HHS Public Access

Author manuscript

Curr Neurol Neurosci Rep. Author manuscript; available in PMC 2020 April 04.

Published in final edited form as:

Curr Neurol Neurosci Rep. ; 19(5): 25. doi:10.1007/s11910-019-0940-0.

Update on the Clinical Approach to Spatial Neglect

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Abstract

Purpose of Review—Spatial neglect is asymmetric orienting and action after a brain lesion, causing functional disability. It is common after a stroke; however, it is vastly underdocumented and undertreated. This article addresses the implementation gap in identifying and treating spatial neglect, to reduce disability and improve healthcare costs and burden.

Recent Findings—Professional organizations published recommendations to implement spatial neglect care. Physicians can lead an interdisciplinary team: functionally relevant spatial neglect assessment, evidence-based spatial retraining, and integrated spatial and vision interventions can optimize outcomes. Research also strongly suggests spatial neglect adversely affects motor systems. Spatial neglect therapy might thus "kick-start" rehabilitation and improve paralysis recovery.

Summary—Clinicians can implement new techniques to detect spatial neglect and lead interdisciplinary teams to promote better, integrated spatial neglect care. Future studies of brain imaging biomarkers to detect spatial neglect, and real-world applicability of prism adaptation treatment, are needed.

Keywords

Spatial neglect; Right brain; Cognitive rehabilitation; Prism adaptation treatment; Implementation science; Functional brain imaging; Brain network activation

Introduction

Spatial neglect is asymmetric reporting, responding, or orienting to one side of space after a brain lesion, causing functional disability [1]. This condition is frequently classified as a higher-order visual dysfunction, affecting thinking and mental abilities. However, spatial neglect is not only a visual and cognitive condition. A maladaptive spatial movement bias (e.g., disinclination to move in one direction with the eyes, head, arms, or whole body) is

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Conflict of Interest Kevin Houston declares no potential conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

also well-established as a primary manifestation of spatial neglect [2–5] and may selectively respond to spatial neglect treatment [6]. Maladaptive and spatially asymmetric movements may be limb-specific: the arm opposite the side of a stroke may not be particularly weak; however, it may not move well or may demonstrate poor persistence of movement [7]. Spatial movement bias may also be direction-specific. We frequently observe, for example, that a patient with spatial neglect has eye and head deviation toward the side of a brain lesion, which is a form of rotational behavior or directional hypokinesia [8] also observed in animals [9, 10]. Lastly, maladaptive, spatially asymmetric movements can be a "wrong way" —a stroke survivor may have an increased, abnormal propensity to make movements to the contralesional side of space, particularly of the eyes [11], or may even demonstrate a sustained contralesional eye deviation [12]. Both eye movements and limb movements can be directionally asymmetric [11, 13]. Asymmetric gaze and movements (for example, in ambulation) are integral components of functional performance assessment in spatial neglect [14, 15].

In this review, we will summarize major advances affecting treatment of spatial neglect. Sufficient information is now available to implement a care pathway for spatial neglect, and this can significantly enhance outcomes of stroke and traumatic brain injury care. The potential to achieve good outcomes in patients with spatial neglect has advanced by development of practice standards for assessment and treatment. There has also been improved information about how functional performance can be included in clinical assessment and treatment, so that symptoms which primarily affect movement, rather than perceptual, systems, can be tracked during care. Improved information about implementing both vision therapy and spatial neglect care can help us safely and effectively improve outcomes of stroke and traumatic brain injury. Lastly, spatial-motor aiming errors [5] profoundly affect the ability to perform activities of daily living in the first days and weeks after stroke and contribute independently to disability. There is some emerging work suggesting that interaction of spatial and motor networks in the brain may be a useful biomarker to identify spatial neglect and track its recovery.

Because the acute and post-acute hospitalization may critically influence the ability of a stroke patient to transition back to the community, the high prevalence of spatial neglect in hospitalized stroke (more than half of patients; [16]) and traumatic brain injury patients (about 30% of patients [17••]) may be very important. An optimal plan to reduce in-hospital morbidity and improve outcomes during inpatient care may need to include stroke treatments. In this manner, we can target spatial neglect and address increased fall risk [16], prolonged inpatient stays [18], and impaired recovery of paralysis, balance, and ambulation [19–21].

