A primer for the optometric management of unilateral spatial inattention

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Background: Unilateral spatial inattention (USI) (a.k.a. neglect, unilateral neglect, visual neglect) is a common occurrence after stroke. It can also occur subsequent to traumatic brain injury. Insult to the right inferior (posterior) parietal cortex is the structure that is virtually always involved, although other brain areas have been implicated. The major consequence of USI is that the patient is unaware of one side of the body, and/or one side of visual space. Current literature expresses this as USI in the individual's personal, peri-personal, and extra-personal spaces.

Methods: We discuss the condition's natural history, occurrence and behavioral consequences.

Conclusions: We propose a system for the optometric management of USI in extra-personal and peri-personal spaces.

Key Words: Acquired brain injury, allesthesia, anosagnosia, Behavioral Inattention Test, cerebral vascular accident confrontation testing, extra-personal space, Fresnel prism, homonymous hemianopia, parietal cortex, personal space, peri-personal space, scanning techniques, spatial neglect, stroke, traumatic brain injury, unilateral spatial inattention, visual neglect, yoked prisms

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The terms *neglect, unilateral neglect, visual neglect, spatial neglect*, and *hemi-inattention* are among the names that have been used to designate a condition, characterized by a particular group of behaviors, that can be a consequence of acquired brain injury.[1] We suggest that the various terms indicate both the complexity of the condition and the use of more-precise descriptors as its underlying neurological mechanisms and consequent behaviors have become better understood. Recently, Driver and Vuilleumier[2] defined the entity as:

> "...a relatively common and disabling neurological disorder after unilateral brain damage. It is characterized by a lack of awareness for sensory events located towards the contralesional side of space (e.g., toward the left following a right lesion), together with a loss of orienting behaviors, exploratory search, and other actions that would normally be directed toward that side. Neglect patients often behave as if half of their world no longer exists."

In this article we use the term *unilateral spatial inattention* (USI) to denote the condition, except when we are directly quoting or paraphrasing other authors. This is indicative of our belief that *neglect* carries the connotation of a willful act on the part of the individual, while *inattention* more accurately describes the individual's unawareness of, and lack of attentional control over, the condition. We present an overview of what we believe is the current core knowledge of USI. This will serve as basic and necessary background information for our proposed system for the optometric management of the visual aspects of USI.

The parietal cortex

Although USI is present after various types and locations of unilateral brain damage, it is more frequent and longer lasting after insult to the right inferior parietal lobe, which is also identified as the right posterior parietal lobe.[1-4] Stein[4] has extensively reviewed the evidence indicating that this brain area's functions are primarily for the cognitive representation of both personal space, or body image, and external space. Consequently, it would be logical to expect somatic and/or visual consequences as the result of insult to the right inferior parietal lobe. Further, since it is the right inferior parietal lobe that is usually involved, it follows that these dysfunctions would be present on the left side of the body and the left side of external (visual and auditory) space. Stein summarized these into two general categories. He first described somatic dysfunctions, which include impaired tactile perception, and denial of the existence of the left side of the body. These are understood to be dysfunctions in *personal space*. The second category includes dysfunctions of visual motor control, visual localization, and impaired visual representation of the outside world (i.e., *extra-personal [visual and auditory] space*). He further divides this space into *peri-personal space*, in which the individual makes purposeful motor actions, such as reaching for and manipulating objects. Stein also makes the point that while these spaces are interactive and interdependent, the body image, which is the cognitive aspect of personal space, forms the basis for the integrity and cognitive aspects of extra-personal space. This concept is not new to optometry, although different terms have been used to denote the primacy of the body image in various aspects of vision development and integrity. For example, Skeffington[5] used the term *anti-gravity* to denote the same concept as basic to normal vision development. Suchoff[6] used *invariant* as the foundation for visual spatial development. He later proposed it as a key component in human self-lateralization and the development of left–right directional concepts.[7]

Thus, USI can be conceptualized as an umbrella term that encompasses motor and cognitive dysfunctions of various somatic, visual, and auditory components. Further, to paraphrase Robertson and Halligan,[1] the commonality is the individual's inability to respond or direct attention to sounds, or visual information from one side of external space, or to sensations to, or awareness of, one side of his body. Heilman et al.[8] have proposed a neglect syndrome that identifies some of the relevant components. These are:

Hemi-inattention: This refers to a general lack of awareness of one side of space, and can be determined by relatively casual observation of the patient.

Hemi-spatial neglect: This requires careful observation of the patient and/or the use of structured testing to document the specific behavioral areas of unawareness.

Extinction: This is a concept familiar to optometrists. It describes the situation in which the patient shows awareness to a stimulus presented singularly to the contra-lesional side of the body (personal space) or to a contra-lesional visual or auditory stimulus (extra-personal space). However, the patient becomes unaware of the contra-lesional stimulus when the same stimulus is presented simultaneously to both sides of the body or both sides of extra-personal space.

Allesthesia: This describes the tendency of the patient to attribute kinesthetic or visual stimuli that are applied to the affected side to stimulation on the non-affected side.

Anosognosia: This term denotes the patient's unawareness, denial, or minimization of the behavioral consequences of USI, or other impairments. Diller and Weinberg[9] have recognized this denial as a significant impediment to the rehabilitation of these patients. They proposed a denial scale, going from active resistance when the problems are pointed out, to awareness and acceptance of the problem, at least on a gross level.

Natural history of USI

The most-common etiology of USI is cerebral vascular accident (CVA, stroke)—particularly when the middle cerebral artery is involved.[3,10-12] The severity of USI depends on the magnitude of, and time lapse after, the stroke. Gainottti et al.[3] describe the most-severe form as the patient lying in bed with eyes and head rotated toward the side ipsilateral to the lesion, and sometimes being unable to look into the contralateral side of space, even when spoken to from that side. Some days later, the eyes–head orientation may become significantly less. However, as the patient is able to perform more activities of daily living, other manifestations of USI are evident. For example, the patient may fail to pick up food on the contralateral (usually left) side of the plate, and may consistently forget to lock the left side of the wheelchair.[3]

The above depiction of the stroke patient shows that initially the most-florid manifestations of USI appear in personal space, and then proceed to peri-personal space. At this juncture, however, it is usually not possible to thoroughly evaluate dysfunctions in extra-personal space, although this *does* vary with the severity of the stroke.

