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Unilateral Spatial Neglect

Neglect has been defined as “the failure to report, respond, or orient to novel or meaningful stimuli presented to the side opposite a brain lesion, when this failure cannot be attributed to either sensory or motor defects.” The purpose of this update is to provide a focused review of unilateral spatial neglect (USN). This update will describe the 3 major categories of USN, identify USN as an attentional deficit by describing a model for directed attention, and discuss the incidence and treatment of USN. An understanding of the different types of neglect and the emerging treatment ideas is important for physical therapists to provide optimal care for individuals with USN. This update will not address homonymous hemianopsia, hemihypesthesia, or hemiparesis that may occur after a stroke. Although these impairments frequently occur with USN, they are separate entities from USN.

Categories of Neglect
Researchers have subdivided USN into 3 major categories of attentional deficits: the memory and representational deficits, the action-intentional disorders (motor neglect), and inattention (sensory neglect). Neglect of representational space has been described by Bisiach and Luzzatti, who asked 2 patients with left unilateral neglect to describe, from memory, a square in Milan that contained a cathedral, shops, and palaces. The patients were oriented to their place in the square in relation to the cathedral. The patients described the right side of the square accurately, but they omitted descriptions of the left side. When the patients were “turned around” in their memory, they began to accurately describe what had previously been to their left while omitting what had previously been to their right. This study

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suggested that the memory of extrapersonal space is stored with a body-centered coordinate system. For these patients with right parietal lobe damage, the attentional deficits in mental representations reflected this body-centered frame of reference. More recently, Beschin et al5 described a patient who had had a cerebrovascular accident (CVA) of the right parietal lobe. This patient had a "pure" representational neglect. The patient showed no evidence of a visual perceptual neglect, but had great difficulty describing details of imagined representations from his long-term memory. The studies of representational space have demonstrated that neglect is not limited to motor and sensory deficits and that behavioral aspects of brain function can be involved.

Motor neglect is not a deficit of the motor pathway, but rather a failure or decreased ability to move in the contralesional space (space contralateral to the damaged hemisphere) despite being aware of a stimulus in that space.1 Motor neglect can be seen in the eyes, head, limbs, or trunk of the individual.1 The concept of hemispace is crucial to understanding the research studies that have examined action-intentional disorders. Hemispace is a frame of reference for right and left that is defined with respect to a specified person. The trunk of the person is the reference point for defining hemispace, with the left side of the trunk in the left hemispace and the right side of the trunk in the right hemispace. Because the eyes and head can rotate in reference to the trunk, they may be shifted partially or wholly into the right or left hemispace.3 When a person is positioned with the trunk, head, and eyes facing directly forward, his or her right hemispace is the field that starts at the midline of the body and extends laterally to the right.1 The left hemispace is the field that begins at the midline and extends laterally to the left.1 If the person shifts his or her eyes to a rightward gaze without moving the head or trunk, then the right and left visual fields are now in the person's right hemispace.1 As the person turns his or her head to the right, the entire head enters the right hemispace.1

Watson et al6 demonstrated support for neglect exhibiting the signs and symptoms of an action-intentional disorder. These researchers trained 5 monkeys to open a door to their right after left leg stimulation and to open a door to their left after right leg stimulation. Unilateral lesions were surgically completed in the frontal arcuate gyrus or the intralaminar nucleus of the thalamus and the mesencephalic reticular formation. The unilateral lesions were placed in the right or left hemisphere of the brain. Post surgery, the monkeys demonstrated USN, as seen by their orientation to right and left sides and by their response to visual or light touch stimuli. None of the monkeys displayed weakness of their limbs. When retested on the door-opening task, the monkeys made mistakes when the stimulus was applied to the ipsilesional limb (the limb ipsilateral to the damaged hemisphere) (the contralesional limb response was in error). When the stimulus was applied to the contralesional limb, the monkeys correctly performed the task with the ipsilesional limb. Watson et al showed that motor responses were being made following a sensory stimulus; however, the contralesional limb motor responses were

Unilateral spatial neglect is a complex deficit in attention that may occur following stroke.

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Unilateral Spatial Neglect and a Model for Directed Attention

Unilateral spatial neglect can occur with a lesion in any of the following areas: posterior parietal cortex, frontal lobe, cingulate gyrus, striatum, and thalamus. Although these areas are located throughout the brain, they are all important components in the process of attention. Some experts have focused on the posterior parietal lobe as the focal point of lesions that resulted in USN. More recent research has shown that attention is mediated by a network of many different anatomic areas working together. Although there are extensive interconnections among the anatomic areas contributing to attention, only the major pathways will be discussed here.

