

THE EFFECT OF HEMISPATIAL SUNGLASSES ON UNILATERAL NEGLECT
AMONG PERSONS WITH RIGHT HEMISPHERE STROKE.

by

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Abstract

This study examined the effectiveness of hemispatial glasses (HSG) in persons with left unilateral neglect (UN). The glasses reduced the amount of visual stimuli entering the non-neglected visual field and presumably enabled attention to be transferred to the neglected side. Two studies were conducted. Study #1 compared the performance of 13 persons with unilateral neglect on line bisection and shape cancellation with and without HSG. Three different types of HSG were compared. The response to the HSG varied across person, type of HSG, and test. One subject who demonstrated a benefit from the HSG participated in the second study. Study #2 assessed the impact of the HSG on activities of daily living (ADL) (eating, room look about, and shelf scanning) and standardized measures of neglect (shape cancellation). Single subject methodology (a multiple baseline design across behaviors with an embedded withdrawal) was used. The HSG had no effect on mobility or shelf scanning. Wearing the HSG during the room look about resulted in a marked improvement in scanning. The subject entered a generalization phase during which the HSG were worn for 4 hours daily but not for testing. During this phase, improvements on room look about increased and carryover occurred on the shape cancellation test. The data were analyzed visually and using semi-statistical techniques. Incidental findings include previously undocumented high variability in the shape cancellation test and BIT insensitivity to neglect over a large space. HSG are shown to be beneficial for neglect rehabilitation. The implications of the varied findings are discussed in terms of general neglect theory and treatment. As well, this study provides further support for the "forced use" model. The Subjective Neglect Questionnaire and a closing interview were performed to explore social validity issues.

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CHAPTER ONE – INTRODUCTION

Stroke or cerebrovascular accident (CVA) is the leading cause of neurological disability in North America. It is also the most frequent diagnosis among adults receiving occupational therapy treatment in the hospital or home (Trombly, 1995). Stroke survivors may be left with a number of cognitive, behavioral and perceptual impairments that impede their ability to fully recover and independently resume their activities of daily living (ADL) (Cermak, et al., 1995). Of these impairments, unilateral neglect (UN) is one of the most dramatic (Herman, 1992) and disabling consequences of an injury to the brain (Denes, Semenza, Stoppa & Lis, 1982; Kinsella & Ford, 1985; Kotilla, Niemi & Laaksonen, 1986). No area of human cognition, with the exception of language disorders, has generated more research than the search for an explanation and treatment for UN (Robertson, 1994).

UN is defined as the inability of a person to respond to stimuli on the side opposite the brain lesion (Heilman, Watson, & Valenstein, 1993). Although this definition is accurate and widely accepted it does not capture the functional consequences of this impairment. Persons with severe UN are no longer able to dress, eat, read, watch television or walk without the assistance of others. For those most profoundly affected, it is as though one half of the world and all it contains, has ceased to exist (Herman, 1992). For persons having survived a stroke, the presence of UN poses the greatest barrier to returning to independent living (Van Deusen, 1993).

Perhaps most disturbing about UN is the paucity of proven effective treatments. At best, treatment benefits have been equivocal (Robertson, 1994). New treatments that show promise with some individuals fail to be effective with larger numbers of people. For these reasons, any study suggesting therapeutic benefit is worthy of further investigation.

This research proposal describes a study to determine the effects of hemispatial sunglasses on unilateral neglect. It is based on a study by Arai, Ohi, Sasaki, Nobuto, and Tanaka (1997) that found that several persons with unilateral neglect demonstrated improved scores on line bisection and letter cancellation tasks when they wore the hemispatial sunglasses. Anecdotal information suggested that the intervention also improved performance in activities of daily living (ADL). The proposed study will take repeated measures of performance on both pencil and paper measures of UN and ADL.

The balance of this chapter defines relevant terminology, information pertaining to the incidence of UN in persons with stroke, a more detailed description of the impact of UN on ADL, and the efficacy of present treatments for UN. This information will justify the need for further investigation into UN treatment. A brief description of the objectives of this study is also provided.

Terminology

UN is defined as the inability to orient, respond, or report stimuli on the side contralateral to a brain lesion, which cannot be explained by damage to the motor or sensory systems (Heilman, Watson, & Valenstein, 1993). As with many other clinical phenomena, UN is not the only term used to describe this syndrome. Used with equal frequency are the terms; hemispatial neglect, hemispatial agnosia, visuospatial neglect, unilateral spatial neglect, hemineglect, contralesional neglect, visual spatial inattention, and hemi-inattention (Bradshaw & Mattingly, 1995; Heilman, Watson & Valenstein, 1993). The terms are frequently used interchangeably and there is no consensus regarding taxonomy within the literature (Bradshaw & Mattingly, 1995). The label used by one researcher may reflect his or her theoretical bias (Van

Deusen, 1993). For instance, some researchers who use the term visual spatial inattention may do so because they believe that UN is caused by a disruption of the neural mechanisms that mediate attention processing. This paper will refer to the aggregate of clinical symptoms as UN or neglect.

Incidence and Prevalence of Neglect

CVA Incidence

The most frequent cause of neurological disability in North America is stroke. Each year 50,000 Canadians suffer a stroke (Heart & Stroke Foundation of Canada, 1996). Mortality rates are declining and of those diagnosed with stroke 70 percent will survive (Duncan, 1994).

Survivors of a stroke may be left with a number of impairments that impede their ability to resume their previous level of independence (Cermak, et al., 1995). Residual symptoms may include language problems, paralysis, visual impairments, or cognitive disorders. Greater than 50 percent of survivors are dependent in activities of daily living at the time of discharge (Dombovy, Basford, Whisnant, & Bergstrahl, 1987).

Mechanisms

The most common cause of unilateral neglect is damage to the right parietal lobe following a CVA (Heilman, Watson, & Valenstein, 1993). Hartman-Maeir and Katz (1995) reviewed twelve studies conducted since 1974 that reported the incidence of unilateral neglect following right hemisphere damage. Rates for UN varied from 12% - 90%. The average

incidence reported in these studies was 43% and the most frequently reported incidences were between 33% and 48%.

There is increasing evidence of UN following a left hemisphere stroke, however the UN manifested by persons with left hemisphere damage is qualitatively different from the neglect observed with persons having sustained right hemisphere damage (Halligan, Burn, Marshall & Wade, 1992). It is generally accepted that UN associated with right hemisphere damage is more severe, more prevalent, and primarily observed for the space or body contralateral to the lesion site (Weintraub, Daffner, Ahern, Price & Mesulam, 1996; Weintraub & Mesulan, 1987). This research proposal will be restricted to literature relevant to right hemisphere CVAs and the resulting left UN.

Overall, incidence rates for UN depend on the sensitivity of the tests used, the selection criteria for the study, and the investigators' operational definition for UN. Schenkenberg, Bradford, and Ajax (1980) demonstrated that the reported frequency of UN (for the same group of people) could vary from 30%-90% as a function of the nature of the test used and the scoring criterion. However, whichever incidence rate is accepted, given the prevalence of strokes, UN is not an uncommon occurrence (Hartman-Maeir & Katz, 1995).

Relationship between Visual Neglect and ADL Function

Impact on Recovery

There is a clear relationship between the presence of unilateral neglect and a poor prognosis for recovery of independence in ADL (Brockmann Rubio & Van Deusen, 1995).

Denes, Semenza, Stoppa, and Lis (1982) compared the ADL (bed activities, bed-chair transfers,

personal hygiene, feeding, dressing, locomotion, household activities, and outdoor independence) outcome of patients diagnosed with right hemisphere and left hemisphere CVA. Initially, the two groups did not differ on measures of independence. However, six months after stroke, the group that sustained right hemisphere damage was significantly less independent than the group that sustained left hemisphere damage. The two groups did not differ in terms of motor recovery. The only variable that approached statistical significance was the presence of UN in the group with right hemisphere damage. The authors suggest that UN is the critical variable, because "once the effect of this variable has been partialled out, the two groups could not be distinguished..." (p.549).

The study by Denes et al. (1982) has been supported by many that followed. On average, people with right hemisphere lesions and UN are less independent in ADL than people with right hemisphere lesions without UN, and people who sustained left hemisphere lesions (Kinsella & Ford, 1980, 1985; Kotilla et al., 1986). Chen Sea, Henderson, and Cermak (1993) studied 65 people with right hemisphere brain damage. They found that persons with UN performed significantly worse on tests of ADL than persons with right hemisphere damage and non-lateralized attention deficits or normal attention. The negative relationship between ADL status and UN remained even after controlling for sensation, motor, and visual deficits. In terms of occupational performance and rehabilitation outcomes, UN may be the most significant barrier to functional recovery by stroke survivors (Van Deusen, 1993)

Efficacy of Present Treatment

Halligan, Donegan, and Marshall (1992) state that any therapy must meet at least two criteria before it can be said to have any practical significance; the therapy must have enduring positive effects on the task which was trained, and the effect must generalize to other tasks and situations. They report that to date, no therapy for UN can claim to have met these criteria.