The literature on recovery is not definitive. Dombovy and Aggarwal[12] stated that gross neglect appears to resolve to a large extent by 8 to 12 weeks after the event, but subtle defects that can impede performance in a busy environment often remain. A group of hospital-based Israeli researchers[13] divided 40 consecutive admissions with right hemispheric stroke into two groups. One group of 19 was diagnosed with "unilateral spatial neglect" and a second group (of 21) did not show this condition. They reported that most improvement occurred in the first 5 months for both groups. However, the group with neglect scored lower than the other group on measures of activities of daily living, as well as sensory and motor performance, both initially and at 6 months after discharge. Allegri[14] reported that a third of his sample, who were initially diagnosed with "unilateral neglect," continued to have the condition one year after the stroke.

Robertson and Halligan[1] proposed that major spontaneous recovery of USI occurs within the first 6 months after the injury, but that residual effects can last for years. They further stated that the effects can be insidiously disruptive in the patient's life, long after the more-dramatic symptoms have resolved. They underscored their point by citing a study that reported features of USI some 12 years after the stroke.[15] In many instances, the residual dysfunctions are often undiagnosed for what they are and are attributed to such things as clumsiness, poor attention span, or lack of motivation.[1]

Occurrence of USI

Estimates of the occurrence of USI vary; two medical rehabilitation specialists estimated it at 12% to 49% in right-brain stroke patients.[12] Allegri[14] compared the incidence of USI in right vs. left hemisphere stroke patients. He reported 31% to 46% in the former and 2% to 12% in the latter group.[14] Four Swedish researchers used a community-based study design (i.e., their subjects were not hospital patients). They estimated that in their sample of stroke patients, 23% had visual-spatial neglect, 8% had personal neglect, and 17% had anosognosia.[16] Robertson and Halligan[1] presented a chart that summarized the presence of visual neglect from 10 studies. The percentages vary from a high of 95% in a study with 136 subjects to a low of 12% in a study with 40 subjects.

There are reasons for the variability of these estimates. In most of the above studies, it is unclear whether incidence or prevalence was being reported. Further, different researchers used different methods to determine the presence of USI, and it was not always made clear as to the time elapsed since the stroke. Nevertheless, there is sufficient evidence to state that USI can be present in stroke patients—albeit, significantly more when the incident occurs in the right inferior parietal lobe. There is evidence that it can occur in the other brain areas, and as a consequence of traumatic brain injury (TBI).[2,4] However, it appears to occur more frequently in stroke than in TBI.[1]

Behavioral consequences of USI

General considerations

The effects of the condition are conceptualized to occur in personal, peri-personal, and extra-personal space. In the following bulleted sections, we list some of the most-common behavioral consequences of USI in the individual spaces. All consequences discussed in this section—and for the rest of this article—are on the left body or in left peri-personal or extra-personal space, and hemianopia designates a visual-field impairment that is homonymous.

The behaviors listed here are primarily a function of USI, and "cannot be attributed entirely to elementary sensory-motor deficits, such as weakness, clumsiness, or poor acuity."[17] This quotation is core to truly appreciating the essence of USI. For example, it means that the patient with USI may or may not have a basic neurological motor dysfunction, or a hemianopia caused by a basic visual sensory defect. Even when basic motor and/or sensory impairments do exist, however, the USI behavioral consequences cannot be totally explained by these impairments. The key lies in the fact of the patient's unawareness or denial of the impairment(s).

An example will amplify this important point. Consider three patients who recently had cerebral vascular accidents. The first individual has incurred a lesion in the motor pathway to the left arm. When asked to move that arm, he tells you he can't. This person has a basic neurological dysfunction and is **aware** of it. Consequently, there is no USI.

The second patient also has a lesion in the motor pathway to the left arm. When asked to move that arm, he tells you he did. However, there is no movement. This person has a basic neurological dysfunction, but is **unaware** of it. Thus, there is USI in the presence of a basic neurological dysfunction.

The third individual has no lesion in the motor pathway to the left arm. When asked to move that arm, he tells you he did, but there is no movement. This **unawareness** of the motor dysfunction indicates USI. This is an example of USI in the absence of a basic neurological dysfunction.

Personal Space USI Behaviors

- *anosognosia*, a failure to recognize a severe hemiplegia or other motor dysfunction; *asomatognosia*, a failure to acknowledge body parts as one's own[8,18]
- extinction, hemianaesthesia; hemiparesis, hemiplegia[19]
- body schema unawareness, an impairment of the internal three-dimensional, dynamic representation of the spatial and biomechanical properties of one's body[20]
- instability of the body in space: patient observations such as "I feel unsteady"; "I'm not grounded"; "I'm out of synch with the world."[21]
- *akinesia*, the failure to move a body part; *hypokinesia*, a delay in moving a body part; *hypometria*, body part movements of decreased amplitude; *impersistence*, a failure to persist a body movement or to maintain posture[1]

Peri-Personal Space USI Behaviors

- failure to apply makeup to, or shave one side of the face; failure to comb hair on one side; misses food on one side of the plate; failure to read one side of text[1]
- unawareness of objects that are pictorially represented across a page on one side of the page, but aware of them on the other side; failure to copy or spontaneously draw one side of pictures [3,22]
- unawareness of objects placed on one side of a table, bedstand, etc.; failure to place limbs into shirt and/or trousers on one side when dressing[23]

Extra-Personal Space USI Behaviors

- a general unawareness, inattention,[2] imperception[4] of one side of the external world. The individual is unresponsive to, and not cognizant of, sounds and/or objects and/or people on that side.
- frequent collisions with objects and people and the inability to discern oncoming traffic when crossing the street or driving, sudden "popping up" of objects or people.[1,24,25]

There is evidence that USI affects not only immediate extra-personal space, but also the visual memory, or imagery of that space. Patients of Bisiach et al.[26,27] all had lesions of the right temporo-parietal region. They were asked to imagine standing on a square in Milan that was quite familiar to them. They were further instructed to imagine being lined up with the front of a cathedral, which formed the center of the actual scene, and name the buildings on either side. The patients reported a significantly greater number on the right than left. They were then asked to imagine viewing the scene from the back (180-degree difference). The same type of performance was evident, even though the buildings that were previously not identified from the front view were now named, and vice versa.

