standard glasses containing noncorrective clear lenses. Paper was positioned to cover half of each eyeball with the patient looking straight ahead. This study investigated three patching conditions: right-field eye patching, left-field eye patching, and no patching (**Fig. 2**).

Procedure

The visual attention tests used were the line bisection test, the line crossing test, the star cancellation test, and the letter cancellation test included as BIT conventional subtests. The line bisection test comprised three horizontal lines drawn on an A4 sheet of paper. The top line was located to the right side of the paper, the middle line was in the center of the paper, and the bottom line was located to the left side of the paper. The deviation of the patient-indicated center from the true center was measured in millimeters for each line. The other three tests were analyzed by counting independently the number of omission errors in the right and left halves of the A4 sheets of paper. The patient was familiar with these tests because she had done them many times previously without eye patching. Each test was carried out only once, in accordance with the standard method for BIT.

Table 1. Behavioral inattention test: subtest scores

Item	Score	Cutoff point
BIT conventional subtest	121/146	131/146
Line crossing	36/36	34/36
Letter cancellation	32/40	34/40
Star cancellation	43/54	51/54
Figure and shape copying	2/4	3/4
Line bisection	9/9	7/9
Representational drawing	0/3	2/3
BIT behavioral subtest	63/81	68/81
Picture scanning	4/9	6/9
Telephone dialing	8/9	7/9
Menu reading	9/9	8/9
Article reading	3/9	8/9
Telling and setting the time	5/9	7/9
Coin sorting	5/9	8/9
Address and sentence copying	9/9	8/9
Map navigation	9/9	8/9
Card sorting	6/9	8/9

Left field eye patching

Right field eye patching

Fig. 2. The hemi-visual field eye-patching glasses. The images in Figure 2 is of one of the article's authors.

All tests were performed with the patient seated at a desk. The sheet for each test was placed in front of her and was centered at the midline of her body. The patient held a felt pen in her right hand and the movement of her head was not

restricted. Tests were first carried out in the no patching condition, followed by right-field eye patching and then left-field eye patching.

Table 2. Deviation from the true center in the line bisection test

Position of the line	NP	RP	LP
Top (mm)	2	−1	−2
Middle (mm)	3	13	5
Bottom (mm)	7	31	24

NP: no patching; RP: right-field patching; LP: left-field patching.
Deviation to the right from the true center is positive.

RESULTS

The line bisection test responses showed rightward deviations for the middle and bottom lines in both patching conditions compared with the no patching condition. This effect was most notable for right-field eye patching (**Table 2**). In the line crossing test, there were no omission errors under any patching condition. In the star cancellation test, there were small differences between the three patching conditions. However, in the letter cancellation test, the number of omission errors with left-field eye patching was markedly reduced in the right half of the sheet compared with right-field eye patching and no patching (**Fig. 3** and **Table 3**).

DISCUSSION

In this study, both patching conditions worsened the rightward deviation in the line bisection test. This tendency was strongly observed in the line to the left side of the sheet and was most notable during right-field eye patching. Halligan *et al.*¹⁶⁾ reported that the degree of rightward deviation in the line bisection test was not relative to left visual field deficits in patients with left visuospatial neglect. Although wearing left-field eye-patching glasses may appear to produce left visual field deficits, simulated deficits that are only observed while testing would be unable to elicit the same reaction as true deficits. Arai *et al.*⁶⁾ reported that wearing right-field hemispatial sunglasses improved the rightward deviation in left spatial neglect in 4 of 10 cases and worsened it in 2 of 10 cases. To date, no study has investigated pencil-and-paper test responses of participants wearing neglected-field eye-patching glasses. Ishiai *et al.*¹⁷⁾ designed a line extension task that requires participants to extend a horizontal line leftward to double its original length. They reported that patients who displayed left spatial neglect in the line bisection test were able to accurately complete the line extension task, which requires intentional checking of the line length. Patients with left spatial neglect seem to decide the subjective midpoint of a line quickly, without carefully searching for the left edge

of the line. Thus, hemi-visual field eye patching would result in lines being recognized as shorter than the actual lines because of the reduced amount of visual information caused by patching. Furthermore, with left-field eye patching, as in left visual field deficit, the patient would bisect partially missing lines in the rightward (un-neglected) visual field. Conversely, with right-field eye patching, as in right visual field deficit, the patient would have to bisect the lines in the leftward (neglected) visual field. Therefore, the results of the line bisection test are likely to be affected by such differences among the three eye-patching conditions.

