Eye Patching in Unilateral Spatial Neglect: Efficacy of Two Methods

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ABSTRACT. Beis J-M, André J-M, Baumgarten A, Challier B. Eye patching in unilateral spatial neglect: efficacy of two methods. Arch Phys Med Rehabil 1999;80:71-6.

Objectives: To determine whether patches obscuring half the visual field affect eye movement in subjects with unilateral spatial neglect and whether there is consequent improvement in the subject's everyday life, and to interpret the potential changes observed with the aid of a theoretical model.

Design: Prospective and randomized study.

Setting: Rehabilitation medicine department in an urban general hospital.

Patients: Twenty-two subjects with left unilateral neglect.

Intervention: Two eye-patching procedures—right half-field patches (n = 7) and right mononuclar patch (n = 7)—and control group (n = 8).

Main Outcome Measures: Functional tests (FIM) and analytical tests (measurement of right eye movements by photo-oculography) at admission and after 3 months.

Results: Results of the paired comparison tests showed (1) significant differences between the control group and the group with the half-eye patches for total FIM score (p = .01) and the displacements of the right eye in the left field (p = .02), and (2) no significant differences between the control group and the group with the right monocular patch.

Conclusion: Patching the right half-field helped subjects initially regain voluntary control over the deficit. The actual interpretation is based on physiologic and psychophysiologic models.

UNILATERAL SPATIAL neglect (USN) occurs in many animals, including humans.[1-3] This syndrome, defined by the inability to respond to stimuli present in a particular visual half-field, often results from lesions of the right hemisphere.[4] Several hypotheses of USN have been put forward: the representational hypothesis,[5] the arousal hypothesis,[2] and the spatial attention hypothesis.[6] Posner and associates[7] have also suggested that some aspects of spatial disorientation after parietal lesion might be interpreted as difficulty in disengaging attention from the side of the space ipsilateral to the lesion.

Several signs associated with USN, such as anosognosia and asomatognosia, indicate that the disorder will become incapacitating and a handicap.[8,9] The rehabilitation of unilateral visual neglect syndrome is difficult and functional assessments are often conflicting. Halligan and colleagues[10] analyzed the methods of USN rehabilitation training[11] and concluded that "no known therapy can reliably meet the criteria of producing long lasting effects and a generalization to everyday situation." There may be a significant improvement after treatment, but only in the specific tasks in which the subjects were trained.[12,13] There can also be general improvement in tasks similar to those of everyday life.[14]

Other rehabilitation techniques, such as vestibular stimulation,[15,16] optokinetic stimulation,[17] and neck muscle vibration,[18] are of a more theoretical nature. Their sometimes spectacular effects are short-lived and difficult to evaluate in daily use. Butter and Kirch[19] found that the use of eye patches was effective in 11 of 13 patients in 1 of 5 tests (line bisection test). They emphasized that this effect was limited to the period during which the patch was worn. They also evaluated the isolated and combined effects of eye patching and of left-side dynamic stimulation of vision in 18 subjects with left visual neglect caused by stroke.[19] The combination of eye patching and lateral visual stimulation was significantly more effective in the same line bisection test. This improvement was dependent on age, sex, time since vascular damage, visual disorders, and, potentially, associated eye movements. Walker and coworkers,[20] however, found that right-eye patching did not produce a consistent reduction in the severity of neglect. Only 3 of 9 patients showed a decrease in neglect after right-eye patching on one or more of the tests used—cancellation, line bissection, clock drawing, word reading, and text reading. Arai and associates[21] showed that use of right half-field patches improved performance in three tasks: line bisection, line cancellation of 40 randomly oriented lines, and figure copying of a cube. There was long-term functional improvement in one patient.