Optometric management of USI in extra-personal space

General considerations

Optometric interventions for USI are primarily concerned with extra-personal and peri-personal spaces. We recommend that the clinical determination of USI in extra-personal space precede that of peri-personal space.

USI can occur with or without a basic sensory or motor dysfunction. This is true in the visual aspects of the condition, and can be particularly confusing. For example, a patient can manifest the behavioral consequences of USI in extra-personal space, yet conventional static and kinetic perimetric testing do not indicate a hemianopia. Or conventional perimetric testing can indicate a hemianopia, but the patient will deny or be unaware of its existence and manifest USI behaviors.

To fully appreciate the situation, it is productive to consider two major visual pathways. The first extends from the retina to the lateral geniculate

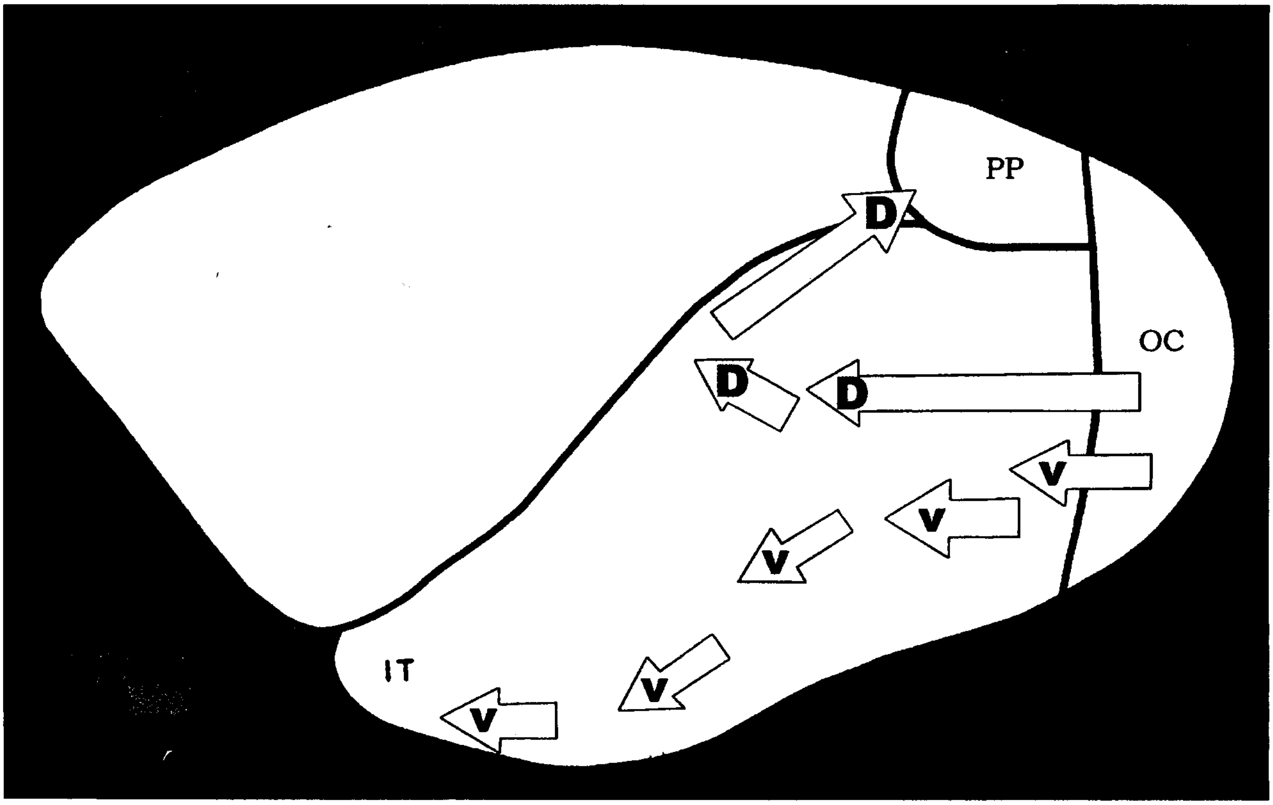

Figure 1 A schematic representation of the extended visual cortex. The dorsal (**D**) stream proceeds from the occipital cortex (**OC**) to the posterior parietal cortex (**PP**). The ventral (**V**) stream proceeds from the OC to the inferior temporal (**IT**) cortex.

body, and then proceeds to the occipital (visual) cortex. Because of the decussation of the visual fibers at the optic chiasm, a lesion in the post-chiasmal portion of the right track results in a partial or complete loss of sensitivity in a section (homonymous quadrantanopia) or one half of the left visual field (homonymous hemianopia) of each eye, and vice versa. Perimetric testing will reveal these field cuts, since they are retinotopic (i.e., a function of the pathway from the retina to the occipital cortex).[25] A portion of the second major pathway (the extended visual cortex's[28,29] dorsal stream[30-32]) proceeds from the occipital (visual) cortex to the parietal cortex (*see* Figure 1). A lesion in this pathway presumably does not result in a visual field defect that is evident by conventional perimetric testing, but rather in USI. This is because the lesion is not retinotopic. Consequently, several possibilities can occur as the result of stroke or traumatic brain injury: if only the first visual pathway is affected, a field cut will be evident by perimetric testing, and the patient will be aware of it. If both the first and second pathways are involved, there will be a field cut that is evident by conventional perimetric testing. However, the patient's awareness of the cut varies according to the severity of the accompanying USI. If only the dorsal stream of the second major pathway is involved, conventional perimetric testing will not reveal a field cut. Nevertheless, the patient will show USI behavioral consequences in external and/or peri-personal space.[25]

