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Patching for Diplopia Contraindicated in Patients with Brain Injury?

Kevin E. Houston, OD and A. M. Barrett, MD

Spaulding Rehabilitation Hospital, Boston, Massachusetts (KEH), Department of Ophthalmology, Harvard Medical School, Boston, Massachusetts (KEH) Massachusetts Eye and Ear, Boston, Massachusetts (KEH), and Kessler Foundation, West Orange, New Jersey (AMB)

Abstract

Purpose—Patching for double vision is a common palliative treatment for head-trauma patients with acquired strabismus when prisms are not feasible.

Methods—We review literature on spatial neglect and discuss possible effects of monocular occlusion on spatial attention.

Results—Patching the left eye has been shown to worsen spatial judgments in some brain-injured patients with left neglect by inhibiting the right superior colliculus (SC) further impairing contralateral leftward orienting (the Sprague Effect).

Conclusions—Since more peripheral parts of the visual field increasingly project to the contralateral SC with the temporal crescent being entirely contralateral, avoiding patching of the temporal crescent was advised, and in most cases can be achieved by taping off the spectacle lens and avoiding an elastic eye patch.

Keywords

strabismus; patching; monocular occlusion; hemispatial neglect; spatial neglect

Of the many vision problems occurring after brain injury, strabismus is among the most common,¹ bothersome,² and debilitating, increasing the risk for injury from falls.³ Negative subjective and functional symptoms are related to images falling on non-corresponding retinal points leading to visual confusion (seeing images of 2 different objects in the same visual direction, i.e. overlapping images) and diplopia (seeing the same object twice). Monocular occlusion (i.e. “patching”) is a quick and cost effective method to eliminate these symptoms, however in addition to considering eye dominance, asymmetries in visual acuity, ocular motility and visual field, it may be important to consider effects on spatial attention. Spatial attention may be simply defined as selective processing of stimuli based on their 3-dimensional location.

Patients with unilateral or asymmetric brain injury frequently have functional disability caused by biased spatial attention, favoring the side ipsilateral to the brain injury, referred to

as *spatial neglect* (hereafter, neglect). Left neglect is more common than right neglect due to right cerebral hemisphere specialization for spatial functions. As most of the available literature has centered on left neglect after brain injury from right brain stroke, our discussion in this review will report known characteristics from this population. A popular definition of left neglect is failure to respond, report, or orient to sensory stimuli located to the left which causes functional disability.⁴ Neglect and homonymous hemianopia often occur together, but they are separable conditions, and left neglect frequently can and does occur when the visual fields are full. Based on clinical observations, we propose a systematic approach dividing clinical presentations of left neglect and hemianopia into the three groups described in Table 1. This is meant as a guide to help illustrate differences between hemianopia and neglect.

Severe Neglect

Moderate to severe functional disability caused by left neglect is readily observed when there is, for example, failure to shave the left side of the face, or failure to don clothing on the left side, failure to eat food from the left side of the plate, or in the eye exam room failure to read the left side of the Snellen chart. When asked to draw a scene or copy a figure, patients with severe left neglect may only draw the right side. Severe left neglect results in extreme functional impairment with disruption of walking,^{5, 6} wheelchair ambulation,⁵⁻⁷ and reading.⁸ Neglect patients have poorer rehabilitation outcomes, more falls during hospitalization, and are hospitalized longer.^{9, 10, 11} Patients with moderate to severe left neglect are frequently unaware or unconcerned about their physical deficits (e.g. hemiparesis or vision loss), a behavior termed anosognosia, and while they may have other cognitive or memory disturbances because of the neurological injury, spatial neglect does not by itself produce disorganized thinking, memory impairment, or intellectual deficits. Patients are often easily engaged in conversation, exhibit normal recall of short-term and long-term events, and can often follow multi-step commands. Their affect may be flat and easily misinterpreted as lack of interest or impatience, because of deficits in emotional processing. Repetitive or obsessive behaviors, referred to as perseveration, are common and interfere with the completion of tasks.