Eye patching techniques are of interest because they are based on the use of anatomic, physiologic, and psychophysiologic models,[19,21,22] and they are inexpensive and practical to use. Our hypothesis was that eye patches can be used to alter the processing of visual information by affecting the information-processing structures of the central nervous system. The eye patch should increase eye movements toward the contralateral space in a healthy subject.[23] Single-eye patching has been shown to decrease visual neglect in monkeys subjected to surgical lobotomy.[24] In practice, eye-patching techniques of the right eye cause the patient to look toward the left, either by eye movements or by movements of the head, and increase attention. These effects encourage the development of voluntary, deliberate control of attention in the short term and the development of automatic shifts of attention over the longer term.[25] This prospective, randomized study describes the effects of entire patches over one eye and half patches over both eyes in patients with left hemineglect. The aims were to determine whether patches obscuring half the visual field affected eye movements, to determine whether there was a general improve-

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ment in the subject's everyday life, and to interpret the potential changes observed with the aid of a theoretical model.

METHOD

Subjects. Twenty-two subjects were assigned randomly to one of three groups. Group 1 (consisting of seven men, one woman; mean age = 51.5, SD = 3.5; time from onset of symptoms to test, 49 ± 7 days) were the controls; group 2 (consisting of five men, two women; mean age = 51.4, SD = 3.7; time from onset of symptoms to test, 48 ± 4 days), were given half-eye patches; and group 3 (consisting of five men, two women, mean age = 50.8, SD = 6.03; time from onset of symptoms to test, 51 ± 3 days) were given complete eye patches. Written consent was obtained from all subjects before the experiment. The criteria for inclusion were the existence of a right cerebral vascular lesion as shown by computed tomography or magnetic resonance imaging, and unilateral visual neglect as shown by Diller's test.[26] All patients were younger than 70 years and right-handed. The criteria for exclusion were age (older than 70) and a history of psychiatric or neurologic disorder.

Evaluation. The visual fields of all subjects were evaluated using a computer-driven perimeter. This device consisted of an array of red light-emitting diodes set in a horizontal semicircle. Two sweep sequences were used—random and simultaneous right and left from the periphery toward the center. This computerized test makes it possible to detect visual field defects, visual extinction, or mixed disorder.[27] The device included an automatic analysis of the results and a standard report indicating diagnosis of neurovisual disorders. Diagnosis of USN was based on Diller's test (letters cancellation task),[26] interpreted according to the criteria determined by Seron (number of targets omitted from the left side of a page, max = 50).[28] Letter cancellation was chosen as a task that may be influenced by spatial forms of neglect. All 22 patients showed signs of left-sided neglect on this test. The movements of the right eye, observed while four subjects read aloud a series of letters, were recorded by photo-oculography.[29,30] Two measures were performed: the number of times the subject looked at the zone and the time spent looking at letters in two reference zones, one in the right half-field and the other in the left half-field (figs 1 and 2). The independence of each individual was then evaluated using a scale of functional independence, the Functional Independence Measure (FIM).[31] The FIM consists of 18 items that assess a broad range of activities of daily living within 13 motor items (eg, transfer bed, toileting, and dressing) and five cognitive items (eg, comprehension, expression, and social interaction).

Material. The subjects were given standard spectacle frames containing noncorrective lenses to which a right monocular patch or right half-field patches could be attached (fig 3). Patching was done after any refraction problems were solved, using the patch and the patient's corrective lenses.

Procedure. Each subject was assigned randomly to group 1, 2, or 3. Diller's test,[26] a study of the visual field, analysis of right-eye movements, and calculation of a total FIM score were carried out by two researchers. These studies were performed, without the patches, on admission and after 3 months. All patients, both control and treated, underwent the same rehabilitation program.[11] The patched glasses were worn throughout the day. The average length of time the subjects wore the patches was 12 hours. The subjects wore the specially adjusted glasses for the entire period from admission to 3 months afterward.