The just-presented discussion offers a pragmatic and dichotomous model that reflects the pertinent knowledge to differentiate between a visual field defect that is the product of a basic visual sensory insult (hemianopia), and one that is the product of insult to the pathway from the occipital to the parietal cortex (USI). As such, it presents the possibilities as absolutes in terms of the patient's awareness (i.e., the hemianopic individual is always aware of the field cut, while the USI individual always lacks awareness of one side of external space). Our clinical experience indicates, however, that while some patients usually function in one or the other absolute manner, most individuals do not. We have previously suggested a dynamic continuum—one end of which is absolute awareness of a visual field defect (hemianopia), and the other a total lack of awareness (USI).[21] This allows the clinical observations that at times some hemianopic

Extremes of the continuum between HH visual-field defect and the type of defect in USI

Homonymous hemianopic	Unilateral spatial inattention
• Post-chiasmal pathway to Occipital	• Right Posterior Parietal
• Basic visual sensory dysfunction	• Higher-order perceptual dysfunction
• Is retinotopic. (+) perimetric findings	• Is not retinotopic. (–) perimetric findings
• Patient is AWARE	• Patient is UNAWARE
• (–) for USI behaviors	• (+) for USI behaviors

Box

patients will lose awareness of the field cut under certain conditions, such as when driving or walking on a city street with a complex visual and motion content. They will fail to "scan into" the affected field and will have "fender benders" or walk into objects or people on that side.

The opposite is proposed to occur with some USI patients; they will sometimes become aware of the affected field because of previous mishaps under the same environmental conditions and be more attentive to that side of space. Nevertheless, while each group of these patients can move more toward the center of the continuum, their overall mode of behavior is primarily toward one or the other extreme. The Box summarizes the differences between the extremes of the continuum, from the hemianopic visual-field defect to the USI defect.

This indicates there can be a variability in USI. Another example is that the condition can occur in extra-personal space, but not in peri-personal space, or vice versa. There are further examples that USI is not an "all or nothing" condition. Thus, some patients' performance on the same test in extra-personal or peri-personal space varies considerably over time, and some show USI for one part of a test, but not another.[1]

Diagnosis of USI in extra-personal space

1. *General clinical principles and observations*

Ocular and visual dysfunctions consequent to acquired brain injury (ABI)—i.e., stroke and traumatic brain injury (TBI)—are significant and frequently go undetected.[33-35] Consequently, protocols have been recommended for optometric[36] and ophthalmologic[37] evaluations of these patients. These include complete medical and ocular/vision histories, evaluations of ocular health, refractive status, oculo-motor integrity, motor and sensory binocular and accommodative functions, contrast sensitivity, visual-field intactness, and visual information processing. All these areas should be evaluated as far as possible with all ABI patients. Since there are reports that visual-field defects occur in from 32%[36] to 75%[38] in samples of these patients, a valuable rule of thumb is to suspect some type of visual-field defect for all ABI patients until proved otherwise.

For the purpose of this article, the differential diagnosis is to determine if there is a visual-field defect and—if one is present—to determine whether it is primarily hemianopic or USI. This clinical strategy is in accord with Driver's and Vuilleumier's documentation[2] that USI has been present where there is damage to subcortical, frontal, cingulate, and superior temporal structures. Further, it recognizes the possibility that USI can be present in both stroke and TBI patients.

We recommend that the evaluation should start with knowledge of the precipitating cause of the ABI. Individuals with right traumatic brain damage—particularly when there is documented neurological evidence—and all stroke victims are strong potential candidates for USI. During the history, the patient should be asked if it appears that "one side of the world is missing" and whether he or she "frequently bumps into people or objects on one side." The predominantly hemianopic patient will answer both questions in the affirmative. The predominantly USI patient answers negatively, demonstrating anosognosia (denial)—which is characteristic of the condition.

It is also valuable to observe the patient walking down a corridor. The patient without hemianopia or USI will generally not favor one side or the other. In contrast, the right-lesioned hemianopic patient tends to veer toward the left and exhibits a head-turn or scanning eye movements toward that side, since there is an awareness of the defect. The USI patient veers toward the intact side (right) and generally does not turn the head or scan toward the affected side, since that part of the world does not appear to exist.

In distance visual acuity testing, the hemianopic patient initially leaves out some of the figures on the affected field side of the acuity chart. When it is pointed out that figures were omitted on that side, patients will tend to actively scan or head turn so that the figures are called out on succeeding lines. In contrast, the USI patient will continue to omit the figures even after being told that figures are being missed.

2. *Visual-field testing*

Determination of the existence of USI and its differential diagnosis (USI, with or without hemianopia) requires an aggressive and complete regimen of visual-field testing. This should start with careful confrontation testing, since it allows probes into the extent of each field, and the extinction phenomenon, which is a key to determining the existence of USI. It has been recommended that this testing be done by two examiners.[38] In this method, one examiner presents the stimuli from behind the patient, while the other examiner constantly monitors the patient's fixation. The presenting examiner first tests for integrity and extent of the examined eye's left and right fields. Where there is intactness, the test for extinction is conducted: there is a presentation of one or two fingers from each hand into different portions of each field simultaneously (simultaneous double stimuli presentation). This method is more sensitive than the single examiner method because the patient devotes most attention to the monitoring examiner, and is not diverted by motion of the second examiner's hands.[38]

Whatever the results of confrontation testing, some type of perimetric testing should then be undertaken. This is possible with both projection and static perimetry for the majority of ABI patients within several months after the injury, as long as accommodations are made to account for the patient's disabilities, fatigue factor, and often-limited attention span. Further, when using static perimetry to determine the existence of USI, thresholding programs should not be used because of the time involved and attention required. Rather, a screening program that is greater than the central 30 degrees is more sensitive. When the results of the extinction part of the confrontation testing are equivocal, a three-zone strategy is beneficial. Here, if the patient does not respond to the supra-threshold stimulus, the point is again tested at a stimulus intensity significantly above the original.[38]

3. *Differential diagnosis*

The differential diagnosis is a product of the site of the lesion in the brain, the degree to which the patient exhibits USI behaviors in extra-personal space, the general clinical observations, and the visual-field testing. With these variables in mind, we propose the following diagnostic categories:

Category I

Confrontation and perimetric testings indicate hemianopia. The patient is aware of the field loss and does not demonstrate USI behaviors.