Research aimed at determining the effectiveness of treatments for UN suggests that UN treatment provides only minimal gains or equivocal outcomes (Robertson, 1994). In his review of the literature Robertson concluded that training effects (if any) are evident only for material that shows the same characteristics as the training material. For example, training to improve visual scanning - using verbal and visual cues - did not generalize to conditions other than the scanning sheet which was used for treatment and evaluation purposes.

Psychologists have conducted the majority of research evaluating treatment effectiveness, however, most treatment for UN is performed by occupational therapists. Because of the role of occupational therapists in stroke rehabilitation, and the barrier UN poses to independence, there is no shortage of material within the occupational therapy literature pertaining to UN. Several articles describe theories related to UN, tests to detect UN and the impact of UN on ADL (Chen Sea, Henderson & Cermak, 1993; Hartman-Maeir & Katz, 1995; Herman, 1992; Neistadt, 1988, 1990; Van Deusen, 1988). Also stressed in the literature is the need for occupational therapists to conduct research that evaluates their treatments and determine if they make a difference.

Justification for the Study

CVA is the most common diagnosis in adults receiving occupational therapy services (Trombly, 1995). Unilateral neglect is a frequent consequence of a stroke or damage to the right hemisphere. UN is not only frequent, but also the single greatest problem for stroke survivors to overcome in order to achieve favorable occupational performance and rehabilitation outcomes (Van Deusen, 1993). Persons with UN are more dependent following a stroke than other stroke survivors (Denes, Semenza, Stoppa & Lis, 1982; Kinsella & Ford, 1985; Kotilla, Niemi, & Laaksonen, 1986).

Equally troubling is the lack of proven effective treatments. Very few studies have demonstrated treatment effectiveness that transcends the testing situation and positively influences the person's ability to perform daily living activities (Halligan, Donegan, & Marshall, 1992; Robertson, 1994). For these reasons it is critical that occupational therapists, whose primary concern is to enhance daily living for persons with cognitive or perceptual deficits (Poole et al, 1991), develop and evaluate treatments which may ameliorate the disabling effects of this impairment.

Purpose of the Study

The primary purpose of this study was to examine whether hemispatial sunglasses (HSG) are a beneficial treatment for UN. It will examine the effect of HSG sunglasses on both pencil and paper measures of UN and ADL.

A recent study by Arai et al. (1997) inspired this research. The authors examined the effectiveness of HSG sunglasses on ten persons with stroke. Several of the participants demonstrated improved scores on line bisection and letter cancellation tasks. One subject who

frequently collided with doors and other obstacles when he walked was given the glasses to wear throughout the day. The authors' reported that he immediately stopped colliding with objects and after one week of wearing the glasses, no longer needed them.

The Arai and colleagues' (1997) study is interesting because it is theoretically sound, easy to implement in an occupational therapy setting, demonstrated beneficial effects on pencil and paper measures, and significantly affected the ADL status of the one subject. Unfortunately, the subjects wore the glasses for only a single session during which a pre-test (without the HSG sunglasses) and post-test (with the HSG) was performed. In addition, the only measures taken were pencil and paper measures of neglect. Although one subject received the glasses for daily wear and reportedly improved in ADL, the results were anecdotal. However, these criticisms are not unique to the above study and in no way detract from the compelling nature of their findings. In fact, the bulk of research aimed at exploring the effectiveness of a given intervention has used only a single exposure to the treatment followed by a single measure for evaluation.

The research that follows is a replication and extension of Arai and colleagues' (1997) study. It examined the impact of the glasses on pencil and paper measures of neglect and ADL. The effectiveness of the HSG on ADL was evaluated using single subject design methodology. Immediate and cumulative effects of the treatment were explored by systematically providing and removing the glasses. The subject was asked to complete a questionnaire at the beginning and end of the study. The questionnaire attempts to measure subjective account of the difficulties she experienced having UN (Towle & Lincoln, 1991).

This study supports the findings of Arai and colleagues (1997). It has demonstrated that some people with UN, when wearing HSG, will experience an immediate decrease in UN. This decrease was seen on both pencil and paper measures of UN and one type of ADL. The study

also strongly suggests that when worn for a long period of time each day, effects from the HSG will carryover to other tasks. The HSG did not need to be worn during a task for the subject to benefit.

This information is important for occupational therapists, other professionals interested in stroke rehabilitation, and researchers of human cognition and perception. It has both clinical and theoretical implications. Although the bulk of the research has demonstrated that treatments are ineffective, the relative frequency of UN and its consequences on the independence of those persons with this impairment demand further critical investigation of any treatments that may provide benefit.

Study Objectives

This research was conducted to evaluate the effectiveness of HSG as a treatment for UN. Two separate studies were conducted. Study One used standardized pencil and paper measures to evaluate immediate response to the glasses in 13 persons with neglect. The second study evaluated the effect of the HSG on ADL by employing multiple baseline methodology with an embedded withdrawal across the three ADL. Potential carry-over effects of the HSG were assessed by increasing the length of time the HSG were worn and evaluating the subject's performance on measures never exposed to the HSG.

Study One investigated the following questions:

- 1) Did wearing HSG while performing line bisection and shape cancellation test cause an immediate change in performance when compared to performance without the glasses?
- 2) In how many of the 13 subjects was change evident?
- 3) What was the degree of change evident in each subject?
- 4) Which of the three types of HSG (92% light blocked, 72% light blocked, or taped) produced the greatest effect?

When the study was proposed, the investigators were uncertain whether any of the subjects would experience an improvement in Study One. The second study was contingent on the HSG causing a significant improvement on line bisection or shape cancellation for one of the subjects in the first study. A subject did demonstrate an immediate improvement on the measures of UN when wearing the HSG; therefore, Study Two was conducted. It answered the following questions:

- 5) Would wearing the HSG during shelf scanning lead to an immediate improvement in performance
 - 1) Would wearing the HSG during mobility lead to an improvement in performance?
 - 2) Would wearing the HSG while looking around the room lead to an improvement on performance?

- 3) Would wearing the HSG sunglasses for four hours each day (but not while the measures were taken) lead to an improvement on the ADL? Do the glasses need to be worn during the activity for them to be of benefit?
- 4) Does the extended wearing of the HSG (four hours each day) cause possible carryover effects on shape cancellation tasks that were never exposed to the HSG?

CHAPTER 2: LITERATURE REVIEW

History of Unilateral Neglect

One of the first well-documented descriptions of UN was a case study published by Hughlings Jackson in 1876 (Bradshaw & Mattingly, 1995; Halligan & Marshall, 1994). During the late 1800s, many authors wrote of behaviors that today, appear to share much in common with UN, however the term neglect was not used until 1931 (Halligan & Marshall, 1994). At that time Pineas used the term neglect to refer to a 60 year old woman with what he concluded was no appreciable understanding of left personal and extrapersonal space and for whom left space had ceased to exist.

UN phenomenon was not conceptualized as a discrete neurological condition until a 1941 article by Brain (Bradshaw & Mattingly, 1995). Halligan and Marshall (1994) credit Brain with being one of the first researchers to conceptualize UN as a disorder of perceptual space, associate the disorder with lesions of right posterior parietal lobe, and demonstrate that damaged sensory systems were insufficient to explain the behavioral manifestations of UN. Brain used the concept of body schema to explain the connection between disruptions in extrapersonal space and personal space. According to Freidland and Weinstein (1977) (cited in Halligan & Marshall, 1994) establishing a relationship between neglect for half of one's own body and neglect for one's physical environment was critical. By doing so, neglect of the physical environment could not be accounted for by a hemianopsia or visual problems. Brain's conclusions not only served as the basis for the UN research at that time, but continue today as the dominant conceptual framework accepted by the research community.

Since 1970, a tremendous amount of research has been devoted to the study of UN (Halligan & Marshall, 1994). Halligan and Marshall attribute this resurgence to the potential for UN studies to reveal the mechanisms that underlie normal spatial processing, attention mechanisms, and mental representation. Interest in human perception and cognition, and an awareness of disabling effects of UN and its negative impact on rehabilitation efforts, have compelled many therapists to become active in the area.

Clinical Presentation of Unilateral Neglect

In general, persons with UN demonstrate a strong lateral bias, seemingly ignoring information in the space on the contralesional side, while being pathologically biased to stimuli on the ipsilesional side (Bradshaw & Mattingley, 1995). UN is not an impairment of the sensory systems, but reflects a disturbance of the higher order processing of spatial information (Lennon, 1994). Although the general characteristics of UN are adequately captured by the definition, the presentation or symptomatology can vary in several subtle, but important ways.

The most basic continuum along which UN will vary is severity. Very mild UN may only be evident under highly stressful or novel situations (personal observation) or through systematic extinction testing (Benson, 1994; Heilman, Watson, & Valenstein, 1993). Extinction occurs when the subject fails to respond to two stimuli when they are presented simultaneously but can identify each when they are presented individually. Typically it is the contralesional stimuli that are "extinguished" (Bradshaw & Mattingley, 1995). If the relative intensity of the stimulus is increased, by wiggling the fingers or increasing the intensity of a light, the deficit can be overcome (Benson, 1994). Heilman, Watson, and Valenstein classify extinction phenomenon as part of the UN syndrome, however whether UN and extinction are the same phenomenon

differing only by degree, or two distinct phenomenon is an area of controversy (Bradshaw & Mattingly, 1995; VanDeusen, 1993).