Statistical analysis. The three groups were compared using nonparametric tests because of the distribution of the variables and the population size. We used the Kruskal-Wallis H test. The results were significant when all three groups were compared simultaneously, so we used the Mann-Whitney *U* test to compare the groups in pairs. The significance level used was $p = .05$. The dependent variables were the change in total FIM score over 3 months, time spent looking at the letters, and the number of glances toward each reference zone on the right and left. The statistical analysis was performed using the BMDP 7.0 program.[32]

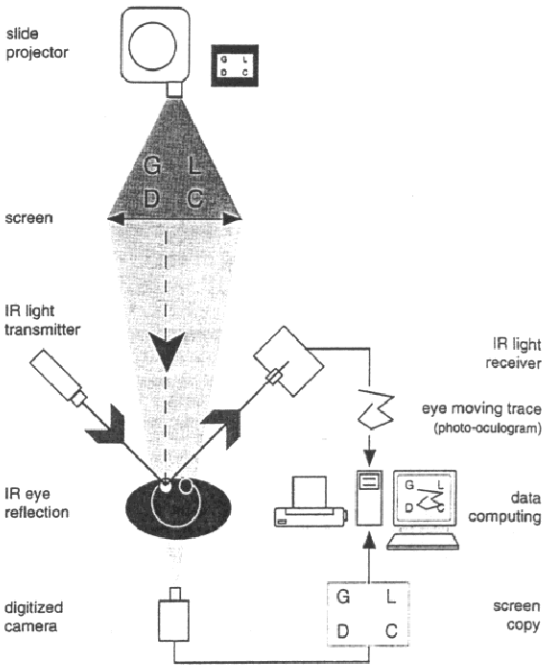

Fig 1. Optic eye tracker set-up.

RESULTS

Figures 4, 5, and 6 show the changes in total FIM score, time spent looking at the letters, and the number of times the right eye looked at each reference zone on the right and left, between the assessments at admission and at 3 months. The changes in total FIM score were greatest in subjects wearing right half-field patches. The time spent looking at the left reference zone was longest in the treated subjects after 3 months. This was most marked among those with right half-field patches. The same pattern was observed for the number of times the subject looked at the left reference zone. The results of the statistical analysis for each group are shown in table 1. The results are significant when all three groups are analyzed together for total FIM score ($p = .009$) and the number of times the subject looked at the left-hand reference zone ($p = .03$). The results of the paired comparison tests showed a significant difference after 3 months for total FIM score ($p = .01$) and the number of times the subject looked at the left-hand reference zone ($p = .02$) between the control group and the group with right half-field patches.

DISCUSSION

Eye patching is a simple method that most patients find acceptable, although many may feel uncomfortable at first.