Diagnosis: Hemianopia without USI

Category II

Confrontation and perimetric testings indicate hemianopia. The patient is unaware of the field loss and demonstrates fairly consistent USI behaviors.

Diagnosis: Hemianopia with USI

Category III

Confrontation testing does not indicate hemianopia on single stimulus testing. However, on simultaneous double stimuli presentation, there is extinction of the left field. Perimetric testing indicates a relative loss of sensitivity in the left, as compared to the right field. The patient is unaware of the relative field loss, and exhibits USI behaviors inconsistently.

Diagnosis: Incomplete hemianopia with USI

Category IV

Neither single-field stimulus confrontation nor perimetric testing indicates hemianopia or relative field loss. Simultaneous double stimuli confrontation testing indicates extinction of the left visual field. The patient is unaware of a field loss, and exhibits USI behaviors consistently.

Diagnosis: USI without hemianopia

Computer-based testing can be used to further specify the nature of any loss, but is particularly valuable when previous testing has indicated USI. Gianutsos[38,39] developed one such system* and proposed it as "functional field testing." The com-

* Life Sciences Associates, Bayport, New York.

ponents of functional field testing are unique in that they are performed in typical room illumination and do not necessarily require monitored fixation on a central target. They can be done monocularly and/or binocularly, do not require the patient to maintain a fixed head position, and can be performed under different contrast settings. As such, they more closely simulate daily living conditions than conventional perimetry.

Two of these tests are particularly valuable in confirming and further specifying USI. For both tests, the patient is seated at the usual viewing distance from a computer monitor. The field subtended is usually about 40 degrees, but can be varied in terms of the size of the screen and the patient's distance from it.

In Reaction Time Measure of Visual Field (REACT) the patient presses a button each time a single stimulus that appears at random locations on the screen is perceived. The stimulus is a digital counter that increases in increments of 0.01 sec. In this manner, the precise reaction time is recorded by the computer when the patient presses the button. The stimuli are presented in a butterfly-shaped array of 16 trials. When the button is pushed, the time is recorded, and a printout allows the examiner to compare the reaction time in one lateral field to the other. This can provide further clinical evidence of USI, in addition to an estimate of its severity.

The Single and Double Simultaneous Stimulation Test (SDSST) is a more sensitive measure of the extinction phenomenon than confrontation testing. Minus (-) and equal (=) signs are the basic stimuli. Either single or double presentations of these stimuli are randomly presented at the extreme sides of the computer screen in 45 discrete trials. Responses are recorded and scored in terms of patient awareness and accuracy. This allows a further estimation of the patient's general position on the continuum shown in the Box.

Therapies for USI in extra-personal space

1. *Inform and educate*

It is imperative that once the diagnosis of USI has been made, the patient's family and members of the rehabilitation team be informed and educated. There are those instances in which the condition has been previously undiagnosed or in which any visual-field loss has been called "neglect." Another type of critical misunderstanding occurs when the field loss has been diagnosed, but is understood to mean that the patient's eye on the side of the loss is blind. We have found that a method to demonstrate the dilemma of USI to the patient's significant others is to adhere translucent tape to cover half of each lens of their glasses, or to a pair of mounted plano lenses, corresponding to the patient's affected field. These significant others are then given the opportunity to walk on a busy street or navigate an unknown room with furniture or other potential obstacles. This provides a simulation of what it is like when one half of the visual world is absent or ill defined. This demonstration, along with a discussion of how the visual-field loss affects activities of daily living, can go far to educate the patient, the family, and the rehabilitation team.

2. *Behavioral methods*

The major behavioral method to ameliorate the effects of USI has been scanning training.[1,38,40,41] This method is designed to encourage the patient to become aware of, or look into, the affected field. The use of the computer-based programs—particularly, REACT and SDSST as training devices, with verbal interventions by the therapist—can be beneficial.[38] Other techniques include the use of an electrically lit horizontal scanning board. Here the patient is required to point to lights on the non-affected side, and to gradually become aware of and point to lights on the affected side as they are sequentially lit.[41]

While the previously described behavioral methods can be tried to help USI patients, expectations for success should be tempered in terms of where the person is judged to be on the continuum (*see* Box). Thus, patients with severe USI do not respond well, since they are asked to look into a part of space that for them does not exist. However, these methods are more successful when the awareness of the field defect is greater.

3. *Optical methods*

Various devices to ameliorate the consequences of peripheral visual-field defects have been proposed. The most popular can be generalized into two categories: mirrors and yoked prisms.[38,44-46]

Mirrors are either mounted or clipped to the nasal side of the spectacle lens that is on the same side as the affected field (i.e., left spectacle lens for a