In contrast to mild UN, the presentation of florid UN is unmistakable and its impact on occupational performance is profound. Severe UN significantly restricts independence in ADL. It manifests as a complete unawareness of the body and physical environment contralateral to the lesion site (Herman, 1992). Functional limitations include: not eating off one side of a plate; washing, grooming, dressing only one side of the body (Caplan, 1987; Cermak & Lin, 1994), and difficulty telling time, using the phone and reading. Persons with UN have difficulty ambulating alone because they collide with people and objects to their left (Halligan & Marshall, 1994). They easily become lost when navigating between hospital departments and can even become "turned around" in their own room because they do not process the full visual picture. They are resistant to cues to "look to the left" and will draw only one half of a clock or a person.

Memories and imagined scenes may also reveal neglect (Bisiach & Luzatti, 1978). Persons with UN omit landmarks from the imagined scene that would be located in contralesional space. This impairment of imaginal space demonstrates that UN is not restricted to external sensory information, and cannot be attributed to damage to the sensory systems (Mattingly & Bradshaw, 1995).

Perhaps most importantly; persons with UN may not recognize or understand their errors (Cermak & Lin, 1994; Halligan & Marshall, 1994). For the most profoundly impaired, the side of the body and the physical world opposite to the lesion site have ceased to exist (Heilman, Watson, & Valenstein, 1993). Understanding this, it is not difficult to imagine how someone with intact motor, sensory, and cognitive abilities can become extremely dependent because of UN.

Neglect Versus Sensory Dysfunction

Neglect can be observed for visual, auditory, and tactile stimuli (Heilman, Watson, & Valenstein, 1993), however the clinician must distinguish UN from a pure sensory deficit such as hemianopsia (a visual field loss) (Van Deusen, 1993). Research into lesion sites also has substantiated claims that UN is not a result of damage to primary sensory systems (Vallar, 1993).

The occipital lobe contains the visual cortex, the area of the brain that receives sensory information originating from the retina (Snell, 1992). Lesions in the primary visual cortex will cause a visual field deficit, yet there is a lack of UN among persons with discrete lesions (Halligan, Marshall, & Wade, 1990). Persons with occipital damage report that they are seeing only half an image; but, unlike the person with UN, they are aware that the image they see is not complete and will spontaneously turn their head or eyes to see the full picture. In contrast, persons with visual neglect do not perform a complete visual search. In fact, some persons with UN will fail to search contralateral space even when blindfolded: further evidence that UN is not a visual deficit (Vallar, 1993). Halligan, Marshall, and Wade (1990) observed that many persons with unilateral neglect for visual information do not have a hemianopsia. Should one exist, the severity of the neglect is not related to the degree of visual field impairment.

Neglect is evident in persons without hemianopsia, sensory deficits, or hemiparesis (Halligan, Marshall, & Wade, 1990; Weintraub & Mesulam, 1987). Vallar, Sandroni, Rusconi, and Barbieri (1991), conducted an electrophysiologic study to measure the evoked potentials of persons with UN. They discovered normal stimulus detection thresholds in persons with UN although these same individuals did not report seeing stimuli. The authors suggested their study provides physiologic evidence that normal early sensory processing has occurred: UN is not a

problem with primary sensation but more likely due to disrupted processes which subserve conscious perception.

Subcategories of Unilateral Neglect

The clinical presentation of UN is strikingly heterogeneous and varies in ways other than severity (Bradshaw & Mattingly, 1995). Heilman, Watson and Valenstein (1993) divided UN and related disorders into several categories. These categories include: sensory neglect, spatial neglect, personal neglect, motor neglect, and representational neglect. The following five sections describes each of these forms of UN.

Sensory Neglect

Sensory neglect is suspected when a person ignores sensory information (visual, auditory or tactile) on the side contralateral to the lesion site, and their lack of awareness cannot be attributed to damage to the primary sensory systems or their connections. Unless the lesion site is known, it may be difficult to distinguish between a sensory deficit and sensory neglect. However, sensory neglect is assumed if the person's awareness of stimuli can be increased by cueing or introducing novel stimuli.

Spatial Neglect

Spatial neglect is the inability to perform a task in the hemispace contralateral to the lesion site (Heilman, Watson & Valenstein, 1993). In most cases, UN is a result of damage to the right side of the brain (Vallar, 1993). The ignored or neglected contralateral hemispace is the region to the left of the person.

Bisiach, Perani, Vallar, and Berti (1986) demonstrated that spatial variables impact the presentation of UN. Persons with UN may have difficulties acting in body centered contralesional space, or only on the left side of an object (object centered UN); or both (Heilman, Watson, & Valenstein, 1993). Determining what is "left" is problematic because left is not absolute but rather relative to some central point.

Egocentric space is the term used to indicate that a particular point in space is being referenced relative to the person. However, defining the relationship between a person and a point in space is complicated (Heilman, Watson, & Valenstein, 1993). It depends not only on the location of the object, and the person; but the position of the person's trunk, head and eyes. The direction of the eyes defines the visual field, whereas spatial fields are determined by the position of the trunk and head. These fields are congruent only when the person has his head in midline and is looking straight ahead. If the head is turned and the eyes are everted, the three fields will be non-congruent.

The location of an object, relative to any of these spatial fields, may affect the ability of a person to detect it. Hornak (1995) presented incomplete images and figures to a group of people with left UN. The subjects failed to report the missing left side of an image when the missing side fell in their left visual field. The subjects were able to report the missing image when it was presented to their right visual field. The authors concluded that the position of a stimulus within the visual field is of critical importance.

Space is further divided into the following three regions: personal space (space immediate to the body), peripersonal space (within arms' reach) and extrapersonal space (beyond arms' reach) (Halligan & Marshall, 1994; Riddoch & Humphreys, 1994). A subject typically

demonstrates UN in all three of these regions although exceptions have been discovered (Halligan & Marshall, 1994).

Spatial neglect is usually considered a disorder of a hemispace (right or left), therefore it is most frequently evaluated in the horizontal plane. However, UN has been demonstrated in other planes (Ladavas, Corletti, & Gori, 1994). Kageyama, Imagese, Okubo, and Takayama (1994) discovered that many people exhibit vertical and radial neglect, and argued that occupational therapists should consider these spatial planes when assessing for UN.

A person's capacity to direct spatial attention and the spatial coordinates in which UN is manifest can be affected by the properties of the stimuli being examined (size, contents, location, meaningfulness), and the type of response required (Bradshaw & Mattingly, 1995; Hornak, 1994; Karnath, 1994). Marshall and Halligan (1995) designed geometric figures and letters composed of smaller letters to disassociate what they define as global and focal processing. They used a large letter E made up of small Hs to analyze the processing of a woman with severe left UN. They found that their subject was able to correctly identify the large letter E; a task that required global processing. She attended to both sides of visual space. However, when she was asked to cross out all of the Hs forming the letter E (a task requiring focal attention), she only crossed out those on the right side of the E. Their subject was also not aware of the discrepancy between what she initially saw (the entire letter E) and how she responded (crossed out only the Hs on the right of the figure). Marshall and Halligan concluded that conscious awareness of the whole does not necessarily require visual processing of the individual parts.

Personal Neglect

The failure to dress, or groom one side of the body is symptomatic of personal neglect (Heilman, Watson, & Valenstein, 1993). Persons with severe personal neglect, will completely ignore the contralesional side of their body, do not recognize their contralesional limbs as being their own, and when they discover these limbs may become fearful or angry that someone else must be in bed with them. A less severe form of personal UN results in an indifference to, or disassociation with, the left side of the body, however these persons would not deny that their arms and legs were part of their body.

Representational Neglect

Discussions of UN cannot be limited to the perception of "real" stimuli. Internally generated images may also reveal a marked deficit in spatial awareness. Persons displaying/exhibiting representational UN fail to describe both sides of an imagined or remembered image. Heilman, Watson, and Valenstein (1993) have classified this category of symptoms as representational neglect.

One of the most frequently cited examples of this phenomenon is the work of Bisiach and Luzzatti (1978). In their study, two persons with UN were asked to describe - from memory - a well-known city square in Milan. They were instructed to visualize and describe the scene from two different and opposite perspectives: First looking at the cathedral from across the piazza, and secondly, from the front doors of the cathedral (reverse perspective) looking out across the piazza. From the first perspective, the subjects described the scene but were unable to describe the landmarks that would have been to their left. When the subjects were asked to assume the opposite perspective, they were able to describe the previously "unseen" landmarks, but omitted

the buildings and structures they had just previously mentioned. Again, the omitted items were to the left of the scene.

The example illustrates that the effects of UN are not limited to the physical world. UN may compromise the very memories people have of objects, situations and places. This is important because mental representations of objects and space are necessary to plan and execute activities (Smania, Bazoli, Piva & Guidetti, 1997). A person will reach for the left side of a plate because he understands it exists. A person with compromised images or memories has difficulty responding to the complete field of stimuli and may not recognize his or her errors because his or her memories do not suggest that something is missing. The person who draws only one half of a clock may be completely baffled by the therapist who comments "the clock is not complete". The patient with representational UN may actually live in a demi-world where the present physical world and their inner world (memories and the mental representation of places and objects) have ceased to exist in full form.