Neglect is very common in the first few months after the brain injury, having been diagnosed in up to 50% of patients with right brain stroke,^{12, 13} and up to 47% of left brain stroke.^{13, 14} While neglect is also not uncommon after head trauma (30% moderate to severe traumatic brain injury¹⁵), substantially less emphasis has been given to this population in terms of research. While this review and clinical perspective will cite primarily neglect stroke literature, concepts discussed also apply to left neglect from head trauma.

Mild and Subclinical Spatial Neglect

Neglect will typically improve substantially over the first 6 months after the brain injury.^{16, 17} While left neglect behaviors may improve rapidly such that much less than the 50% afflicted with the condition exhibit it chronically, there is substantial evidence from multiple studies suggesting left neglect frequently persists in a mild form in the majority of cases.¹⁸⁻²² These studies and our personal clinical observations suggest that even recovered

right brain-injured patients have spatial biases which persist mildly or at a subclinical level. Frank neglect symptoms may re-emerge with increased attentional demand or fatigue, when patients are ill, or when patients who have recovered from neglect are exposed to benzodiazepines.²³ Could a simple treatment such as monocular occlusion also adversely affect spatial attention?

Monocular Occlusion and Spatial Attention

As we noted in the first section, neglect after brain injury can be disabling. Iatrogenic worsening of neglect can occur because of medications, illness, or fatigue. Additionally, monocular occlusion (e.g. eye patching) may induce or exacerbate spatial neglect in brain-injured patients, or reveal neglect behaviors in patients with mild or subclinical neglect.^{24–26}

Collicular Attentional Pathways - Sprague Effect

Theories that monocular occlusion affects spatial attention is based upon the largely monocular input to the contralateral superior colliculus (SC) resulting in disruption of normal intra-collicular competition (which is balanced in non-lesioned brains), often referred to as the Sprague effect.^{27–30} The SC are involved in orienting of attention and facilitation of eye movements to salient visual stimuli (for a review, see Anderson and Rees).³¹ In primates, the inputs to the SC from the eyes are primarily monocular and contralateral (see Figure 1).²⁷ While the foveal projection to the SC is essentially equal from both eyes, more peripheral parts of the visual field increasingly project to the contralateral SC with the temporal crescent being entirely contralateral.³² Therefore when activity in the ipsilesional SC is suppressed by a monocular patch, a pathologic bias in spatial attention may be induced²⁶ or worsened.²⁵

Monocular Occlusion to Treat Spatial Neglect

Posner and Rafal are credited with first suggesting that the effect Sprague observed in cats might be relevant to the treatment of left spatial neglect in humans.³³ Increased orienting to the left might be achieved by reducing activity in the left SC, achieved with monocular occlusion of the right eye. This theory has been supported by some studies.^{34–37} However, patching the right eye did not reliably improve spatial neglect;²⁴ some individuals experienced no beneficial effect^{25, 38} and other individuals demonstrated paradoxical effects (patching right eye worsened or patching the left eye improved left neglect).^{24, 25, 34, 35, 37} Less relevant to neglect treatment but important in patching for strabismus, and consistent with Posner and Rafal's theory, multiple studies found that patching the left eye can worsen left neglect.^{24, 34, 35, 39} There is some evidence to suggest the variability in response to patching may be in part due to the type of neglect: perceptual attentional vs. motor intentional.^{24, 25, 39}

DISCUSSION

Considering potential unintended effects on spatial attention from monocular eye patching in patients with strabismus and brain injury, we recommend first attempting to restore binocular vision with a prism lens when possible. Press-on prisms (3M, St. Paul, MN) for

acquired strabismus are well tolerated by patients even in the early recovery period after neurological injury, when fitted over the non-dominant or lesser eye reducing the power as needed as strabismus improves.²