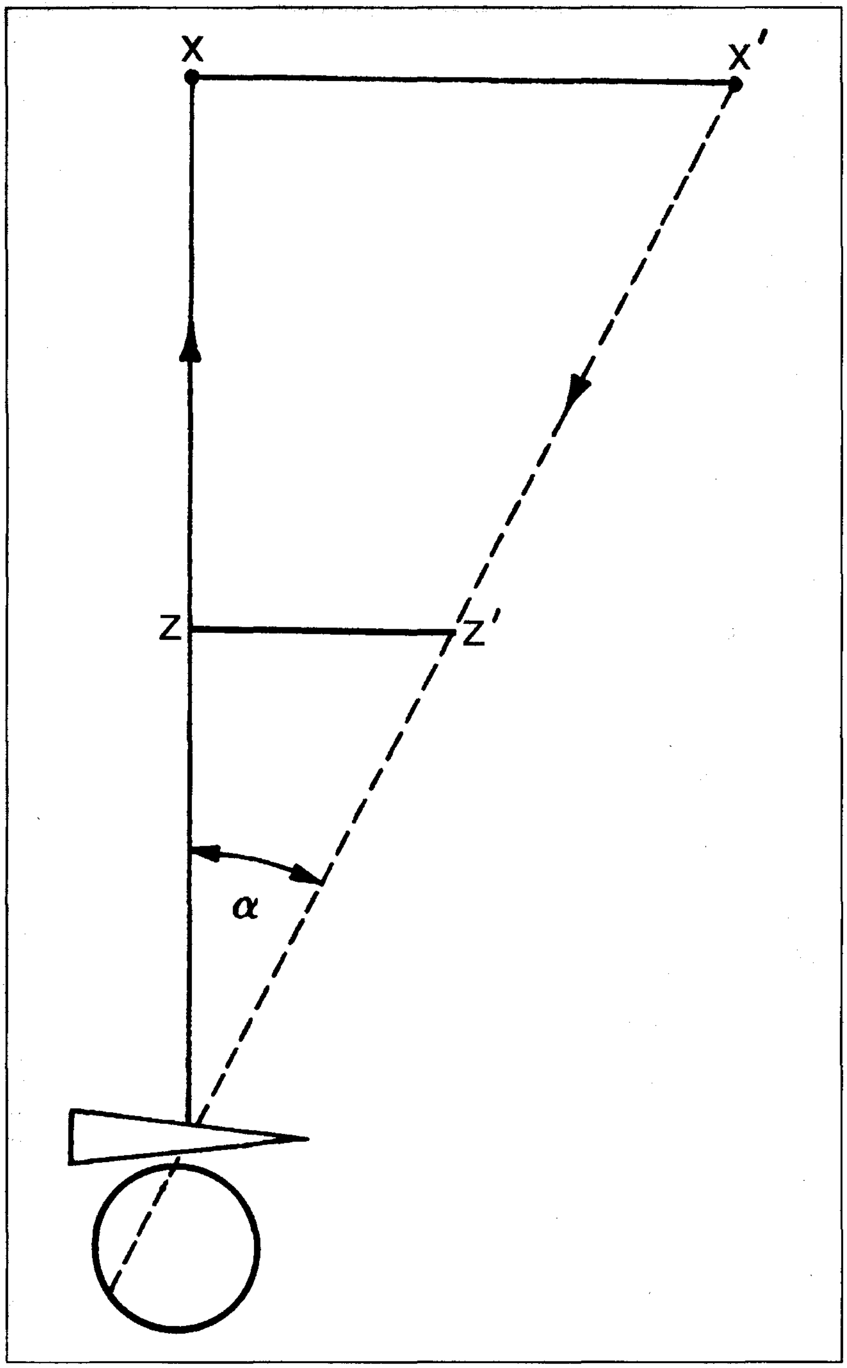

Figure 2 The yoked prism displaces point **X**, which is the true or objective "straight ahead," to **X'**. A closer point to the patient, **Z** is displaced to **Z'**. In both instances the angular separation (a) between the original and displaced points remains the same. However, the linear displacement is a function of the original point's distance from the patient (i.e., the greater the distance, the greater the displacement).

left field defect). The mirror is tilted to reflect the compromised field into the patient's left eye. The patient is then required to actively look into the mirror to obtain a view of that field. There are some difficulties with this device: the patient sees a reversed image of that field and must resolve the superimposition of the mirror's image with the image of the other eye. Further, the cosmetic appearance of the device is not acceptable to many patients.[47]

We have used various types of yoked prisms. One variation is partial (or half-field) yoked prisms. Here the prisms are either attached (Fresnel prism) or ground into the half portion of each spectacle lens that corresponds to the affected field. The base of each prism is placed in the direction of the field loss (i.e., base left for a left field defect).[47] As the patient views through the prisms, the image is shifted toward the apex, so that less of an eye movement is required to visualize targets in the non-seeing area. However, the patient must actively look into each prism to reap the benefit. These devices are effective with hemianopic patients, depending on their level of awareness of the field cut. The devices are more difficult for USI patients, because of their absolute or relative unawareness of the compromised field and the need—as with the mirror device—to actively look into that field.

Our greatest successes with USI patients have been with full-field ground in yoked prisms. These do not require the patient to look into the compromised field, as do the aforementioned devices. Rather, because each prism covers the entire lens, the effect is that visual space is shifted equally in the direction of the apex of each prism. This has the effect of shifting the patient's locus of true, or objective, "straight ahead" toward the apices (*see* Figure 2). This results in a reorganization of the wearer's visual space. Consider base-left yoked prisms' fit on a USI patient. A portion of the left (compromised) field is moved to the right. The result is an example of "robbing Peter to pay Paul";[38] that is, the gain in the left field results in a loss of the peripheral intact right field (*see* Figure 3). However, the patient now becomes somewhat more aware of people and objects in the compromised field. This does not ameliorate the total effect of USI, but rather provides an "early warning system" in that an approaching person, vehicle, or an object in that field comes into the patient's visual awareness perhaps several seconds before it did without the yoked prisms.