The posterior parietal lobe is the site of converging information from visual, auditory, somatosensory, and vestibular unimodal areas. Mesulam has proposed that the integration of the many sensory inputs leads to the formation of a sensory representation of extrapersonal events (events occurring in the hemispheres surrounding the individual). The primary anatomical region for attention in the parietal lobe is centered on the sulcus separating the superior and inferior parietal lobes; however, adjacent parietal areas also are probably involved. The posterior parietal lobe has extensive interconnections with the premotor cortex, the frontal eye fields, the superior colliculus, and the paralimbic areas. The cingulate gyrus is the strongest interconnection between the posterior parietal lobe and the paralimbic areas.

Mesulam postulated that the limbic system’s role in attention is organized into 2 components. The anterior cingulate gyrus plays a role in the motivational relevance of the many extrapersonal sensory inputs. The posterior cingulate gyrus monitors post-saccadic shifts in the direction of overt visual attention.

Input from the reticular activating system originates in the raphe nuclei and nucleus locus coeruleus of the brain stem, the nucleus basalis, the ventral tegmental area, and the intralaminar thalamic nuclei. The intralaminar thalamic nuclei determine the relevance of stimuli and control transmission of information from the thalamus to the cortex. The primary function of the reticular pathway is to control the activation and level of arousal of the attentional network.

Mesulam speculated further that motor planning and output are focused in the frontal eye fields and the adjacent premotor areas. These regions are directly involved in overt and covert shifts of directed attention. Researchers studying the neuroanatomy of monkeys have found extensive interconnections between the frontal eye fields and the posterior parietal cortex, cingulate gyrus, thalamus, subthalamic nuclei, superior...
colliculus, and other premotor and prefrontal areas. The cortical and subcortical input to the frontal eye fields and adjacent motor regions directs the eyes, head, and limbs to scan and explore the environment.

Mesulam has developed a model of the neural networks involved in the distribution of attention (Fig. 2). The posterior parietal lobe, limbic system, and frontal eye fields/adjacent premotor areas are self-contained local networks, and each has a role to play in attention. These local networks have extensive interconnections with each other and the reticular activating system that form a larger neural network for attention. The task of the larger network is to form a representation of the external environment, target specific stimuli, and then explore those stimuli through visual scanning and motor acts. The posterior parietal lobe is primarily responsible for creating a sensory representation of extrapersonal events, and for targeting specific stimuli. The cingulate gyrus determines the motivational relevance of the extrapersonal sensory input. The frontal eye fields and adjacent premotor areas regulate visual scanning, orient the head and eyes to explore the environment, and initiate motor acts for limb movement. Although it may be tempting to associate deficits with a lesion in one area, Mesulam cautions us against this. Mesulam contends there are no rigid boundaries of different types of USN because the attentional network is tightly interwoven. A specific behavior is not a product of one specific anatomic area, but rather a result of the many connections that are found within that area and with other more distant regions.

Incidence of Unilateral Spatial Neglect

The incidence of neglect is not clearly documented in the literature. Stone et al reported that over 80% of patients demonstrate a visual neglect following a right CVA, whereas Denes et al reported a 17% rate of occurrence of USN following a right CVA. Left neglect after a right hemisphere stroke is most common, but right neglect after a left hemisphere stroke can
has also been reported.\(^{17}\) The normal variations that occur in the side of cerebral dominance\(^{18}\) may account for the variations in the side of neglect and location of the stroke. Left neglect is more severe, as measured in neuropsychological testing, than right neglect,\(^{13,19}\) and larger lesions increase the severity of neglect.\(^{20,21}\) Although neglect is most apparent in one hemispace, test batteries have revealed that neglect occurs in both hemispheres.\(^{22}\) The rate of recovery from neglect is greatest in the first month poststroke,\(^{22}\) and recovery can range from a persistent neglect to complete recovery.\(^{15}\) The presence of neglect has been associated with poor outcome measures on functional activities following a stroke.\(^{23,24}\) Patients with neglect have been found to have longer lengths of stay in rehabilitation facilities and lower scores on the Functional Independence Measure (FIM),\(^{25}\) and thus require more assistance at discharge than patients without neglect.\(^{13,26}\)