Motor Neglect

Some persons demonstrate a failure to physically respond to a "seen" stimulus. Heilman, Watson, and Valenstein (1993) refer to this absence of movement as motor neglect or an action intentional disorder. Motor neglect is defined as a diminished response to external stimuli (Heilman, Watson, & Valenstein, 1993). The authors believe that movement is produced in response to either external stimuli (exo-evoked) or internal stimuli (endo-evoked); and refer to both of these disorders as akinesias.

Motor neglect can manifest as a difficulty moving the head eyes or limbs toward or within contralesional space. Patients with this deficit show a marked preference for utilizing

limbs on only one side of their body during a physical activity (Benson, 1994). Motor UN is not restricted to the limbs. Eye movements into contralesional hemispace are also diminished (Heilman, Watson, & Valenstein, 1980 in Bradshaw & Mattingly, 1995; Karnath 1994).

Motor neglect is not the result of any primary motor deficits (Heilman, Watson, & Valenstein, 1993). The person is able to move the ignored limb on request; but engages in activities using only one arm. This occurs even when performing difficult bilateral activities. For example, persons with this type of deficit may attempt to tie up their shoes, catch a ball, or don a shirt using only one arm. The person with motor neglect struggles with these tasks but does not incorporate the ignored limb.

The direction of the movement required is a critical variable. Butter, Rapcsak, Watson, and Heilman (1988) demonstrated that it did not matter which hemifield a visual target was located in: Persons with UN frequently fail to move their eyes and in a contralesional (leftward) direction.

In summary, the numerous classifications of neglect serve to underscore the diverse nature of UN. Several researchers have developed assessment strategies to distinguish between sensory neglect and motor neglect, however performance on the majority of clinical tests (line bisection, letter cancellation for example) requires a complex interaction of perceptual and motor factors (Weintraub & Mesulam, 1987). They cannot be disassociated, nor the relative contributions of motor and perceptual skills quantified. The demarcation between sensory neglect (attention) and motor neglect (intention) is obscure and frequently patients present with a combination of both (Benson, 1994; Bradshaw & Mattingly, 1995).

Prognosis and Recovery

It is generally accepted that a proportion of patients with UN will demonstrate spontaneous recovery over time (Hier, Mondock, & Caplan, 1983). The most dramatic recovery from UN occurs over the first 10 days (Stone et al. 1992) and recovery plateaus between the second and third month (Hier et al., 1983; Marsh & Kersel, 1993; Stone et al., 1992). Unfortunately, several studies indicate that for some individuals UN persists (Mattingly, Bradshaw, Bradshaw, & Nettleton, 1994; Zarit & Kahn, 1974 in Zoccolotti, Antonucci, Judica et al., 1989).

Kinsella and Ford (1985) evaluated a group of subjects for UN at four weeks, eight weeks, 12 weeks and 18 months post CVA. At 18 months, UN symptoms had resolved in most but not all of the groups. Further, the group who no longer had UN (according to tests) continued to be limited in performance ADL. The researchers suggested that the subjects had improved on test taking strategies; but the underlying spatial problems had not resolved. Similar results and conclusions were reported by Colombo, De Renzi, and Gentilini (1982, as cited in Zoccolotti et al., 1989). At six months post CVA, several subjects who previously demonstrated UN, showed substantial recovery, while other subjects with UN remained unchanged.

Over time the more florid manifestations of neglect diminish, yet neglect may continue to persist (Harvey & Milner, 1999; Riddoch & Humphreys, 1994). Heilman, Watson, and Valenstein (1993) suggest that recovery from UN in humans is slow and incomplete. In a study by Marsh and Kersel (1993), subjects were tested at 15-20 days, 30 days, 60 days, and 90 days post CVA. During initial assessment, 13 patients were identified as having UN. The researchers performed follow-up studies on nine of the subjects and discovered that five of the nine demonstrated UN at 90 days. The individuals with persisting UN had performed most poorly on

the initial tests of UN, leading the researchers to conclude that poor test scores are a good prognosticator of poor recovery.

Riddoch and Humphreys (1994) urge caution before accepting the notion of spontaneous recovery. They state that few systematic studies have been conducted and that neglect may persist, though not as dramatically. These studies must be interpreted judiciously and should not be taken to mean that UN is a symptom from which most persons will recover. The lack of sufficiently sensitive instruments to detect neglect may account for what appears to be spontaneous recovery.

However, none of the research that suggested a spontaneous recovery period mentioned the effect of treatment for UN on those recovery rates. The studies were undertaken in hospitals (both acute and rehabilitation), therefore it is likely that the subjects were receiving some form of treatment for their CVA symptoms. Although the authors suggest a "spontaneous recovery period" no one had compared recovery rates of persons receiving treatment to those who did not. Nor did anyone attempt to standardize the intensity, duration or type of treatment. In fact, only Stone et al. (1992) acknowledged that the amount and type of treatment that subjects received following their CVA was not standardized.

There is evidence that some persons do not recover from UN. Most people with significant degrees of UN will continue to demonstrate UN over time. Pizzamiglio et al. (1992) argued that the stability of neglect symptomology and its negative impact on the ability of the person to perform his or her ADL point to the need for rehabilitation of this impairment.

Anatomy of UN

A significant portion of the research in the neurosciences is devoted to identifying the brain structures responsible for higher order cognitive functions. It is anticipated that correlations between damage to a particular site and resulting symptoms will permit researchers to gain insight into the workings of the healthy brain. However, the highly varied symptoms grouped as UN reflect the complex nature of neuroanatomical relationships and neural processes involved. Although most anatomically based research focuses on lesion sites, the inter-relatedness of brain processes must be stressed. A single lesion can disrupt an entire cortical system, therefore the deficit manifest cannot be indicative of the function of any one lesion site with absolute certainty (Penfield, as cited in Herman, 1992).

Importance of the Right Hemisphere

UN symptoms are most frequently associated with right hemisphere brain damage (Riddoch & Humphreys, 1994). Until recently, it was presumed that damage to the right hemisphere of the brain was the exclusive cause of UN, that all effects were contralateral to the lesion site, and therefore, UN would only be observed for stimuli on the left. There are however, increasing reports of UN following a left hemisphere CVA (Stone, Halligan & Greenwood, 1993; Halligan, Burn, Marshal, & Wade, 1992); and UN for targets in space ipsilateral to a right hemisphere CVA (Halligan, Burn, Marshal, & Wade, 1992; Robertson et al., 1994; Small, Cowey & Ellis, 1994; Weintraub & Mesulam, 1987).

Benson (1994); and Stone, Halligan, and Greenwood (1993), suggest that reports of neglect following a left hemisphere CVA may be obscured by concomitant language deficits. Stone, Halligan and Greenwood stated that the UN rates reported in the literature ranged from

33-85% following a right hemisphere CVA to 0-24% for those occurring in the left hemisphere. They assessed 171 patients 2-3 days post stroke using a number of tests and discovered evidence for hemi inattention in 70% of right and 49% of left hemisphere strokes. In contrast, Weintraub and Mesulam (1987) found evidence of marked left UN in patients with right hemisphere lesions and no space related deficits in patients with left hemisphere damage.

Although several studies suggest that UN can result from damage to the left hemisphere, Halligan, Burn et al. (1992) demonstrated that the UN following left hemisphere damage is qualitatively different than that following right hemisphere damage. Weintraub, Daffner, Ahern, Price, and Mesulam (1996) discovered that UN of the right side is most frequently a consequence of bilateral brain damage.

Stone, Patel, Greenwood, and Halligan (1992) compared the severity of, and rate of recovery from UN symptoms between patients with right hemisphere and left hemisphere damage. Their results indicate that persons with UN following right hemisphere damage present with more severe UN and take longer to recover than those with UN following left hemisphere stroke. Weintraub and Mesulam (1987) compared persons with right brain damage and left brain damage to healthy controls and found that their results confirmed previous studies: Contralateral neglect is significantly more severe following right hemisphere injury. In general, the research supports the position that UN following right hemisphere damage is more frequent, more severe, and manifests in contralesional hemispace (Caplan, 1985; Riddoch & Humphreys, 1994; Weintraub, Ahern, Daffner, Price, & Mesulam, 1992; Weintraub & Mesulam, 1987).

Over the years, research established the unique and dominant role of the right hemisphere in directing attention over space (Weintraub & Mesulam, 1987). This has had two consequences: The bulk of information about UN and lesion sites has been gathered from persons with right

hemisphere damage (Bradshaw & Mattingly, 1995), and theories were developed to account for the differences seen following right hemisphere and left hemisphere damage. Several theories have been developed to explain UN phenomenon. These theories (to be discussed later) by and large propose right hemisphere dominance for spatial tasks in an effort to account for the asymmetry between right hemisphere and left hemisphere damage.