If prisms are ineffective or not available and a patch must be used, we recommend conservatively patching as illustrated in Figure 2. If considering total occlusion (e.g. with a “pirate” patch), it is important to assess whether spatial bias or spatial neglect symptoms emerge when the patch is on. Common methods for assessing neglect include paper and pencil tests and functional surveys. Paper and pencil tests such as line bisection (marking the exact center of a line), cancellation tests such as Bells Test⁴⁰ or Star Cancellation⁴¹ (crossing out bells or stars amongst various distractors), drawing tests such as clock drawing⁴² or figure copying⁴¹ fail to assess auditory spatial skills, poorly characterize real-world functional deficits, and may fail to detect neglect in personal space (e.g. ignoring or losing the left arm). Buxbaum et. al found multiple test batteries were all negative in 28% of right brain stroke patients who tested positive in other modalities; perceptual, personal, or motor.¹⁴ A functional task screening, rated by a caregiver or therapist, the Catherine Bergego Scale(CBS), is reported to be the single most sensitive test,^{13, 43} and may be combined with paper and pencil tests. A process to increase the reliability of CBS administration (the Kessler Foundation Neglect Assessment Process or KF-NAP) has been developed and validated.¹³

Sector or spot patching a portion of the field rather than total occlusion of an eye as has been suggested previously⁴⁴ is supported by collicular attentional neuroanatomical characteristics described in previous paragraphs and Figure 1 (input to the SC from the temporal field is almost entirely monocular and contralateral), and the fact that the extent of the binocular visual field would be preserved (assuming no HFD). There could theoretically be value to a semi-translucent patch such as an occlusion foil rather than an opaque patch, but this should be weighed against the binocular rivalry induced by this method. Subjective trial framing is effective in evaluating this effect. In clinical situations, if patient responses are reliable, the occlusion foil can be gradually brought in from the nasal side until the strabismus symptoms are reported as resolved, followed by a short trial allowing head and eye movements. If the patient cannot provide reliable responses, placement must be objectively measured.

CONCLUSIONS

Effects of monocular occlusion on spatial attention are relevant to the clinical management of strabismus in patients with a history of brain-injury. Total occlusion is contraindicated when done without spatial neglect assessment, or when it worsens spatial bias. Prism lenses should be used to correct strabismus when possible. Additional studies to determine the best methods of patient selection when applying monocular occlusion in the treatment of spatial neglect would be helpful to eye care and rehabilitation professionals and their patients.

References

1. Rowe F. Prevalence of ocular motor cranial nerve palsy and associations following stroke. Eye (London, England). 2011; 25:881–7.