Although the other tests (the line crossing test, the star cancellation test, and the letter cancellation test) are all mainly related to intentional selective attention, they vary in difficulty level because of the difference in the cognitive load required for selective attention. The letter cancellation test is the most difficult of the three tests because it is composed of a dense array of letters with a large variety of obstructive letters. Moreover, these tests require visual searching, in contrast to the momentary judgment required for the line bisection test.

This study showed the very interesting result that left-field eye patching greatly improved inattention in the letter cancellation test, most notably in the right half of the sheet. However, the line crossing test was completed successfully regardless of the difference in patching conditions. Desimone *et al.*¹⁸⁾ proposed “the biased competition model,” which states that top-down neural mechanisms control the competition for processing resources required to capture various objects on the basis of bottom-up neural mechanisms. The line crossing test could be executed with few resources because of the task’s low cognitive load. Consequently, differences between patching conditions were not evident. However, the letter cancellation test uses many resources because of the high cognitive load of the task. Because eye patching reduces unintentional perceptual information related to bottom-up neural mechanisms, the processing resources available for selective attention are enhanced, allowing the letter cancellation task to be carried out more effectively. Patients with left

Fig. 3. Results of the letter cancellation test for each patching condition. Top, no eye patching; middle, right-field eye patching; bottom, left-field eye patching.

Table 3. Number of omission errors in the cancellation tests

Test	No patching		Right-field patching		Left-field patching	
	Left	Right	Left	Right	Left	Right
Star cancellation	2	1	1	3	1	0
Letter cancellation	10	7	6	5	7	1

Left: left half of the sheet of paper; right: right half of the sheet of paper.

spatial neglect are likely to attend to rightward objects and space. Therefore, errors in the pencil-and-paper tests would likely decrease in the right half of the sheet as a result of eye patching. Moreover, the visible field would be positioned to the right space during left-field eye patching and, inversely, to the left space during right-field eye patching. Therefore, left-field eye patching greatly decreased the number of omission errors in the right half of the sheet, and right-field eye patching slightly improved overall inattention. If these differences among the three patching conditions were affected by the learning effect, left-field eye patching would decrease the rightward deviation in the line bisection test compared with no patching condition. However, this was not the case. In previous studies,^{6–14} researchers have reported the influence of right eye patching or right-field eye patching on left spatial neglect. However, there is currently no general agreement about the effect. Moreover, both positive and negative effects were reported by similar studies.^{6,7,11,13} Smania *et al.*¹⁹ suggested three theories for the rationale of eye patching in hemispatial neglect: the Sprague effect theory, the interhemispheric balance theory, and the visual exploration constraint theory. These theories focus on spatial inattention. Other researchers have reported that training for non-spatial attention had improved not only non-spatial but also spatial inattention in patients with left spatial neglect.^{2,20–23} Consequently, it is evident that the visual attention system is composed of multiple networks. The current patient seemed to have both spatial and non-spatial inattention because she missed targets on both the left half and right half of the sheet in the letter cancellation test. It seems that she was affected mainly by non-spatial inattention. Therefore, it would be better to plan attention training using left-field eye-patching glasses taking into account the reduction in the extent of covering. Because this study was a case report, it was impossible to clarify the relationship between the field eye patching and the visual network system. Therefore, the task of future research is to elucidate this issue by investigating more cases.

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CONFLICTS OF INTEREST

There are no conflicts of interest to declare.

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