Anatomical Correlates

Because UN following a right hemisphere CVA is typically more frequent, severe, and persistent than UN following left hemisphere damage (Caplan, 1985; Riddoch & Humphreys, 1994; Vallar, 1993; Weintraub & Mesulam, 1987), the bulk of data concerning the brain structures implicated in UN has been derived through studies of patients with right hemisphere damage (Bradshaw & Mattingly, 1995). Vallar's (1993) review of the literature suggests that the UN is most frequently correlated with a lesion of the right temporo-parieto-occipital junction or inferior parietal lobule (Watson, Valenstein, Day & Heilman, 1994).

Although it is predominantly the inferior parietal lobe that is implicated in UN, damage to other structures (both cortical and subcortical) has been associated with UN phenomenon. Vallar (1993) provided evidence that lesions to subcortical regions of the brain are linked with UN. His review of the literature implicated damage to the posterior and medial thalamus, basal ganglia, and posterior limb of the internal capsule in the clinical presentation of UN.

Damage to the frontal cortex has been linked to symptoms similar to UN - though to a much lesser degree than more posterior lesions (Heilman & Valenstein, 1972; Vallar & Perani, 1986). Vallar and Perani (1986) found evidence of neglect in only one out of 12 patients who had sustained damage to the frontal cortex. They contend there is little evidence to indicate a

relationship between frontal damage and UN. UN following frontal damage may reflect individual differences in brain organization.

Different lesion sites may account for the varied symptoms or categories of UN (Riddoch & Humphreys, 1994). Motor neglect, an impairment of spontaneous movement of the limb contralateral to the brain lesion, can be dissociated from perceptual neglect based on symptomology and lesion locus. Vallar (1993) concluded that UN (motor) or hypokinesia is linked to damage to the frontal areas of the brain. Ladavas, Umiltà, Ziani, Brogi, and Minarini (1993) discovered that all their subjects with directional hypokinesial had frontal lesions, whereas those persons with UN symptoms of a perceptual nature sustained no damage to the frontal cortex. Spatial perceptual neglect is typically associated with damage to the right posterior parietal regions of the cortex (Vallar, 1993).

Corbetta, Miezin, Shulman, and Petersen (1993) used positron emission tomography (PET) to investigate the neural systems involved in attention. They observed activity in the superior parietal region following both voluntary and automatic attention shifts. This activity was observed whether or not a behavioral response was required. However, the frontal region of the brain became active only when a motor response was necessary. The authors stated that the results confirm speculation that the posterior parietal cortex contains a map for sensory representation of extrapersonal space, whereas the frontal cortex is responsible for creating a map that guides the movements associated with exploration. The results support both the representational and motor intentional models.

Diaschisis

Diaschisis is a phenomena whereby, damage to one area of the central nervous system can disrupt the function of another area (Meyer, Obara, & Muramatsu, 1993). Diaschisis

potentially confounds many brain mapping studies that attempt to correlate behavior with lesion site because it strongly suggests that structures distant from the lesion site may be functionally impaired (Vallar, 1993). For this reason, the behavioral presentation of UN cannot simply be attributed to the structures implicated using computerized axial tomography (CT).

Vallar and Perani (1986) suggest that PET scan can be used to solve the "riddle" of how damage to brain structures (frontal cortex), not typically associated with cognitive functions (ex. spatial representation) may affect the structures that are responsible for those functions. Neuroimaging techniques, such as PET, reveal areas of neural activity in the brain of a living human. These techniques can be used to provide information about the functional relationships between neural structures and the far-reaching consequences of damage to an isolated area. Several such studies have demonstrated that a massive blood flow reduction occurs in brain structures ipsilateral to those damaged during the CVA (Chollet et al., 1991; Lagreze et al., 1987; Olsen et al. cited in Vallar & Perani, 1986). Using measures of regional blood flow and metabolic activity, decreased activity in the fronto-parieto-temporal cortex was discovered in patients with no damage to these structures: Actual damage was restricted to subcortical structures.

Perani, Vallar, Paulesu, Alberoni, and Fazio (1993) used PET to analyze brain activity following right hemisphere damage. Initial scans were performed during the acute stage when neglect symptoms were florid. As expected, the damaged sight was hypometabolic (not as active as other areas in the brain). However, the researchers noted that a corresponding area in the contralateral undamaged hemisphere was also significantly hypometabolic. After the subject had an almost complete recovery, a follow up PET analysis indicated that metabolic activity returned to normal in the contralateral site, but not the damaged site. Chollet et al. (1991) conducted a

similar study and concluded that the contralateral hemisphere is responsible for recovery of function.

Diaschisis is not an infrequent phenomenon. Lagreze et al. (1987) discovered contralateral hypometabolism in six out of seven persons with a CT confirmed unilateral CVA.

Diaschisis studies suggest that areas remote from the lesion site may be affected. UN symptoms (particularly following frontal or subcortical lesions) may be a consequence of diaschisis (decreased blood flow and metabolic activity) in areas appearing undamaged on CT (Vallar & Perani, 1986). Much of the interest in brain damage and the resulting symptoms is a consequence of the assumption that these studies will provide information about the workings of a healthy brain. However, a correlation between lesion sites and UN symptoms does not assure one that the function of the damaged structures was spatial perception. UN may not be a direct result of the area damaged but rather, a disruption of functional systems involving other brain regions (Bradshaw & Mattingly, 1995; Vallar, 1993).

Mechanism of Recovery

It is generally accepted that axons in the central nervous system (CNS) (except in extremely rare cases) will not re-grow once they have been damaged (Kolb, 1992). The damaged CNS nerve cells will degenerate and disappear (Snell, 1992). Knowing this, and the evidence that specific areas of the brain are responsible for specific types of behaviors, one would expect that damage to a particular anatomical site would result in permanent loss of the behavior associated with that site. This is not the case. In fact, many people who have sustained some sort of brain injury have made remarkable recovery. The apparent plasticity of brain function and its ability to reorganize is an area of considerable investigation within the neurosciences. It

is hoped that by identifying the neural mechanisms that contribute to neural plasticity, more effective treatments for brain injury will be developed.

Several possible mechanisms for recovery have been postulated: 1) adjacent cortex assuming function, 2) recruitment of previously dormant synapses, 3) subcellular plasticity, 4) regeneration of neurons, 5) synaptic sprouting, and 6) the contralateral cerebral hemisphere assuming function (Miller Fisher, 1992).

Recent discoveries in neuroscience suggest that behavioral recovery following brain damage is strongly correlated with an increase in dendritic arbor of the spared neurons (Kolb, 1989, 1992). When undamaged neurons sprout new dendrites they increase the number of synapses between any two neurons. The increase in the number of synapses may increase the interaction between any two neurons and thereby compensate for the neurons lost during a stroke or other brain injury.

It is important to note that not only is there a strong correlation between behavioral recovery and dendritic arborization, but also an equally strong connection between the richness of the environment and the degree of dendritic arborization (Kolb, 1989, 1992). It is clear that environmental influences can affect changes in the brain at the cellular level.

Therapists manipulate the environment (via level of stimulation and task demands) to enable their patients to learn to perform an activity. These variations increase the environment's richness and may promote changes on the neural level. The neural changes may account for the improvements seen behaviorally. The type of intervention itself may be a critical factor promoting brain reorganization.

Most therapists likely do not consider neural reorganization when planning their interventions, yet design extremely effective treatments. Often treatments are guided by models

of practice that focus on higher level components of human behavior. However, anytime someone is learning new strategies or skills to compensate for an impairment, changes are occurring at the cortical level. The therapist may not always be, (and need not be) cognizant of the manner in which interventions are effecting neural reorganization; learning or reorganization occurs.

Theories of Neglect

The search for a single comprehensive explanation for UN has eluded researchers. To date, no unifying theory exists which adequately explains all of the phenomena defined under the rubric of UN (Halligan & Marshall, 1994). Several different and competing theories have been proposed to explain UN phenomenon. Halligan and Marshall argue that UN is a term in which several discrete impairments are conflated. Many behaviors subsumed under the label of UN may be only superficially related and are, in reality, a consequence of damage to different areas and the interruption of different systems. For this reason, the theories used to explain neglect are useful for individual cases, but are unable to explain all UN phenomena. The search for a single explanation for UN may be as ill conceived as searching for a single cause for an inability to walk.

The range of behaviors defined as UN is widely discrepant in terms of severity, stimulus type, location etc. Examples include: the ability to draw the letter E, but not cross out all the individual letters from which it was composed (Marshall & Halligan, 1995); the inability to report landmarks to the left of an imagined scene (Bisiach & Luzzatti, 1978), the inability to recognize one's left arm and leg as being one's own, and the inability to dress the left side of

one's body. The man who reports that he cannot see the left side of a picture yet correctly guesses what it contains is also said to have UN (Karnath, 1994).