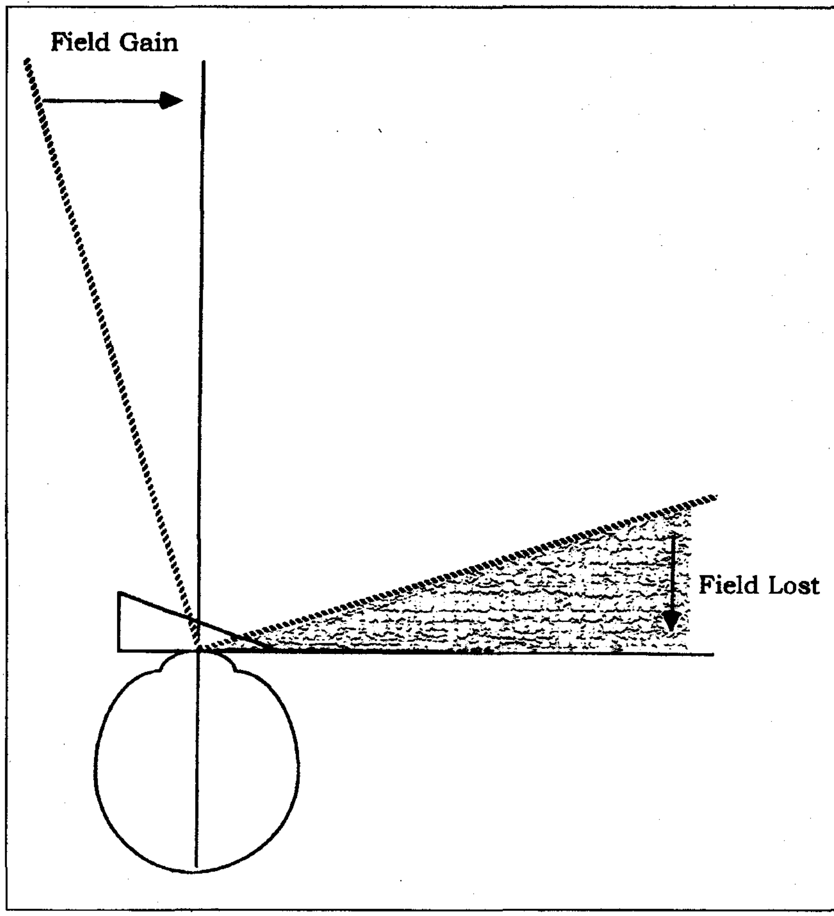

Figure 3 As a result of the yoked prisms, targets in the left compromised field are moved more toward the right uncompromised field. However, there is a corresponding loss of the peripheral right field. The extent of the loss depends on the strength of the yoked prisms. (After Cohen & Waiss.[47])

Several things are important to keep in mind when prescribing yoked prism for both hemianopia and USI. The power of the prisms should be the least at which the patient reports a visual awareness of objects or people in the compromised field that was not present without the yoked prisms. While greater prism power will move a greater extent of that field into the intact field, it will also result in greater optical distortions, such as chromatic abberation and non-uniform magnification. This is in agreement with the method proposed by Cohen and Waiss.[47] They recommended a starting point of 6 to 8 prism diopters of yoked prism (for each eye), with the usual amount being no more than 10 prism diopters.[47] A second important consideration is that the linear displacement of objects or people in the affected field will vary according to the distance the observer is from the particular object of regard. Thus, the further from the observer, the greater the displacement and vice versa.[48] This explains why a particular amount of yoked prism power will be effective at distances in extra-personal space, but not in peri-personal space (*see* Figure 2).

When some USI patients are fitted with yoked prisms they report that they "feel more grounded" or that "the world is now moving with me."[21] This is in contradistinction to hemianopic patients without neglect, who often report the opposite. A possible explanation lies in the notion that some ABI patients have what has been termed a *midline shift*.[49,50] A more-spatial component for this shift has been proposed for USI patients: it has been suggested that these individuals' perception of "straight ahead" (or egocentric spatial frame of reference localization) is shifted to the right of the true, or objective "straight ahead."[21] The first scientific demonstration of this was presented by Karnath.[51] He found that his USI subjects localized "straight ahead" an average of about 15 degrees to the right of the actual position, as opposed to that of his controls. Thus, it is possible that with USI patients, the yoked prisms' shift of visual space toward the apex (to the right) resolves the previous mismatch between true "straight ahead" and their impaired egocentric perception.[21,52] This could at least partially explain the USI patient's comfort with the yoked prisms and the non-USI hemianopic patient's frequent discomfort and need to adapt to the prisms.

There is an increasing body of evidence attesting to the efficacy of yoked prism in USI.[46,50,52,53]

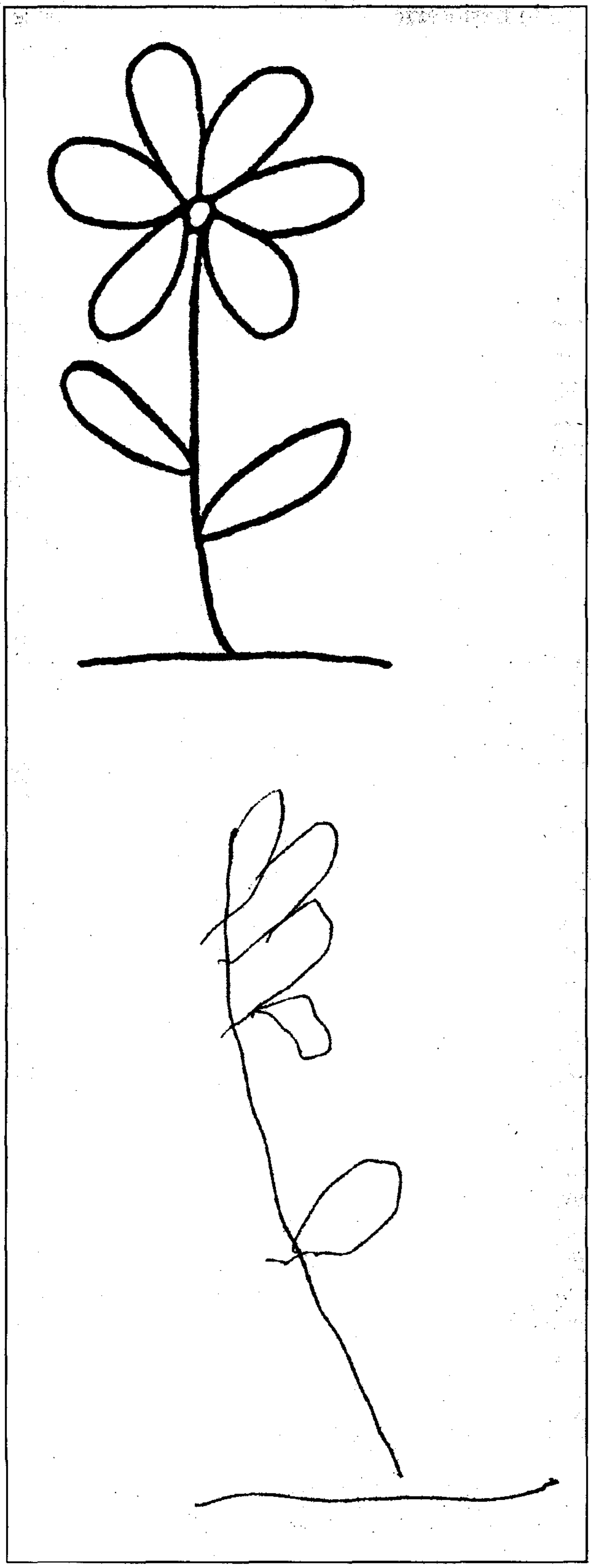

Figure 4 The model of the flower to be copied is at the top. Note the complete absence of the left side of the flower and the clumping of the petals at the top of the reproduction of this 62-year-old USI patient.