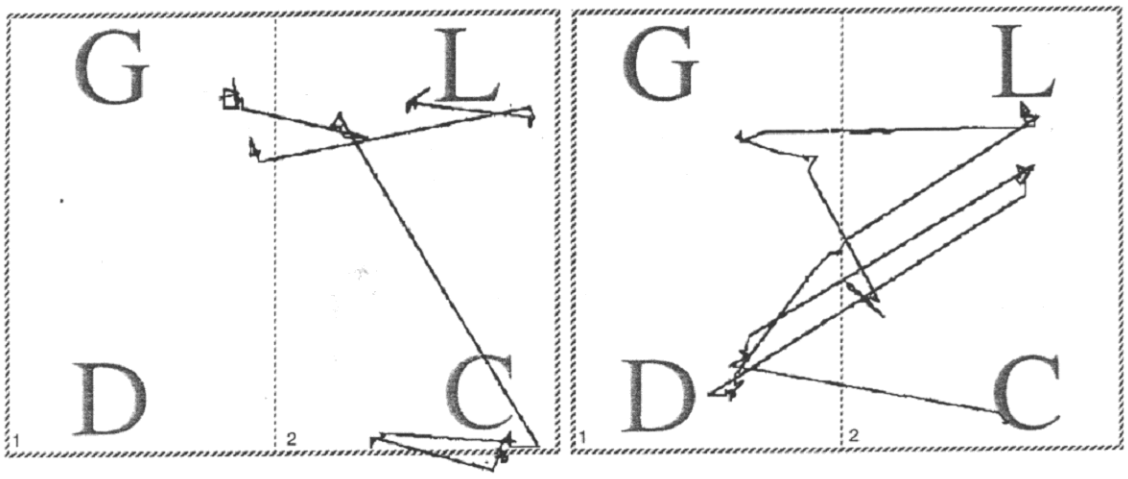

Fig 2. Recording of right eye movements by photo-oculography: test of reading letters aloud. The results of subject 4, group 2, are shown as an example. On the left: T = .79 sec (time taken to visually explore zone 1 and read the letters G and D); F = 2 (number of times the subject looked at zone 1) = 2; T = 1.36 sec (time taken to visually explore zone 2 and read the letters L and C); and F = 3 (number of times the subject looked at zone 2). On the right, the results of the same subject with right half-field patches at 3 months: T = 1.8 sec (time taken to visually explore zone 1 and read the letters G and D); F = 4 (number of times the subject looked at zone 1) = 2; T = 2.01 sec (time taken to visually explore zone 2 and read the letters L and C); F = 3 (number of times the subject looked at zone 2)

There was a significant reduction in visual neglect after 3 months, in patients treated with right half-field patches. The movements of the right eye in the left field improved and the patient was more independent in everyday life. The groups did not differ with respect to the variables age, time since onset of stroke, and CT lesions. For the variable FIM, the control group appeared different from the treatment groups at the outset of the study. The control group (group 1) was at a higher level than the treatment groups (groups 2 and 3). The control subjects may have reached a "ceiling" for this variable before the onset of treatment. However, for the variables number of times gaze drifted to the left field and seconds spent looking at the letters, the control and therapy groups did not differ significantly at the outset of the study. Furthermore, comparisons of before and after differences using the control group as a reference were meaningful. This indicates that the comparison of change from before to after treatment was valid.

The effects of the different eye-patching methods can be interpreted using models (fig 7). Anatomic and physiologic models suggest that patching reduces the inhibition by the healthy superior colliculus, whereas psychophysiologic models focus on a deficit in the control over shifts of attention.[6,7] Posner and Rafal[33] suggested eye patching as a plausible rehabilitation technique, based on the consideration that the primate eye has been thought to have a stronger projection to the contralateral

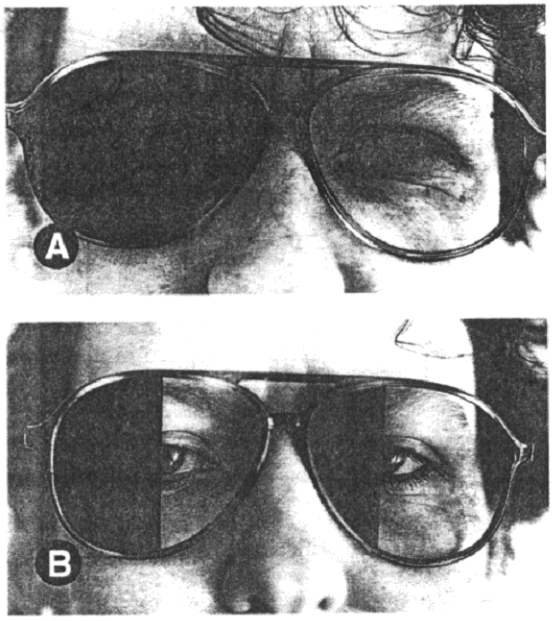

Fig 3. (A) Glasses and complete right patch; (B) glasses and right half-field patches.