2. Houston KE, Keilty M. Initial response to prism treatment in an inpatient rehabilitation hospital setting: preliminary results. *Arch Phys Med Rehabil.* 2015; 96:e73.
3. Pineles SL, Repka MX, Yu F, Lum F, Coleman AL. Risk of musculoskeletal injuries, fractures, and falls in medicare beneficiaries with disorders of binocular vision. *JAMA Ophthalmol.* 2015; 133:60–5. [PubMed: 25340322]
4. Heilman, KM.; Watson, RT.; Valenstein, E. Neglect and related disorders. In: Heilman, KM.; Valenstein, E., editors. *Clinical Neuropsychology*. 3. New York: Oxford University Press; 1993. p. 279-336.
5. Turton AJ, Dewar SJ, Lievesly A, O'Leary K, Gabb J, Gilchrist ID. Walking and wheelchair navigation in patients with left visual neglect. *Neuropsychol Rehabil.* 2009; 19:274–90. [PubMed: 18609014]
6. Paolucci S, Antonucci G, Grasso MG, Bragoni M, Coiro P, De Angelis D, Fusco FR, Morelli D, Venturiero V, Troisi E, Pratesi L. Functional outcome of ischemic and hemorrhagic stroke patients after inpatient rehabilitation: a matched comparison. *Stroke.* 2003; 34:2861–5. [PubMed: 14615613]
7. Dawson J, Thornton H. Can patients with unilateral neglect following stroke drive electrically powered wheelchairs? *Br J Occup Ther.* 2003; 66:496–504.
8. Caplan B. Assessment of unilateral neglect: a new reading test. *J Exp Neuropsychol.* 1987; 4:359–64.
9. Bisiach E, Luzzatti C, Perani D. Unilateral neglect, representation schema and consciousness. *Brain.* 1979; 102:609–18. [PubMed: 497807]
10. Wee JYM, Hopman WM. Comparing consequences of right and left unilateral neglect in a stroke rehabilitation population. *Am J Phys Med Rehabil.* 2008; 87:910–20. [PubMed: 18936556]
11. Wilkinson D, Sakel M, Camp S, Hammond L. Patients with hemispatial neglect are more prone to limb spasticity, but this does not prolong their hospital stay. *Arch Phys Med Rehabil.* 2012; 93:1191–5. [PubMed: 22483722]
12. Chen P, Goedert KM, Shah P, Foundas AL, Barrett AM. Integrity of medial temporal structures may predict better improvement of spatial neglect with prism adaptation treatment. *Brain Imaging Behav.* 2014; 8:346–58. [PubMed: 22941243]
13. Chen P, Chen CC, Hreha K, Goedert KM, Barrett AM. Kessler foundation neglect assessment process uniquely measures spatial neglect during activities of daily living. *Arch Phys Med Rehabil.* 2015; 96:869–76. [PubMed: 25461827]
14. Kleinman JT, Newhart M, Davis C, Heidler-Gary J, Gottesman RF, Hillis AE. Right hemispatial neglect: frequency and characterization following acute left hemisphere stroke. *Brain Cogn.* 2007; 64:50–9. [PubMed: 17174459]
15. Chen P, Ward I, Khan U, Liu Y, Hreha K. Spatial neglect hinders success of inpatient rehabilitation in individuals with traumatic brain injury: a retrospective study. *Neurorehabil Neural Repair.* 2016; 30:451–60. [PubMed: 26338431]
16. Jehkonen M, Laihosalo M, Koivisto AM. Fluctuation in spontaneous recovery of left visual neglect: a 1-year follow-up. *Eur Neurol.* 2007; 58:210–4. [PubMed: 17823534]
17. Farne A, Buxbaum LJ, Ferraro M, Frassinetti F, Whyte J, Veramonti T, Angeli V, Coslett HB, Ladavas E. Patterns of spontaneous recovery of neglect and associated disorders in acute right brain-damaged patients. *J Neurol Neurosurg Psychiatry.* 2004; 75:1401–10. [PubMed: 15377685]
18. Houston KE, Woods RL, Goldstein RB, Peli E, Luo G, Bowers AR. Asymmetry in the collision judgments of people with homonymous field defects and left hemispatial neglect. *Invest Ophthalmol Vis Sci.* 2015; 56:4135–42. [PubMed: 26120818]
19. Goodale MA, Milner AD, Jakobson LS, Carey DP. Kinematic analysis of limb movements in neuropsychological research: subtle deficits and recovery of function. *Can J Psychol.* 1990; 44:180–95. [PubMed: 2200594]
20. Hier DB, Mondlock J, Caplan LR. Recovery of behavioral abnormalities after right hemisphere stroke. *Neurology.* 1983; 33:345–50. [PubMed: 6681880]
21. Hamilton RH, Coslett HB, Buxbaum LJ, Whyte J, Ferraro MK. Inconsistency of performance on neglect subtype tests following acute right hemisphere stroke. *J Int Neuropsychol Soc.* 2008; 14:23–32. [PubMed: 18078528]