The extreme heterogeneity of the UN clinical syndrome has led to the formation of different and competing theories. These theories are frequently posited in opposition to one another with researchers from each camp trying to generate proofs that strengthen one position over the other. The results are frequently contradictory and the lack of universal definitions has obscured patterns in research results and hypotheses

The UN theories can be separated into two distinct groups, each having merit as an explanation for UN phenomenon. One group of theories shares the core assumption that UN is the result of a deficit in attention processing. Within this theoretical group, there are differences of opinion as to the manner in which attention is controlled and which of the attention mechanisms have been disrupted. The other group of theories, at its core, views UN as a disruption in the processes involved in the representation of space. These processes include the generation of an internal map consistent with internal and externally driven data.

Attention Based Theories

Several theories explain the process of attention and the manner in which an impairment of attention can give rise to the behaviors typical of UN. The most recognized of the attention based theories are; Heilman's hypoactive hemisphere theory (Heilman, Watson, & Valenstein, 1993), Kinsbourne's vectoral theory (Kinsbourne, 1987), Posner's model for attention processes (Posner, Walker, Friedrich & Rafal, 1987) and Halligan and Marshall's (1994) focal versus global processing theory (see table 1). These theories share the assumption that UN is a result of disrupted attention processes. They propose that both the right hemisphere and the left

hemisphere play a role in spatial functions and each hemisphere is responsible for directing attention toward in the opposite hemispace.

Most attention-based theorists share the assumption that the right hemisphere is dominant for spatial attention (Bradshaw & Mattingly, 1995; Heilman, Watson, & Valenstein, 1993; Kinsbourne, 1987). They propose that the right hemisphere is critical to spatial functions because it orients attention toward each of the hemispaces (contralateral and ipsilateral), whereas the left hemisphere only directs attention processes to stimuli on the right. This model serves to explain the preeminent role of the right hemisphere for spatial tasks.

Using this model, attention based theorists are also able to explain the differences in UN incidence and severity that are a function of the hemisphere damaged. Damage to the left hemisphere of the brain will affect its ability to orient to stimuli in right space. Fortunately, the right hemisphere of the brain remains able to direct attention to both hemispaces. This minimizes the functional consequences of damage to the left hemisphere. In essence the right hemisphere of the brain performs a redundant function and permits the person to continue to orient and respond to stimuli in both hemifields.

In contrast, a damaged right hemisphere results in obvious functional loss. The right hemisphere previously directed attention to both the right and left hemifields. The intact left hemisphere can direct attention only to the right hemifield. Stimuli in and responses toward the left hemifield are not processed resulting in the constellation of symptoms known as UN.

PET analysis provided support for many of these assumptions. Corbetta et al. (1993) discovered two distinct areas in the right parietal lobe that became active during attention related tasks. One became activated when attention was directed to the left visual field, the other when attention was directed to the right visual field. The region in the left parietal lobe was active, but

only when activities demanded attention to the right visual field. The researchers suggest that these differences may account for the increased severity of UN seen in persons with right hemisphere damage.

The individual models for attention and the mechanisms for inattention differ according to theorist. These differences impact anticipated deficits, rationale for treatment, and the explanatory power of the model. The following is a brief review of the core assumptions and findings of several attention based theorists (see table 1 for a comparison of general features).

Table 1

Comparison of the Attention Based Theories

<u>Theorists</u>	<u>Neurological Explanation of UN</u>	<u>Functional Outcome of UN</u>	<u>Supportive Research</u>	<u>Treatment Implications</u>
Heilman, Watson Valenstein (1993)	Hypoarousal of the RH.	Diminished ability to attend to stimuli and program movements in left space.	Roberston & North, (1992, 1994).	Suggests that treatments that stimulate the RH should lessen UN.
Kinsbourne (1987)	Uninhibited LH.	Compelled to attend to stimuli rightward across a gradient (left to right).	DeRenzi et al., (1989). Persons with UN superior at locating objects in the right.	Remove stimuli from the right hemispace.
Posner & Rafal (1987)	Damaged right parietal lobe is critical to disengage operation of attention.	Difficulty shifting attention to the left once captured by a stimulus on the right.	Mark, Kooistra, & Heilman, (1988). Improved scores on cancellation sheets when targets erased not marked.	Decrease the amount of stimuli in the right hemifield.
Halligan & Marshall (1994)	RH governs global attention, LH governs focal attention.	Cannot direct focal attention to the left hemifield.	Halligan & Marshall, (1994), Karnath (1994).	

Heilman's Theory: The Hypoactive Right Hemisphere

Heilman, Watson and Valenstein (1993) believe that damage to a brain hemisphere results in hypoarousal of that hemisphere. Hypoarousal results in a diminished capacity to attend to and program movements in contralesional space and a bias to attend to and direct movements toward stimuli in ipsilesional space. According to Heilman's model, UN is consequence of an under active right hemisphere.

Heilman, Watson and Valenstein (1993) view UN as an attentional-intentional disorder arising due to damage to the corticolimbic reticular formation network. Each of the hemispheres of the brain is responsible for governing arousal and orientation in the contralateral hemisphere and organizing an appropriate response to the stimuli. The right hemisphere is unique in that it processes bi-directional capacities: It can activate orientation to both sides of space. The left hemisphere can only perform functions related to the right hemisphere. When the left hemisphere is damaged, spatial awareness of the right hemisphere is not entirely lost because the right hemisphere of the brain can perform those functions. However, if the right hemisphere is damaged, the left hemisphere is unable to direct attention to the left hemisphere and neglect results.

Heilman's theory is used by researchers and therapists to develop treatments for UN. Since Heilman believes that UN is the result of an under-active right hemisphere, it follows that activities that stimulate the right hemisphere should lessen UN. To test this hypothesis, Robertson and North (1992, 1994) conducted a series of experiments with persons with right hemisphere damage and UN. Subjects were asked to complete a letter cancellation task. They demonstrated that active use of the left hand (which stimulated the right hemisphere of the brain) during the cancellation task improved the subjects' ability to recognize objects in the left

hemifield. The subjects' performance was better when they wiggled the fingers of the left hand in the left hemifield, than when they were verbally cued to look to the left, given a visual anchor, or they wiggled the left fingers in the right hemispace. The authors suggest that the left hand wiggling in the left hemifield permitted two neuronal maps to be activated. This was required to overcome the deficit with left space.

Not all research has supported Heilman's theory. Caplan (1985) investigated the impact of stimulus type on UN and whether UN would decrease during tasks which engaged the damaged right hemisphere. He used parallel forms - one verbal the other non-verbal - of a visual cancellation task to determine whether the different stimuli affected performance. The performance of the subjects with UN did not change as a result of the verbal or non-verbal nature of the task. The author suggested that the results do not support the hypothesis that right hemisphere activation will improve performance in individuals with UN. He did find, however, that subjects with UN omitted targets across both visual fields, supporting the view that the right hemisphere is dominant for spatial activities across the visual field.

Heilman's theory is unique in that he attributed some of the symptoms of UN to a disruption of the action - intention system and classified these symptoms as motor neglect (Bradshaw & Mattingly, 1995). Other models share the assumption that UN is largely a result of an inability to detect or attend to stimuli, but Heilman suggested that some of the behavioral manifestations of UN were a result of a person's inability to respond to contralesional stimuli. The right hemisphere is not only responsible for orienting to stimuli, but also planning and organizing the motor response required. The action-intention disorder may manifest in any number body parts: head, eyes, limbs etc., and may be misconstrued for an inability to attend to sensory stimuli (Heilman et al., 1993).

Kinsbourne: Attentional Gradient and a Hyperattentive Left Hemisphere

Heilman and Kinsbourne (Bradshaw & Mattingly, 1995; Heilman, Watson & Valenstein, 1993; Herman, 1992) agree that there is a bias to stimuli in the ipsilesional hemisphere.

Kinsbourne's theory differs from Heilman's in that he does not believe that each hemisphere rigidly attends to stimuli in the contralateral hemisphere (Kinsbourne, 1993). Rather, he proposes that each hemisphere governs attention processing in the direction of the contralateral hemifield. The left hemisphere of the brain actively interprets stimuli from any particular spatial location, provided the response required was "toward" the right. The direction of the attention is critical. Kinsbourne refers to this as an attentional gradient. He suggests that an attentional gradient occurs to the extent that "one stimulus rather than another captures attention, and thereby controls behavior." (1993, p. 65).

Kinsbourne (1993) proposed that interactions occur between the two hemispheres and that each hemisphere inhibits the other. Damage to the right hemisphere diminishes its ability to inhibit the left hemisphere. The result is an uninhibited left hemisphere that is hyperactive. This unchecked activity of the left hemisphere causes the person to orient and attend to stimuli in a rightward direction: The behaviors typical of left neglect.

A 1989 study by DeRenzi, Gentili, Faglioni and Barbieri supports this view. They examined reaction times to target stimuli on a computer display and found that persons with UN reacted most quickly to stimuli presented in the right outermost corner of the display. The subject's reaction times became progressively slower as the target stimuli was moved from farthest right side of the screen to locations closer to midline. Subjects without UN were also tested and had reaction times that were constant across the hemifield. These results suggest that

persons with UN do not consistently demonstrate a right versus left hemifield deficit, but rather that the direction of attention may be a critical factor.