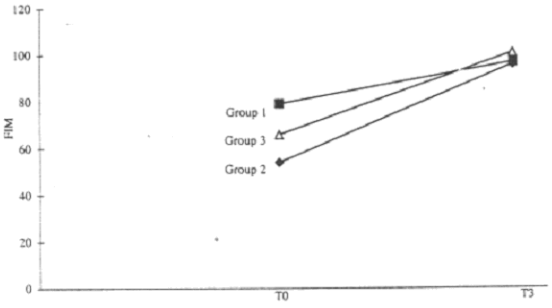

Fig 4. FIM scores at admission (T0) and at the 3-month (T3) assessment for each group (group 1, control; group 2, right half-field patches; group 3, complete right-eye patch).

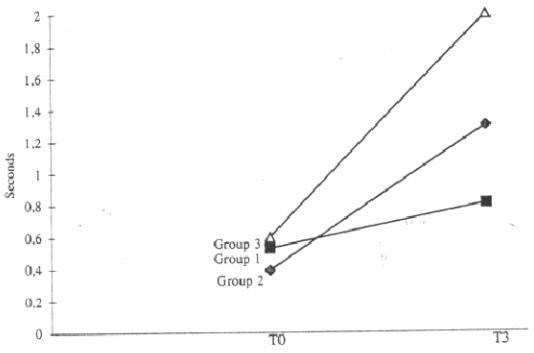

Fig 5. The time (sec) right eye spent examining the left half-field at admission (T0) and at the 3-month (T3) assessment for each group (group 1, control; group 2, right half-field; group 3, complete right-eye patch).

superior colliculus than the ipsilateral colliculus.[34] The superior colliculus is a structure known to be involved in programming saccadic eye movements.[35] Patching the ipsilesional (right) eye of patients with left-sided visual neglect (right brain injury) would reduce the input to the contralateral (left) superior colliculus (which is programming right saccades), thus reducing the tendency of these patients to bias their eye movements to the right side of the space.[36] Three studies[7,37,38] described two kinds of change in the control of attention shifts—internal "covert" changes with no associated eye movements, and external "overt" changes, which are accompanied by eye movements. Three steps are necessary to redirect the gaze from one target to another. There must be disengagement from the initial focal point, movement of attention to the new target, and engagement of attention on the new target. The patient with visual neglect is unable to disengage attention from the first target. The results obtained by Lavadas and coworkers[39] support the idea that the USN results from a deficit in the mechanisms of shifting attention. This deficit is more pronounced in the lower half-field than in the upper half-field and in the field on the side opposite the lesion, even if it occurs in both fields. The authors suggested that the patients regained

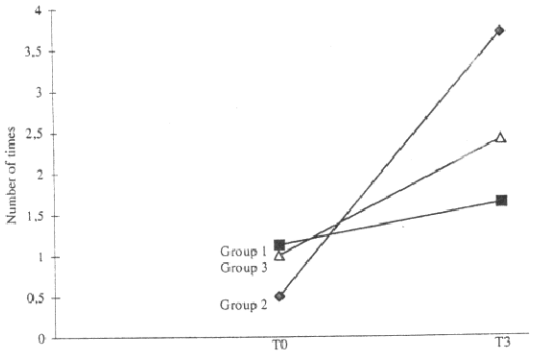

Fig 6. The number of times the subject looked at the left half-field at admission (T0) and at the 3-month (T3) assessment for each group (group 1, control; group 2, right half-field patches; group 3, complete right-eye patch).

Table 1: Comparison of Dependent Variables

Dependent Variables*	Global $p^{\dagger}$	Significant Difference Between 2 Groups‡	$p^{\ddagger}$
FIM	.009	Groups 1 and 2	.01
POG (TR)	NS		
POG (TL)	NS		
POG (FR)	NS		
POG (FL)	.03	Groups 1 and 2	.02

Abbreviations: FIM, functional independence measure; POG, photo-oculography; NS, nonsignificant; TR, time taken to visually explore the zone of interest (R, right half-field); TL, time taken to visually explore the zone of interest (L, left half-field); FR, number of times the subject looked at the zone of interest (R, right half-field); FL, number of times the subject looked at the zone of interest (L, left half-field).
* Difference between admission and 3-month assessment for each variable studied.
† Degree of significance for simultaneous comparison of all groups.
‡ Comparisons of pairs of groups for which global $p < .05$.

some flexibility and became capable of voluntary movement of gaze. They concluded that there may be separate mechanisms controlling involuntary and deliberate attention shifts and that these may have different anatomic locations. Others, such as Ischai and colleagues,[40] have found that hemianopic individuals are conscious of their campimetric deficiency and use overt gaze to compensate for the problem.