Practice Standards

Assessment

More than 50 years ago, Bender described an assessment technique to identify perceptual disorders in patients with penetrating injury of the right parietal cortex [22]. This technique, to identify extinction to double simultaneous stimulation of the left versus right side of the visual field and body, is a useful method of detecting spatial neglect affecting stimulus

awareness [23]. Characteristically, a patient with a stroke is asked to report a stimulus when it is detected. On the contralesional side of space (a visual stimulus in the left visual field, for example, after a right brain stroke), when a stimulus is presented alone, it is reliably identified. However, when a stimulus on the left is presented simultaneously with a stimulus on the right, only the right-sided stimulus is reported. Extinction to double simultaneous stimulation is part of the National Institutes of Health Stroke Scale (NIHSS; [24]), performed routinely, as part of quality stroke care, during thousands of US ambulance examinations and emergency room visits. However, not enough neurologists realize that the NIHSS item specifically focused on extinction to double simultaneous stimulation in the visual and tactile modalities and cannot detect many other disabling symptoms of spatial neglect. This may be the reason why the NIHSS systematically underestimates the severity of a right brain stroke [25, 26]. Although other NIHSS items may be impaired when a patient has spatial neglect (ability to describe all of the items on both sides of a complex picture and conjugate eye deviation toward the side of the brain lesion), these items are not spatial neglect–specific.

Guidelines for stroke rehabilitation that recommend processes for spatial neglect assessment and treatment are available. The American Heart Association [27••], the Veterans Administration/Department of Defense [28], and the National Institute for Health and Care Excellence [29] all recommend that stroke patients should be assessed for spatial neglect and cognitive dysfunction (class 1, level B evidence according to [27••]). Although no guideline specified instruments to use (see Table 1), the Royal College of Physicians (UK) [30••] specifies that “the effect on functional tasks should be assessed.”

We recommend clinicians consider a frequently used standardized spatial neglect measure with published reliability and validity that *evaluates actual functional task performance in real time*; the Catherine Bergego Scale (CBS; [31]). A process (with manual) standardizing administration of this measure for use in occupational therapy evaluation is available for clinician use [15, 32]. This makes the CBS easily adaptable to clinical settings and highly feasible. The measure can be performed during routine occupational therapy admission assessment of daily living activities for inpatient rehabilitation patients, reducing the time burden to documentation only. Administering this measure at admission and discharge is now the standard practice within a 12-facility practice-based network of inpatient rehabilitation sites evaluating implementation of a care pathway for spatial neglect care (Practice-RRuN; [33]).

As noted above, the Catherine Bergego Scale is feasible (can be performed concurrently with functional assessment during the inpatient rehabilitation process, adding only a few minutes of documentation time). It also has excellent sensitivity [34••] and construct validity (assesses both perceptual and motor performance; [35]). Because it is an observational evaluation of patient’s performance of functional tasks, it does not depend on patient comprehension and may be less culture-bound and vulnerable to implicit bias than paper-and-pencil tests. Clinicians within the Practice-RRuN network also find the CBS useful for discussing spatial neglect symptoms with patients and their families, contributing to engagement and patient-centered care.

If a clinician able to administer the CBS is not available, the AHA and UK Royal College of Physicians both also list the Behavioral Inattention Test [36] for spatial neglect assessment. This instrument has a short conventional subtest taking only about 15 min to administer, and most licensed healthcare clinicians can administer it after reading the test instructions, without advanced specific training. Performance on the BIT-c correlates strongly with an occupational therapist report of patient functional disability [37].