Kinsbourne (1993) suggested that the circling behavior evident in unilaterally brain lesioned animals is evidence of an attentional gradient. The animal is compelled to attend to stimuli in outermost region along a horizontal gradient. He stated that this form of neglect is rare in humans although the writer has observed circling behavior first hand in a patient with dense left UN. Although he was able to attend to midline stimuli when instructed, he would preferentially attend to stimuli to his right and would continue to move in that direction until he had started turning himself around in his wheelchair. It was as if stimuli to the right captured his attention. He turned himself to center himself with it, and was then compelled to turn to new stimuli appearing in the right outermost hemifield.

Posner - Attention Shifts

Posner, Walker, Friedrich, and Rafal (1987) agree that attention mechanisms are implicated in the deficits observed with UN, but contend that the impairment results from damage to one of the processes subserving attention. Posner proposed that for any new stimulus to be attended to, three different operations must occur. The individual must (a) first be able to disengage his or her attention from the current stimulus, (b) shift attention to the new target, and (c) focus or amplify attention on the new target. He has suggested that the right parietal lobe is critical to the disengage function of attention. The person with right parietal damage and left UN is unable to disengage his or her attention from stimuli on the right.

Posner (1987; Posner & Rafal, 1987; Posner, Walker, Friedrich, & Rafal, 1984, 1987) contends that attention to the left hemispace is not compromised; it is the attention shift in a

direction contralateral to the lesion site that is problematic. They are not concerned about whether or not a stimulus is in left or right hemispace, but where one stimulus is relative to another. Consequently, many of the studies that support Kinsbourne's attentional gradient can be explained on a processing level by Posner's theory. For example, Di Pellegrino (1995) argued that a person with UN who draws all the numbers for a clock face on the right side of the circle can be viewed as experiencing a deficit of engagement.

Global Versus Focal Attention: Halligan and Marshall's Compromise

Halligan and Marshall (1994) have proposed a model of attention and UN that is compatible with many of the theories mentioned thus far; yet may also account for much of the seemingly contradictory results in the literature. They agree the right hemisphere is responsible for bilateral or full field attention whereas the left hemisphere only has the capacity to respond to right space. Halligan and Marshall's model is unique however, in that it proposes that each hemisphere governs different aspects of attention and therefore attends to different types of stimuli. The right hemisphere is dominant for the sustained and global aspects of attention, whereas focal attention is largely the domain of the left hemisphere.

Damage to the right hemisphere results in damage to the "...automatic ability of the global "guidance" system to direct local attention. " (1994, p. 195). Earlier, this paper discussed a subject who was able to identify the entire letter, but not cross out all of the individual Es of which it was composed (Marshall & Halligan, 1995). Halligan and Marshall's theory can be used to explain this paradoxical behavior. The subject was able to comprehend the entire large letter, but due to her damaged global system could not direct focal attention into that area.

The global versus focal model can explain clock drawings made by persons with left UN (Halligan & Marshall, 1994). Typically, persons with UN draw a complete circle with only the numbers one through six on the right side of the clock, or they draw the circle with numbers reaching higher than six; but these numbers are squeezed onto the right of the diagram. Numbers compressed to the right of the diagram indicate focal attention is no longer constrained by the global form. The global form is understood, but they are unable use the global form to direct more specific focal attention.

Perhaps some of the most intriguing studies are those that reveal "blind sight (Karnath, 1994; Marshall & Halligan, 1988). The authors (1988) presented a pair of pictures of a house to a woman with left UN. The only difference between the two pictures was that the left side of one of the homes was on fire. The subject was asked to describe what she saw. Her responses suggested that she did not recognize that in one of the pictures the house was on fire. The flames fell within her neglected left visual field. However, when asked which house she would prefer to live in, she consistently chose the non-burning house. These results suggest that some degree of processing did occur for stimuli in the left visual field. The person with left UN may have difficulty directing the focal attention required for the specific conscious identification of stimuli (Bradshaw & Mattingly, 1995), but some processing may remain.

Halligan and Marshall (1994) suggest that their theory may explain reports of subconscious knowledge of the left side in persons with UN. Under experimental conditions, patients with UN have correctly "guessed" the complete scene in a picture even when the left side of the picture fell within their neglected field and they denied seeing it (Karnath, 1994). Eye movements were recorded and indicated that the person barely moved his eyes past midline. However, if the picture provided meaningful cues that indicated that the viewer's attention

should be directed to the left, the person was able to more accurately "guess" the scene in the entire picture. Halligan and Marshall propose that there is a similarity between drawing a full circle with the entire set of clock face numbers squeezed on the right, and denying seeing an object but acting as though it was there. On some level, unaware to the individual with UN, the global form is being processed.

Because seemingly contradictory neglect phenomenon can be explained by Halligan and Marshall's (1994) theory, it is particularly attractive. Because the theory retains the concept of right hemisphere dominance for global processing, it can account for the profound left neglect that can arise as a consequence of right hemisphere damage, while also explaining the qualitatively different and more infrequent right neglect resulting from left hemisphere damage.

Representational Accounts for Unilateral Neglect

Another theory that holds promise for explaining UN phenomena is based on the assumption that mental representations of space are compromised following injury to the right parietal lobe. This theory was proposed by Bisiach, Luzatti, and Perani (1979) to explain why some persons with UN consistently excluded details to the left of an imagined scene, regardless of the perspective they were asked to assume. They surmised that the mental representation of an object or scene is topographically mapped across the two hemispheres of the brain: Right hemisphere damage results in an inability to construct complete mental image of the object or environment being imagined.

Representational neglect is evident when persons asked to draw a clock or person produce only half of the image (Roden, 1997). Heilman, Watson and Valenstein (1993), propose three mechanisms to explain this phenomenon: the absence of a complete mental representation

because the left half was destroyed, a complete representation but an inability to activate the left half to create a complete mental image, and an intact mental image that is not correctly inspected. The loss of a mental representation or image of left space would result in an inability to direct attention into left space and an inability to act in left space.

Not all persons with neglect demonstrate the level of impairment that is associated with a representational deficit. For instance, any person who can be made to search left space with cueing or the reduction of right side stimuli does not have representational neglect. The claim of a loss of spatial representation cannot be made unless the person demonstrates attentional deficits, intentional deficits, memory and imagery deficits. Heilman, Watson, and Valenstein (1993) believe that persons with representational neglect have damage to multiple systems. What results is such a significant distortion of their mental representations of left space, that effectively they no longer know it exists.

Bradshaw and Mattingly (1995) suggest that Rizzolatti and Berti's (1993) premotor model of attention can account for both attentional and representational manifestations of neglect. Rizzolatti and Berti believe that a coherent spatial map is the result of a number of anatomically independent spatial systems. These systems act together to produce a coherent spatial reference system which allows movements to be organized. They believe that distorted representations are the result of damage to the perceptual-motor maps.

Role of Occupational Therapy

Occupational therapy is devoted to preventing disability; and promoting, maintaining, and restoring occupational performance, health and spiritual well-being (Health & Welfare

Canada, 1986). Occupational therapists are one of the key professions involved in enabling persons to overcome or adjust to disabilities produced by stroke (Titus, Gall, Yerxa, Roberson & Mack, 1991; Trombly, 1995). The occupational therapist is responsible for identifying barriers to optimal performance of occupational tasks and for selecting appropriate forms of intervention (Health & Welfare Canada, 1986).

Following a stroke, survivors may face a number of physical, cognitive and perceptual impairments; all of which may interfere with their ability to perform occupational tasks (Trombly, 1995). As previously discussed, UN has been identified as one of the greatest barriers to independence. For this reason, perceptual retraining is a fundamental and necessary part of the therapy provided to persons with a brain injury. In fact, perceptual retraining has been a part of occupational therapy services for adults with brain injury for the past 40 years (Neistadt, 1988, 1990).

Assessment

Assessment is a critical first step in the beginning of any treatment plan. A powerful assessment tool identifies problem areas, provides an understanding of the mechanisms involved, serves as a foundation for treatment, and permits predictions regarding course of problem or prognosis (Cermak & Lin, 1994).

As early as 1915, the line bisection task was suggested as a means for detecting visual neglect (Axenfield as cited by Schenkenberg, Bradford & Ajax, 1980). Since that time, many other tests have been developed, and today there are literally hundreds of different tests from which the clinician can chose (Cermak & Lin, 1994).

Line bisection tasks, copying and drawing tasks, cancellation and visual search tasks, and reading tests are referred to as pencil and paper assessments (Halligan, Cockburn, & Wilson, 1991) and are the type of tests most frequently used to identify UN (Cermak & Lin, 1994; Lennon, 1994). They are used alone or as part of a larger perceptual battery employed by occupational therapists. For example the Ontario Society of Occupational Therapists (OSOT) perceptual evaluation (Fisher, Boys, & Holberg, 1991) includes a number of conventional tests (letter cancellation, figure copying and draw a person and clock) to assess for the presence of UN.