Wearing a patch over the two right half-fields causes right homonymous hemianopia and activation of the right hemisphere in isolation, causing an increase in the level of attention. Placing a patch over the right eye of a subject with damage to the right hemisphere is thought to cause simultaneous activation

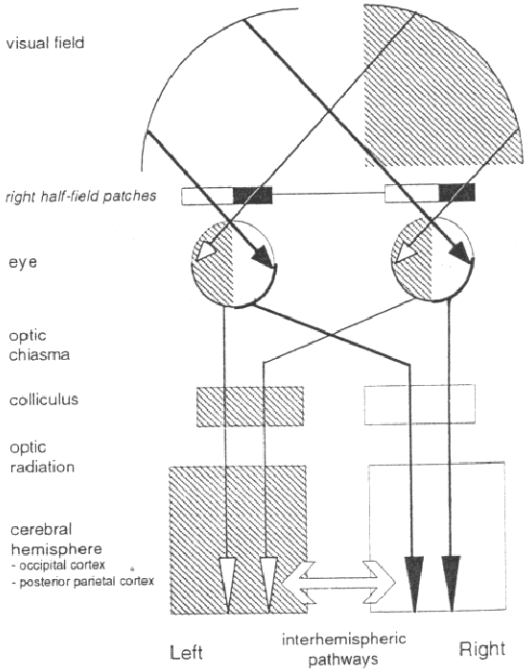

Fig 7. Diagram showing the input from each eye to each hemisphere (normal subject).

of both hemispheres, whereas covering the right half-field should cause activation only of the right hemisphere. A balance between the hemispheres is thus established between the "overactivated" damaged right hemisphere and the "nonactivated" healthy left hemisphere. The complete patch thus has a greater effect on the direction of attention by influencing perception, overall attention, and the management of contextual information. Covering the right half-field should affect the intention of the gaze, influencing foveal perception and the voluntary, deliberate mechanisms of directing the gaze. Our results are consistent with this hypothesis. There was an increase in the number of times the subject's gaze was directed toward the left half-field and in the ability to look at things, indicating an improvement in the mechanisms controlling the overt, voluntary redirection of the gaze, and this had an immediate impact on daily life. We are currently examining the long-term effects (longer than 3 months) of covering the eyes with patches. The durability of the observed improvement is currently unknown.

This study may have consequences for the treatment of unilateral visual neglect. It suggests that methods leading to implicit changes in the behavior of subjects, without requiring training or memorizing, may be most effective. The improvement in FIM scores shows that the compensation methods studied were used in everyday situations. This is probably due to the fact that eye patching has an effect not only during rehabilitation exercises, but also throughout the day in everything the patient does. The long-term continuation of this study, with an assessment of function in daily life, should allow us to determine the value of this technique for overcoming this handicap. USN results from an inability to shift visual attention because of an imbalance between the two hemispheres of the brain.[6] Thus, placing a patch over the eye ipsilateral to the lesion in a patient with unilateral visual neglect should improve the condition. The superior colliculus controls the eye movements determining the direction of gaze with respect to the contralateral space. Most of the retinal afferents of the superior colliculus come from the contralateral eye. Ipsilateral eye patching causes contralateral "de-afferentation" of the superior colliculus by reducing or removing the inputs from the ipsilateral retina. Placing an eye patch over the right eye of a hemineglígent subject reduces the excitatory inputs to the left superior colliculus and thus reduces the inhibition of the damaged, right superior colliculus by the healthy, left superior colliculus. The right superior colliculus then functions more effectively, as it is no longer inhibited by the left superior colliculus.