22. Grujic Z, Mapstone M, Gitelman DR, Johnson N, Weintraub S, Hays A, Kwasnica C, Harvey R, Mesulam MM. Dopamine agonists reorient visual exploration away from the neglected hemisphere. *Neurology*. 1998; 51:1395–8. [PubMed: 9818867]
23. Lazar RM, Fitzsimmons BF, Marshall RS, Berman MF, Bustillo MA, Young WL, Mohr JP, Shah J, Robinson JV. Reemergence of stroke deficits with midazolam challenge. *Stroke*. 2002; 33:283–5. [PubMed: 11779924]
24. Barrett AM, Burkholder S. Monocular patching in subjects with right-hemisphere stroke affects perceptual-attentional bias. *J Rehabil Res Dev*. 2006; 43:337–46. [PubMed: 17041819]
25. Barrett AM, Crucian GP, Beversdorf DQ, Heilman KM. Monocular patching may worsen sensory-attentional neglect: a case report. *Arch Phys Med Rehabil*. 2001; 82:516–8. [PubMed: 11295013]
26. Chen P, Erdahl L, Barrett AM. Monocular patching may induce ipsilateral “where” spatial bias. *Neuropsychologia*. 2009; 47:711–6. [PubMed: 19100274]
27. Sprague J. interaction of cortex and superior colliculus in mediation of visually guided behavior in the cat. *Science*. 1966; 153:1544–7. [PubMed: 5917786]
28. Rushmore RJ, Payne BR. Neuroplasticity after unilateral visual cortex damage in the newborn cat. *Behav Brain Res*. 2004; 153:557–65. [PubMed: 15265654]
29. Payne BR, Rushmore RJ. Functional circuitry underlying natural and interventional cancellation of visual neglect. *Exp Brain Res*. 2004; 154:127–53. [PubMed: 14625667]
30. Weddell RA. Subcortical modulation of spatial attention including evidence that the Sprague effect extends to man. *Brain Cogn*. 2004; 55:497–506. [PubMed: 15223196]
31. Anderson EJ, Rees G. Neural correlates of spatial orienting in the human superior colliculus. *J Neurophysiol*. 2011; 106:2273–84. [PubMed: 21753026]
32. Hubel DH, LeVay S, Wiesel TN. Mode of termination of retinotectal fibers in macaque monkey: an autoradiographic study. *Brain Res*. 1975; 96:25–40. [PubMed: 809107]
33. Posner, M.; Rafal, R. *Cognitive Theories of Attention and the Rehabilitation of Attentional Deficits*. New York: Guilford Press; 1987.
34. Serfaty C, Soroker N, Glicksohn J, Sepkuti J, Myslobodsky MS. Does monocular viewing improve target detection in hemispatial neglect? *Restor Neurol Neurosci*. 1995; 9:7–13. [PubMed: 21551829]
35. Soroker N, Cohen T, Baratz C, Glicksohn J, Myslobodsky MS. Is there a place for ipsilesional eye patching in neglect rehabilitation? *Behav Neurol*. 1994; 7:159–64. [PubMed: 24487330]
36. Butter CM, Kirsch N. Combined and separate effects of eye patching and visual stimulation on unilateral neglect following stroke. *Arch Phys Med Rehabil*. 1992; 73:1133–9. [PubMed: 1463376]
37. Walker R, Young AW, Lincoln NB. Eye patching and the rehabilitation of visual neglect. *Neuropsychol Rehabil*. 1996; 6:219–32.
38. Beis JM, Andre JM, Baumgarten A, Challier B. Eye patching in unilateral spatial neglect: efficacy of two methods. *Arch Phys Med Rehabil*. 1999; 80:71–6. [PubMed: 9915375]
39. Barrett AM, Crucian GP, Heilman KM. Eye patching biases spatial attention after thalamic hemorrhage in a patient without spatial neglect: a case report. *Arch Phys Med Rehabil*. 2004; 85:1017–20. [PubMed: 15179660]
40. Gauthier L, Dehaut F, Joannette Y. The bells test: a quantitative and qualitative test for visual neglect. *J Clin Exp Neuropsychol*. 1989; 11:49–54.
41. Wilson, BA.; Cockburn, J.; Halligan, PW. *Behavioural Inattention Test*. San Antonio, TX: Harcourt Assessment; 1987.
42. Ishiai S, Sugishita M, Ichikawa T, Gono S, Watabiki S. Clock-drawing test and unilateral spatial neglect. *Neurology*. 1993; 43:106–10. [PubMed: 8423871]
43. Goedert KM, Chen P, Botticello A, Masmela JR, Adler U, Barrett AM. Psychometric evaluation of neglect assessment reveals motor-exploratory predictor of functional disability in acute-stage spatial neglect. *Arch Phys Med Rehabil*. 2012; 93:137–42. [PubMed: 22200393]
44. Neuro-Optometric Rehabilitation Association (NORA). [Accessed February 11, 2016] Politzer T. *The Physiology of Double Vision New Occlusion Techniques*. Available at: <https://nora.cc/for->