### Treatment

Treatment strategies for USN most often have been focused on the training of attention in the left hemispace. Weinberg et al\(^{27}\) designed a treatment program to train patients with right hemisphere lesions in scanning to the left. An initial target that served as an anchoring point was placed in the left hemispace of a reading task. The density of the stimuli (size of print relative to lines of print) and the pace of the patient’s visual tracking pattern (slow versus fast) were manipulated by the examiner. A battery of neuropsychological tests were completed prior to and on completion of the treatment program. The experimental group showed improvement over the control group after 20 hours of intervention, and the effects of treatment were still present after 1 year. In a follow-up study, Weinberg et al\(^{28}\) expanded their program to include training of sensory awareness and spatial organization. Patients with right hemisphere lesions were given 20 hours of training in sensory awareness (identifying the location of a light touch stimulus applied to the posterior trunk) and spatial organization (estimating the sizes of plexiglass rods of differing lengths). The experimental group again showed improvement on numerous neuropsychological tests over the control group, and Weinberg et al concluded that the combination of visual scanning, sensory awareness, and spatial organization training is an effective treatment strategy for patients with right hemisphere lesions.

Robertson et al\(^{29}\) designed a strategy to decrease USN by facilitating activation of the sustained attention system. This strategy is based on the premise that sustained attention is a system that engages attention in preparation for response in the absence of external stimuli. Patients with right hemisphere lesions completed sorting tasks while a trainer provided an auditory reminder to attend to the task. The auditory reminder consisted of unpredictable loud knocking on the desk and a loud verbal command to “Attend!” The patients gradually took over the responsibility of performing the auditory command. The auditory reminders were then phased into internal mental reminders, and the patients were encouraged to apply this strategy to their daily tasks. The patients were assessed before and after treatment using 2 measures of sustained attention, 2 measures of neglect, and 2 measures of a control task in which the patients’ performance was not expected to change as a result of the treatment. Robertson et al found changes in 2 of the 4 outcome measures, and no effect in 2 of the outcome measures. The 2 control measures showed no effect. Robertson et al concluded that their treatment program improved the patients’ ability to sustain attention.

More recently, Smania et al\(^{30}\) used visual and movement imagery exercises to target the representational deficits seen in patients with USN. Two patients with USN following stroke were examined in this case study. The patients were more than 6 months post-onset of their stroke, and neuropsychological tests indicated that their level of USN had been stable for 45 days. Thus, the patients in this study were beyond the normal time frame for complete recovery.\(^{22}\) Visual imagery exercises included tasks such as describing the position of objects in a room of their home and visualizing a word and then spelling it backwards. During movement imagery exercises, the examiner began in one posture and then moved to another posture. The patients were required to watch the examiner and verbally describe the changes in postures. The patients also learned a specific sequence of movements while in sitting. They were taught to visualize moving through the sequence and to verbalize their visual representations. Smania et al conducted extensive neuropsychological tests before beginning the visual and movement imagery exercises, at the end of the treatment program (40 sessions), and 6 months after completion of the treatment program. They found improvements in performance at the end of the treatment program. These improvements were sustained at the 6-month follow-up evaluation.

Several researchers\(^{31–35}\) have shown a reduction in USN following manipulation of sensory input that conveys perception of the head in space. A temporary remission of USN has been noted in several studies following vestibular stimulation through caloric irrigation.\(^{31–35}\) The neural pathways responsible for this remission are unknown.\(^{32,33}\) Unilateral spatial neglect has also been reduced temporarily through galvanic stimulation of the vestibular nerves.\(^{34}\) Rorsman et al\(^{34}\) found that galvanic stimulation applied during visuomotor tasks decreased the severity of neglect. The galvanic stimulation was...
removed on completion of the visuomotor tasks, and by the next day, the patient’s prior level of neglect had returned. Karnath et al. found that lengthening of the left posterior neck muscles by trunk rotation induced a transient remission of left USN, presumably due to the sensory input that this supplied to the central nervous system. This effect was seen during lengthening of the muscles accomplished by rotating the trunk 15 degrees to the left while the head remained stationary and during vibration of the left posterior neck muscles.

Modifications of the visual input to patients with USN have shown some success as a treatment intervention. Rossi et al. used prisms that were attached bilaterally to the left half of eyeglasses of patients with left-sided USN. The prisms shifted peripheral images to a more central position on the retina. The patients with USN showed improvement on visual perception tests after 4 weeks of wearing the prisms when compared with patients in the control group. However, there was no difference between the experimental group and the control group on improvement in function as measured by the Barthel Index. Rossetti et al. investigated the use of wide-field prismatic lenses with patients with USN. The wide-field prismatic lenses were fitted to goggles and created an optical shift of the visual field 10 degrees to the right. Twelve patients with USN were randomly assigned to the prism group or a control group. The patients underwent neuropsychological assessments for USN. Immediately after testing, the patients donned their goggles and performed a series of 50 pointing responses to visual targets appearing 10 degrees to the left or right of their body midline. This task took 2 to 5 minutes. Immediately afterward, the neuropsychological assessments were again administered to the patients, followed by a third assessment 2 hours later. The patients wearing the prism lenses demonstrated improvement during the 2 post-tests, whereas the patients wearing goggles without prisms showed no difference. Rossetti et al concluded that the adaptation to the prisms affects spatial representation in the brain.