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References

1. De Renzi E. Disorders of space exploration and cognition. New York: Wiley; 1982.
2. Heilman KM, Bowers D, Valenstein E, Watson RT. Hemispace and hemispatial neglect. In: M. Jeannerod, editor. Neurophysiological and neuropsychological aspects of spatial neglect. Amsterdam: Elsevier; 1987. p. 115-50.
3. Jeannerod M, editor. Neurophysiological and neuropsychological aspects of spatial neglect. Amsterdam: Elsevier; 1987.
4. Heilman KM, Watson RT, Valenstein E. Neglect and related disorders. In: Heilman KM, Valenstein E, editors. Clinical neuropsychology. New York: Oxford University Press; 1985. p. 243-93.
5. Bisiach E, Luzzatti C, Perani D. Unilateral neglect, representational schema and consciousness. Brain 1979;102:609-18.
6. Kinsbourne M. Mechanisms of unilateral neglect. In: Jeannerod M, editor. Neurophysiological and neuropsychological aspects of spatial neglect. Amsterdam: Elsevier, 1987. p. 69-86.
7. Posner MI, Walker JA, Friedrich FA, Rafal RD. Effect of parietal injury on covert orienting of attention. J Neurosci 1984;4:1863-74.
8. Denes G, Semenza C, Stoppa E, Lis A. Unilateral spatial neglect and recovery from hemiplegia. Brain 1982;105:543-52.
9. Hier DB, Mondlock J, Caplan LR. Recovery of behavioral abnormalities after right hemisphere stroke. Neurology 1983;33: 345-50.
10. Halligan PW, Donnegan CA, Marshall JC. When is a cue not a cue? On the intractability of the visuospatial neglect. Neuropsychologia 1992;26:161-6.
11. Diller L, Weinberg J. Hemi-inattention in rehabilitation: evolution of a rational mediation program. In: Weinstein EA, Friedland RP, editors. Advances in neurology, vol. 18. New York: Raven Press; 1977. p. 63-82.
12. Gouvier WD, Bua BG, Blanton PD, Urey JR. Behavioral changes following visual scanning training: observation of five cases. Int J Clin Neuropsychol 1987;9:74-80.
13. Wagenaar RC, VanWieringen PCW, Netelenbos JB, Meijer OG, Kuick DJ. The transfer of scanning training effects in visual inattention after stroke: five single-case studies. Disabil Rehabil 1992;14:51-60.
14. Pizzamigglio L, Antonicci G, Judica A, Montenero P, Razzano C, Zoccolotti P. Cognitive rehabilitation of the hemineglect disorder in chronic patients with unilateral right brain damage. J Clin Exp Neuropsychol 1992;14:901-23.
15. Valar G, Sterzi R, Bottino G, Cappa S, Rusconi ML. Temporary remission of left hemianesthesia after vestibular stimulation: a sensory neglect phenomenon. Cortex 1992;26:123-31.
16. Rode G, Charles N, Perenin MT, Vighetto A, Trillet M, Aimard G. Partial remission of hemiplegia and somatoparaphrenia through vestibular stimulation in a case of unilateral neglect. Cortex 1992;28:203-8.
17. Pizzamiglio L, Frascar R, Guariglia C, Inococcia C, Antonucci G. Effect of optokinetic stimulation in patients with visual neglect. Cortex 1992;26:535-40.
18. Karnath HO, Christ K, Hartje W. Decrease of contralateral neglect by neck muscle vibration and spatial orientation of trunk midline. Brain 1993;116:383-96.
19. Butter CM, Kirch NL. Combined and separate effects of eye patching and visual stimulation on unilateral neglect following stroke. Arch Phys Med Rehabil 1992;73:1133-9.
20. Walker R, Young AW, Lincoln NB. Eye patching and the rehabilitation of visual neglect. Neuropsychol Rehabil 1996;6:219-31.
21. Arai T, Hiroshi O, Sasaki H, Hiroo N, Koh T. Hemispatial sunglass: effect of unilateral spatial neglect. Arch Phys Med Rehabil 1997;78:230-2.
22. André J-M, Yvroud E, Granjon Y, Beis J-M, Hean C-C. Development of glass equipped liquid crystal to distinct central neurovision anomaly. Precision Machinery 1993;4:185-90.
23. Shulman GL. An asymmetry in the control of eye movements and shifts of attention. Acta Psychol 1984;55:53-9.
24. Deuel R. Salutary effects of uniocular occlusions [Abstract]. J Clin Exp Neuropsychol 1985;7:142.
25. Seron X, Deloche G, Coyette F. A retrospective analysis of a single case neglect therapy: a point of theory. In: Seron X, and Deloche G, editors. Cognitive approaches in neuropsychological rehabilitation. Hillsdale (NJ): Lawrence Erlbaum Associates; 1989. p. 289-316.
26. Diller L. Diagnostic et therapie des troubles perceptuels lors des lésions de l'hémisphère droit. In: Seron X, Laterre C, editors. Rééduquer le cerveau. Logopedie, psychologie, neurologie. Brussels: Mardaga; 1982. p. 205-27.
27. Beis JM, André JM, Saguez A. Detection of visual field deficit and visual neglect with computerized light emitting diodes. Arch Phys Med Rehabil 1994;75:711-4.
28. Bergego C, Deloche C. De l'évaluation neuropsychologique à la thérapie dans les lésions de l'hémisphère droit. Concilia Med 1987;1:188-94.
29. Beis JM, André JM, Frenay C, Datié AM, Vielh A, Paysant J, et al. Interêt de la photooculographie dans l'evaluation des troubles