[patients-mainmenu-34/management-of-double-vision-mainmenu-73/the-physiology-of-double-vision.html](#)

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Figure 1. Schematic of the retinotectal pathway as it pertains to the collicular attentional system and the effect of monocular eye patching. Input to the left SC is primarily from the right eye nasal fibers, and left eye to right SC. Patching the left eye effectively inhibits the right SC, and may cause contralateral (leftward) orienting deficits.

Figure 2.

(A) Patient with 15° (26^Δ) of left exotropia with semi-translucent sector occlusion illustrated. (B) Schematic of the same patient's left eye viewed from above looking through a typical spectacle lens with A and DBL dimensions of 52–20, DPD of 60mm (decentration of 12mm), and BVD 11mm + cornea to nodal point (N) of 7mm (drawn to scale). The nasal retinal fibers serving the monocular temporal crescent have complete contralateral input to the SC, and so patching this area is likely to disturb normal collicular competition as well as reducing the binocular visual field by 20° . Fortunately, as illustrated, typical spectacles do not occlude this area even if the entire lens is patched. Peripheral areas are progressively more contralateral in their SC input, so only the minimum amount of the peripheral field needed to eliminate strabismus symptoms should be occluded. In this example (26^Δ LXT) the minimum was determined by adding 15° (4.3mm) to the monocular PD to account for the XT and adding an additional 15° buffer (dashed light gray line) to account for typical maximum horizontal scan path magnitude. Angular projections to the spectacle plane converted to mm were calculated at 8.64mm temporal from the optical center/MRP; an additional 1mm for every 4^Δ of strabismus (beyond the buffer). Area to be patched is illustrated by the solid black line- patching further temporally may be needed if strabismus symptoms are not sufficiently controlled, but may come at the expense of additional spatial bias. In esotropia of the same magnitude, the border of the patch would be placed on the optical center (yellow crosses). A=lens width; DBL=distance between lenses; BVD = back vertex distance; PD = pupillary distance; MRP = major reference point; LXT = left exotropia

Table 1

Proposed patterns of behaviors in patients with left neglect with and without homonymous visual field loss.

	Left Neglect and Left Hemianopia	Left Hemianopia without Left Neglect	Left Neglect Without Left Hemianopia
Visual field testing	Reduced fields	Reduced fields	Normal fields, may extinguish left side targets on double simultaneous presentation
Concern for visual or physical disabilities	Unconcerned	Appropriately Concerned	Unconcerned
Fail to read left side of eye chart	Common	Rare	Common
Fail to follow to the left	Common	Rare	Common
Collide with obstacles on the left when ambulating	Common	Occasional	Common
Veering behavior with ambulation	Common	Rare	Common
Typical Line Bisection Error	Rightward	Leftward	Rightward
Typical Lesion Location	Right Middle Cerebral Artery Territory	Right Posterior Cerebral Artery Territory	Anterior Segment of Right Middle Cerebral Artery Territory (cortical) or striatum (subcortical)