Treatment

Many patients with spatial neglect are not identified or treated [38]. The reasons for this are unclear. There may be breakdown in interdisciplinary communication [39], or it is possible that spatial impairment, as a hidden disability, is difficult for many clinicians to identify routinely [40]. Once patients are identified as having spatial neglect, however, there is not yet consensus about treatment decision-making. Chen et al. [41] recently surveyed expert clinicians on their treatment plans for two patients with spatial neglect. They found that four approaches were frequently selected: visual scanning training, active limb activation, prism adaptation training, and sustained attention training. Of these approaches, we [42] and others [43] strongly suggested that prism adaptation is the most feasible. Prism adaptation treatment for spatial neglect typically involves 10 to 20 sessions of repeated goal-directed hand and arm movements toward a visual target while wearing prisms, which deviate the entire visual field of each eye to the right. Each session takes between 15 min and an hour. The visual shift creates a rightward movement error, which upon repeated trials is eliminated (adaptation). Prisms used in prior studies were most often 10°, i.e., 17.6 prism diopters (Optique Peter); however, 11.4°, i.e., 20 prism diopters (Bernell Vision Therapy, Mishawaka, IN), has been used with similar results [44, 45••]. In a randomized trial, no therapeutic effect was found for lower values of base left yoked prism of 5.7° (10 prism diopters; [46]), suggesting that sufficient magnitude of the visuomotor adaptation is important to obtain a treatment effect. Little is known about how other parameters of the lens such as curvature and design (Fresnel versus ophthalmic “wedge” prism) which can affect levels of lens distortion ([47], impact of high power and incidence angle on prism) may impact adaptation. Prism adaptation treatment has the advantage of requiring little training to administer, and patients do not need to understand and accept behavioral modification, because the approach trains actions implicitly, rather than relying on strategy- or knowledge-building. Lastly, because prism adaptation treatment is movement-based and requires little verbal interaction with the therapist, a clinician can use it even if she does not speak the same language as the patient. Because patients wear the prism lenses only during therapy sessions and not all the time, several patients can be treated with the same prism adaptation equipment (taking their sessions at different times of the day).

There are three major advantages to considering prism adaptation treatment over other initial approaches for spatial neglect treatment after stroke or brain injury. A meta-analysis [48] suggested that prism adaptation was the most effective of interventions considered in 1997–2012 for spatial neglect. Secondly, a systematic review [49••] identified more than 20 controlled studies in which daily functional activities, such as reading and writing, walking or wheelchair navigation, and direct performance of self-care, improved. This supports the idea that our patients and their families may actually see an impact of the treatment to

improve their daily lives. Thirdly, prism adaptation is at this point the only spatial neglect treatment undergoing implementation evaluation. An initial report indicated that prism adaptation treatment was feasible in a 10-inpatient-facility practice-based network, with therapists reporting positive perception of the treatment and patients who received the full protocol of treatment making functional gains exceeding the minimal clinically important difference for the FIM measure [33]. The UK National Clinical Guideline Center [29] estimated that the average cost of administering prism adaptation therapy for spatial neglect would be about $350 per patient, which is potentially affordable in many care contexts. Because multiple patients can share the same equipment, as above, this may be an overestimate of the cost of administering prism adaptation therapy.

Prism adaptation treatment is mentioned as one of the treatment options for spatial neglect in the consensus recommendations published by the American Heart Association [27••], UK Royal College of Physicians and Intercollegiate Stroke Working Party [29], and Veterans Administration/ Department of Defense [28]. However, these formal published guidelines do not yet provide information about which interventions should be considered as first-line, second-line, and third-line approaches. The Royal College of Physicians and Intercollegiate Stroke Working Party took a conservative approach, referencing a Cochrane review [50], which concluded that there is insufficient evidence to support specific approaches for spatial neglect.

Comorbid Vision Impairments and Vision Therapy in Spatial Neglect

Spatial neglect often occurs with other visual impairments which may influence the severity of presentation. Recent literature suggests how we can adapt and integrate spatial retraining with vision rehabilitation to address the deficits synergistically. One visual impairment that is common with spatial neglect is left homonymous hemianopia, with vision loss to the left of the point of fixation due to disruption of the contralateral post-geniculate primary visual pathway. Because the vision loss respects the fixation point, increased gaze shifts to the affected side can allow the individual to compensate for the visual loss [51, 52]. However, when left hemianopia is combined with left spatial neglect, which causes reduced exploration to the left with longer and more frequent fixations to the right [53], the ability to compensate for the left hemianopia is reduced. This causes poor detection of obstacles [54]. Teaching the patient with left hemianopia and neglect to scan to the left requires development of awareness of the deficit, which is time intensive for the therapy team [55]. The field of view expansion in hemianopia with peripheral prisms glasses [56, 57] of up to 40° is possible [47], and a multicenter randomized placebo control trial found significantly improved mobility, but those with spatial neglect were excluded [56]. A preliminary study in patients with neglect and hemianopia was promising with left side detection of obstacles improved from 26 to 92% with *p*-prisms, similar to improvements achieved in those with hemianopia but without neglect [58••].