Several researchers have examined the effects of using an eye patch on USN. Their studies were based on a combination of neuroanatomical, neurophysiological, and psychophysiological models. Research has demonstrated that, in an individual with an intact nervous system, retinal input from the eye is strongest to the contralateral superior colliculus (Fig. 3). Visual stimuli to the right superior colliculus generates leftward saccades (quick, involuntary movements of the eyes as they change from one point of gaze to another), whereas visual stimuli to the left superior colliculus generates rightward saccades. When the entire right eye of an individual with left USN is covered with a patch, the remaining visual stimuli to the left eye presumably follows the stronger pathway to the right superior colliculus, which generates leftward saccades. This eye patch is theorized to affect perception and attention by facilitating the direction of attention. When the right hemifields of both eyes are covered with patches in an individual with left USN, visual input is thought to follow the remaining pathways and converge primarily on the right superior colliculus, generating leftward saccades. This method is thought to control the intention and direction of gaze.

Butter and Kirsch examined patients with a right CVA and left USN and found that placing a patch over the right eye improved performance on a standard test battery for neglect. The patients wore the eye patch only during the administration of the test battery, and the beneficial effect was limited to the time in which the patients wore the eye patch. Walker et al. examined 9 patients with a right CVA and left USN. The patients’ performance on standard tests for neglect were evaluated during normal viewing conditions, while they wore a right monocular eye patch, and while they wore a left monocular eye patch. Walker et al. had theorized that the patients’ performance would improve when the right eye patch was worn and would diminish when the left eye patch was worn. Walker et al. found no differences between the normal viewing condition and when the right or left eye was covered with a patch. Beis et al. studied the effects of eye patches of various types on right eye movements measured by photo-oculography, a letter cancellation test, and the overall score on the FIM. Patients with right CVA and left USN were assigned to a control group, a group with a monocular patch covering the right eye, or a group with a binocular patch covering the right hemifield. The patches were attached to the patients’ glasses and were worn approximately 12 hours per day for 3 months. The patients with the right hemifield covered with a patch showed improvements in FIM scores and right eye movement in the left field when compared with the control group and group with the monocular patch covering the right eye.

Mirrors also have been used as therapeutic devices to facilitate attention to the neglected side. Ramachandran and colleagues placed a mirror in the right parasagittal plane of patients with left USN so that the left hemispace was visible to the patient. When the patients were asked to reach for an object in the left hemispace that was visible in the mirror on the right, some patients were able to locate the object in the left hemispace. Other patients attempted to reach for the mirror image of the object, and Ramachandran and colleagues named this behavior “mirror agnosia.” Ramachandran et al. presented 3 possible interpretations for mirror agnosia: (1) the patient may be projecting the mirror image to the neglected side, thus ignoring the
image along with everything else in the left hemispace, (2) parietal lobe lesions may impair spatial representations, or (3) the patient may have difficulty with use of metaphorical language, resulting in reaching directly toward the mirror image.

Summary

Unilateral spatial neglect is a complex, but fascinating, deficit in attention that may occur following stroke. The phrase “unilateral spatial neglect” belies the complex mixture of disorders in representational memory, hypokinesia in the opposite hemispace, and inattention to sensory stimuli in the opposite hemispace. Unilateral spatial neglect occurs as a result of damage to the posterior parietal cortex, frontal lobe, cingulate gyrus, striatum, thalamus, or specific brain-stem nuclei. This neural network for attention is an excellent example of how different anatomic areas work together to produce a specific behavior. Traditional treatment strategies for USN have focused on training attention in the left hemispace using a variety of techniques, including sensory awareness, visual scanning, and spatial organization. Recently, additional treatment strategies have emerged that focus on representational aspects of brain functioning. These strategies have included visual and movement imagery, manipulation of sensory input that conveys perception of the head in space, and manip-
ulation of visual input using prisms and eye patches. The complex nature of USN provides numerous directions for future research. Continued research will play a pivotal role in devising effective treatment strategies for patients with USN.

References


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