visuospatiaux en rééducation. Ann Réadapt Méd Phys 1995;38: 207-10.
30. Charlier J, Hache JC. New instrument for monitoring eye fixation and pupil size during the visual field examination. Med Biol Eng Comput 1982;2:23-8.
31. Granger CV, Cotter AC, Hamilton BB, Fielder RC. Functional assessment scale: a study of persons after stroke. Arch Phys Med Rehabil 1993;74:133-8.
32. Dixon WJ. BMDP statistical software manual. Berkeley (CA): University of California Press; 1992.
33. Posner MI, Rafal RD. Cognitive theories of attention and the rehabilitation of attentional deficits. In: Meire MJ, Benton A, Diller L, editors. Neuropsychological rehabilitation. New York: Guilford Press; 1988. p. 182-201.
34. Hubel DH, Levay S, Wiesel TN. Mode of termination of retinotectal fibres in macaque monkey: an autoradiographic analysis. Brain Res 1975;96:125-40.
35. Spark DL. Translation of sensory signals into commands for control of saccadic eye movements: role of primate superior colliculus. Physiol Rev 1986;66:118-71.
36. Hornak J. Ocular exploration in the dark by patients with visual neglect. Neuropsychologia 1992;30:547-52.
37. Posner MI, Walker JA, Friedrich FA, Rafal RD. How does the parietal lobe direct covert attention? Neuropsychologia 1987;25: 135-45.
38. Posner MI, Presti DE. Selective attention and cognitive control. Trends Neurosci 1987;10:13-7.
39. Lavadas E, Carletti M, Gori G. Automatic and voluntary orienting of attention in patients with visual neglect: horizontal and vertical dimension. Neuropsychologia 1994;32:1195-208.
40. Ischai S, Furukawa AT, Tsukagoshi M. Eye-fixation patterns in homonymous hemianopia and unilateral spatial neglect. Neuropsychologia 1987;45:675-9.