Another common comorbid visual condition of neglect is strabismus, which occurs in approximately 1 in 5 stroke survivors, most commonly as a result of oculomotor cranial nerve palsies [59]. Strabismus is among the most common [60], bothersome [61, 62], and debilitating vision conditions occurring with neurological pathology, more than doubling the

risk for further injury from falls [63]. Although strabismus results in double vision and spatial confusion, many patients do not report the double vision. In a cohort of stroke patients with confirmed strabismus, only 36% reported double vision [59], presumably due to reduced cognition and awareness from the neurological insult. Although this has not been formally studied, patients with both spatial neglect and strabismus after a right brain injury might be expected to ignore the leftmost double image. Patients with spatial neglect are also generally at risk of being unaware of neurological symptoms [64]; thus, failure to report symptoms would likely be even higher in this group.

Strabismus is often treated by occluding one eye, either with an elastic eye patch or with a tape on one lens of the patient's glasses; however, occluding one eye may exacerbate neglect [1, 65, 66] and should either be avoided or be minimized [67••]. Neurologists may be surprised to learn that prisms applied to shift the diplopic images toward one another are a better approach. It is feasible to obtain press-on prisms to treat strabismus; they are inexpensive (about $30 each), can be applied immediately on the client's regular glasses or nonprescription frames (e.g., Cosmic Eyewear), and are easily changed. Prisms can often restore binocular vision, being successful in 64 to 80% of stroke-related strabismus [59, 68]. In patients with spatial neglect, who are at risk of experiencing worse spatial bias with one eye occluded, there is a particularly strong indication to utilize this well-accepted treatment for strabismus prior to the use of a patch [67]. Different processes of collaboration between neurologists, occupational therapists, and optometrists or ophthalmologists are used at different institutions to prescribe and provide prism correction of strabismus. However, an excellent option is in-person consultation with a vision professional, which is used at many inpatient rehabilitation facilities as a first step in providing vision therapy, with the initial prism prescription provided at that time. A question arises about how to prevent problems as patients who are using prisms recover and their strabismus begins to resolve. Weekly or monthly reevaluation by a vision professional to determine if a new prism prescription is needed is appropriate; however, occupational therapists can also be trained to recognize the reemergence of diplopia behaviors as patients recover, and monthly reevaluation by occupational therapy can be incorporated into the inpatient or outpatient rehabilitation plan. Training occupational therapists to measure strabismus and correct prism prescriptions is not feasible; however, once diplopia behaviors have been detected, teleconsultation using photographic screening devices may be an excellent option, and there are several national vendors (e.g., Plusoptix, Welch Allyn Spot, and Volk Eyecheck).

Neurobiology of Spatial Neglect: Combined Motor and Spatial Brain Function

Detailed review of new findings about the neurobiology or neurophysiology of spatial neglect is largely beyond the scope of this article. However, there are two major advances in knowledge about the spatial neglect syndrome that are relevant to motor rehabilitation. First, it is now demonstrated that people with spatial-motor neglect (termed spatial aiming neglect) may respond well to spatial neglect treatment. Second, disconnection of the spatial and motor systems in the brain may provide a neuroimaging biomarker of spatial neglect, which could help identify patients for clinical trials or even for clinical treatment.

The profound limb-specific or direction-specific motor abnormalities that occur in spatial neglect have been discovered to be associated with a better response to prism adaptation treatment [35, 44, 69]. Patients who responded well in these studies had large strokes and frontal lobe lesions [45, 70] and are likely to come to medical attention. However, because their symptoms are not visual or perceptual, how will we identify these patients?

Diagnosing Motor Symptoms in Spatial Neglect

A clinician can form a mental template of abnormal movements in spatial neglect when we think about animal models of the spatial neglect syndrome [9, 10, 71]. These animals are "stuck," with a tendency to make pathologically asymmetric turns in an ipsilesional direction; they do not have a primary perceptual issue. When they try to move forward, they may simply turn in circles [71]. When these turning errors occur in people, they are a part of the syndrome of spatial-motor aiming neglect [72] and are likely to cause falls, postural imbalance, and safety problems after right brain stroke [73]. This is tremendously important, because it may be responsible for a six times greater risk of falls in people with spatial neglect [16]. It may also explain why people with spatial neglect have disproportionately increased hemiparesis [21]. In the future, targeting treatments at spatial-motor aiming symptoms might require that we routinely combine spatial retraining with motor rehabilitation [4].