Optometric management of USI in peri-personal space

Diagnosis

1. *General clinical observations*

In addition to the questions proposed for the diagnosis of USI in extra-personal space, patients should be queried as to whether they tend to miss words on the left or right side of the page when reading. Other high-yield questions relate to whether they tend to leave food on one side of the plate or are unable to find objects on one side of tables or other surfaces. Questions about their ability to manipulate various objects on themselves are also important: do they tend to shave only one side or ignore applying makeup to one side of the face, or miss putting a leg or arm into trousers or shirts respectively? Patients with USI in peri-personal space will deny most such behaviors, but their significant others will disagree.

Pursuit and saccade testing can give indications of USI in peri-personal space. They can also help determine the co-existence of USI in hemianopic patients. Thus, with saccades, the primarily hemianopic patient will initially use a sequence of small amplitude saccades to locate the target in the affected field, but will progressively use larger saccades with practice. The primarily USI patient will make few if any searching saccades into that field and often will not be at all responsive to the target. In pursuit testing, the primarily hemianopic patient will follow the target fully in the affected field, while the primarily USI patient will be unresponsive to the target in that field.[54] The danger of not considering the possibility of USI in oculo-motor testing is the misdiagnosis of a neurologically based eye movement dysfunction.

Near visual acuity testing during the evaluation can indicate a field loss in peri-personal space in a similar manner as distance acuity testing. The left-field hemianopic patient will miss the first letters or words of the text, but will often realize the omission and compensate. The USI patient will tend to continue the omissions, even when they are pointed out, either verbally or by moving the text into the right field.

2. *Visual-field testing*

Testing for USI should proceed from extra-personal to peri-personal spaces. Consequently, the visual-field testing results are then available and should be interpreted in the manner previously described.

3. *Special testing*

A number of tests have been proposed that require the patient to mark all or particular stimuli that are printed across a page. Others require the patient to draw or copy various pictures. These "paper and pencil" tests are suggestive or indicative of USI when the patient's performance is shown to favor the right field. Figure 4 shows the drawing of a USI patient who copied the flower model.

The Behavioral Inattention Test* has incorporated a number of these "paper and pencil" probes into a single battery. It consists of six of these, which include variations of marking or "canceling" particular stimuli that are printed across the lines of a page, various line bisection tasks, and copying and drawing tasks. In addition, there are nine tests that require more cognitively based actions in peri-personal space. These include probes such as telephone dialing, picture scanning for details, telling and setting time on a round-faced clock, and reading.[55] The battery has been standardized. Thus, the patient's performance is scored and compared to the normative range for each test and to the normative ranges of the aggregate paper and pencil scores, and the more cognitively based aggregate scores.[56] These scores allow an estimation of the degree and type of USI in peri-personal space.

Therapies for USI in peri-personal space

1. *Inform and educate*

Similar to what we recommended for USI in extra-personal space, the patient, family, and members of the rehabilitation team should be informed that the condition is present in peri-personal space. They should also be educated with regard to the effects of USI in this space on activities of daily living. This information can be extremely important in providing rehabilitation techniques and strategies.

2. *Behavioral methods*

The major behavioral methods for peri-personal space are based in scanning training. Generally, these procedures are more cognitively demanding in peri-personal than in extra-personal space. Tasks that mimic the diagnostic paper and pencil tasks at an advanced level are used, such as circling or canceling out specific words on a newspaper page. Other techniques involve reading text with a red tape on the left side of the page ("anchoring") in order to call attention to that side.[9] There are also computer-based programs. One variation presents a target that is centrally located on the screen. The patient's task is to locate that target contained in an array of other targets across the screen by means of a mouse or keyboard. Another variation is for the patient to locate a target that is different in visual detail from other targets that are all the same. A benefit of these techniques is that the patient's performance can be automatically timed and scored for accuracy.[38,39] This provides a record of the patient's progress—or lack of progress—with ongoing therapy.

3. *Optical methods*

The amount of full-field yoked prisms that can have a positive effect on the USI patient for extra-personal space is most often insufficient for peri-personal space (*see* Figure 2). Our experience has been that the average amount of each yoked prism that brings about a positive performance change in the USI patient for this space is no less than 20 prism diopters. These amounts cause significant optical distortions and are often cosmetically objectionable to patients. Consequently, our strategy has been to use the full amount of yoked prisms when the patient is engaged in scanning training in-office and at home. The prisms are not incorporated into the patient's spectacle lenses; rather, the patient is loaned a set of rotatable prism goggles for this purpose.[47] When there is measureable progress as a result of the scanning training, the amount of yoked prism is gradually decreased until the progress ceases. The least amount of yoked prism that maintains the highest level of progress is then prescribed.

Summary

USI is a consequence of unilateral, most-often right parietal brain damage—particularly after stroke involving the middle cerebral artery.[1-4] It can cause negative behavioral changes in the patient's personal, peri-personal, and extra-personal spaces.[4] USI in any of these spaces is often extremely disruptive in both the patient's ability

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to perform activities of daily living and the general rehabilitation process.[1]

USI of extra-personal and peri-personal spaces is poorly understood and is frequently under-diagnosed or undiagnosed.[1] Optometrists are particularly qualified to diagnose and provide behavioral and optical treatments of USI in these spaces. Optimal treatment requires a knowledge of the consequent behaviors, the patient's awareness of the condition, and whether the USI is accompanied by a basic visual sensory impairment. We have presented a system of clinical care to address these issues.

Optometrists are becoming an important part of the rehabilitation team for ABI patients.[25,32,36,57,58] The profession's ability to diagnosis USI, inform and educate the patient's family and members of the rehabilitation team of the condition's consequences, and then provide optical and behavioral therapies can be of great service to these patients.

Disclaimer

The authors have no financial, proprietary, or other interests in the products mentioned or discussed in this article.

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