A Neuroimaging Biomarker?

If clinicians—even stroke specialists—have trouble identifying people with spatial neglect [38, 40], how can we ensure effective healthcare delivery to these patients in the form of rehabilitation? Advanced recent studies suggest that when subjects are quietly resting, brain activity in neuroanatomically-behaviorally related systems spontaneously oscillates in a correlated fashion. This allowed investigators to identify "networks" for brain function such as movement even when the subject is quiet [74]. Three recent studies reported that spontaneous interaction between attention networks and other networks, including the motor network, is reduced in patients with spatial neglect [75, 76••, 77]. Barrett et al. [34••] reported that the degree of ventral attention-motor internetwork interaction can be used to classify patients as having or not having disability-relevant spatial neglect. These findings require replication in large groups of patients before brain network interconnectivity could be used in the assessment of spatial neglect. However, it is interesting that spatial-motor brain interactions are important to this index; it underscores the potential interaction between spatial and motor systems in the disability caused by spatial neglect.

Conclusions

Clinical Summary

Clinicians are increasingly aware that cognitive problems are a major cause of chronic disability in people with stroke and traumatic brain injury. Spatial neglect is unique among the cognitive consequences of stroke: it has thinking and mental aspects, visual and perceptual factors, and, as we described in this article, has motor symptoms that result from a direct effect on 3-D movement functions.

There are three major points that we emphasized in this article. First, patients with frontal lobe brain lesions and asymmetric movements may have both hemiparesis and spatial motor aiming neglect. Motor-related symptoms in spatial neglect can be easy to miss; however, they respond well to spatial retraining during rehabilitation. Guidelines are available to help healthcare organizations: providing stroke care includes assessment and treatment to adequately serve > 50% of patients with spatial neglect after an acute stroke. Through spatial neglect treatment, which is part of stroke care best practices, hospitals can achieve quality improvement and better stroke outcomes. Disability-relevant assessment with instruments like the Catherine Bergego Scale requires the work of therapists; however, it enhances the process of treatment planning and can be helpful to clarify what is happening when communicating with patients and families.

Future Directions

lthough many studies clearly demonstrate that functional disability improves with treatment of spatial neglect, clinical trials are needed to examine whether patients of different sex/gender, ethnic groups, age, and cultural groups respond differently to spatial neglect treatments like prism adaptation. We also need studies confirming the suspected cost-effectiveness of treatment. Brain imaging might offer an objective standard for diagnosing spatial neglect and tracking its response to treatment in clinical trials, and future research should examine this possibility. Confirming the quality and value of stroke care that includes treatment for spatial neglect is needed, to support access to needed resources in the acute hospital, in rehabilitation, and at home and in the community.

Acknowledgments

A.M. Barrett is an employee of the Kessler Foundation and also reports grants from Dart Neuroscience LLC, grants from National Institutes of Health, others from eMedicine/WebMD, grants from Bright Cloud International Corp., outside the submitted work.

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Table 1

Assessment of spatial neglect

Professional organization	Recommended assessment of spatial neglect after stroke?	Recommended specific assessments?	Drawbacks?
American Heart Association [27••]	Yes, as part of cognitive assessment	Two paper-and-pencil neglect tests listed under modality-specific measures (Behavioral Inattention Test and line cancelation)	Paper-and-pencil measures take ~ 15 min or more to administer and may not capture deficits relevant to functional performance. Cognitive reassessment not discussed
Royal College of Physicians (UK) [30••]	Yes	No, stated “standardized measures” and “effect on functional tasks should be assessed”	Assessment recommended for “nondominant” stroke, despite 20–65% incidence of spatial neglect after left brain stroke [15]
Veterans Administration/ Department of Defense [28]	Yes	Stated that evidence is insufficient to recommend specific instruments	Stated assessment should be “ongoing” without recommending any specific intervals