Over the years, several studies have attempted to determine the relative strengths and weaknesses of the UN assessments. Kinsella, Packer, NG, Olver, and Stark (1995) studied the sensitivity and reliability of six conventional tests for UN (five different pencil and paper tests and a tactile maze). The authors administered each of the tests to the same group of patients with right hemisphere damage and compared the resulting rates of UN. Depending on the test used, UN detection rates for the conventional tests varied from 10-48 percent. Shape cancellation and line bi-section were the most sensitive instruments. Shape cancellation demonstrated high sensitivity (43%) and good test-retest reliability .84. Line bisection detected UN in 38% of the subjects, however, it had disappointing test-retest reliability (.64). In a similar comparison study, Marsh and Kersel (1993) found star cancellation (a form of shape cancellation) to be the most sensitive of the tests. Kinsella and colleagues (1995) strongly recommended against the use of a single test to determine the presence or absence of neglect; however, when a brief single test is required they suggested symbol cancellation be used.

Although the pencil and paper tests may serve an important diagnostic function, the relationship between performance on pencil and paper measures and daily living abilities requires investigation (see table 2).

Table 2

Correlation Between Standard Paper/Pencil Measures of UN and ADL.

Study	Test of UN	Measure	
Marsh & Kersel (1993).	Star cancellation	Barthel Index	r= 0.55
Kinsella, Packer, Ng, Olver & Stark, (1995).	Line Bisection, shape cancellation, drawing, tactile maze.	Occupational therapist behavioral ratings.	r= 0.48 (P<0.01) r= 0.40 (P<0.005) r= 0.56 (P<0.01) r= 0.60 (P<0.01)
Halligan, Cockburn, & Wilson, 1991)	BIT (six conventional subtests)	BIT behavioral subtests.	r= 0.92

Recently several studies have attempted to determine if a relationship exists between the conventional pencil and paper tests for UN and the behavioral changes that signify UN. Marsh and Kersel (1993) found that star cancellation scores positively correlated ($r=.55$) with an occupational therapist's ADL ratings using the Barthel Index (a test of independence in ADL). In a later study, Kinsella, Packer, Ng and colleagues (1995) discovered a modest positive correlation between scores on line bisection and shape cancellation tests; and behavioral ratings given by the occupational therapist ($r=.48$ and $.40$ respectively), however tests with a representational component (drawing and tactile maze) provided the strongest relationship to ADL performance.

Unfortunately, most tests that measure unilateral neglect do not provide direct information about the impact of neglect on the performance of everyday tasks (Hartman –Maier

& Katz 1995). The Behavioral Inattention Test (BIT) is one test developed expressly to address this deficit (Halligan, Cockburn, & Wilson, 1991; Wilson, Cockburn, & Halligan, 1987). The BIT (Wilson, Cockburn, & Halligan, 1987) is composed of six conventional tests of UN (letter cancellation, line crossing, star cancellation, line bisection, figure copying task, and a drawing task), and nine behavioral tests (dialing a phone, reading a menu, reading a short article, telling and setting time on a clock, coin sorting, map navigation, card sorting, picture description). The authors state that test was developed by psychologists and occupational therapists based on item testability and relevance to everyday life. The authors investigated the concurrent criterion related validity of the behavioral subtests by assessing them against the conventional subtests (.92) and in relation to an ADL questionnaire completed by the occupational therapist (.67). The occupational therapy literature suggests that the BIT is particularly important to occupational therapists because it examines the impact of a perceptual and cognitive deficit on daily living skills (Poole et al., 1991).

Arnadottir (1990) has developed the A-ONE, an exclusively behaviorally based test for assessing cortical dysfunction. The A-One requires observation of basic ADL: dressing, grooming and hygiene, transfers and mobility, feeding and communication. The occupational therapist records whether any of a number of impairments (perseveration, motor apraxia, abnormal tone, or unilateral neglect - to name a few) impede performance of these tasks. Although this test does not exclusively assess UN, it is an important tool because the presence and degree of neglect is formally assessed during ADL. Pencil and paper tests are not used and therefore, one does not need to speculate on the impact of UN on ADL. Both the degree of UN and the level of independence are evaluated.

Another behaviorally based test for assessing UN was developed by Zocolatti and Judica (1991). Their semi-structured scale determines the presence of UN based on the subject's performance of the following tasks: serving tea, card dealing, description of complex figures, description of the environment and using common objects (comb, eyeglasses and razor).

The semi-structured scale was evaluated to determine its psychometric properties and internal characteristics (Zocolatti, Antonucci, & Judica, 1992). There were a number of interesting findings. The authors discovered that a subject's performance on one task did not necessarily correlate with performance on other tasks. It became apparent that the subjects' performance on the tasks was determined by variables within the tasks. For example, some tasks required subjects to explore extra-personal space, while other tasks required subjects to explore personal space (using a comb eyeglasses and razor). Zocolatti and Judica also discovered that test scores for the functional tasks occurring in extra-personal space - making tea for example - showed a significant correlation with standard tests for UN. This is not surprising: Kinsella, Olver, Ng, Packer and Stark (1993), Kinsella, Packer, Ng, Olver, and Stark (1995), and Marsh and Kersel (1993) found similar results. Of interest, however, was the absence of a correlation between standard tests for UN and the functional tasks involving personal space. The authors described one patient who performed poorly on items assessing personal neglect; yet demonstrated no impairment on line bisection, letter cancellation, reading and other extrapersonal test items. They explain this finding by pointing out that almost all standardized tests for UN (bisection, cancellation, drawing) involve task performance in extra-personal space. There are no standardized tests for the evaluation of personal UN.

Zocolatti and Judica (1991) are not alone in recognizing that the relationship between pencil and paper assessments, and behavioral assessments of UN may vary as a result of

functional fractionations of the UN. Kinsella et al. (1995) suggested that different tests for detecting neglect may each identify different aspects of what is arguably a multifactorial syndrome. They discovered that tests that indicated a distortion of mental imagery (tactile maze and representational drawings) produced the most substantial correlation with behavioral ratings. The authors believe two components underlie UN, deficits in scanning and deficits in spatial representation. Although the two deficits commonly occur together in persons with UN they can be dissociated theoretically and at times clinically. They suggest that their study provides further evidence of the heterogeneous nature of UN.

Assessment Summary Remarks

The above studies investigated a few of the tools currently used to evaluate UN. As discussed earlier, the syndrome of neglect is increasingly viewed as one that is multifactorial in nature and the consequence of a number of impairments. This poses a number of problems for researchers and clinicians alike. Tests for UN differ not only in terms of sensitivity and reliability, but also, and equally importantly, may differ with respect to what they are measuring.

Each type of test has different task demands, and may emphasize different aspects of what could be called the UN syndrome (Kinsella et al., 1995). Some tests require work in personal space, others away from the body, some emphasize scanning while others require a complete mental representation for success. Add to this, the degree to which body position relative to the test, the arm used, and type and number of stimuli will influence results; and one begins to appreciate the difficulty facing the clinician researcher who hopes to accurately assess the problem and design appropriate treatments

Although, there are several standardized and reliable tests for UN, the evidence suggesting UN is not a single impairment, has made test interpretation complex. Researchers and clinicians must identify the demands or conditions in the tests they use, if they wish to establish which subtype of UN a test is evaluating (Marsh & Kersel, 1993; Zocolatti & Judica, 1991). Whether or not someone displays UN may vary as a function of a number of conditions: (a) the distance of the object from the subject (Halligan & Marshall, 1994), (b) the number of stimuli in the environment (Mark, Kooistra, & Heilman, 1988), (c) the type of stimuli being used (Heilman & Watson, 1978), (d) whether a motor response is required and which arm is being used for that response (Heilman, Watson, & Valenstein, 1993; Robertson, 1991; Robertson & North, 1992, 1994). The apparent heterogeneity of UN or the UN syndrome demands a critical review of the assessments currently in use. Since UN impacts one's ability to perform their ADL, the relationship between scores on assessments and a person's ability to perform his or her ADL has also been investigated (Halligan, Cockburn & Wilson, 1991; Kinsella et al., 1995; Marsh & Kersel, 1993; Zocolatti & Judica, 1991).

The heterogeneity of UN affects assessment of individuals and severely limits any conclusions that can be drawn using group analysis (Kinsella, Olver, Ng, Packer & Stark, 1993). In that UN is likely comprised of a number of discrete impairments, members of the experimental group may differ greatly from one another. One cannot expect a uniform response to any experiment, assessment or treatment, and thus the results of such studies must be interpreted judiciously. For this reason, Kinsella and colleagues argue that single case analysis may be the most effective way of investigating this disorder. In all, these issues underscore the need for therapists to be cognizant of the fact that a single test does not sufficiently evaluate the presence of UN.

Treatment of Unilateral Neglect

OT Literature

Many different types of intervention are used by therapists in the treatment of persons with UN. Unfortunately, although there are numerous articles in the OT literature explaining the theories of UN, its significant impact on function, methods of evaluation, the role of OT, and potential treatments; very few studies have been published which investigate the effectiveness of occupational therapy treatment for UN. The following section will review these studies along with efficacy studies published by other disciplines.

Remedial versus functional retraining approaches.

The techniques used by occupational therapists to assist person's with perceptual deficits can be categorized as either rehabilitative or remedial in nature (Neistadt, 1988). Rehabilitative techniques provide direct retraining in the occupational performance area in which the person is experiencing difficulty. Neistadt (1988) suggests that this approach may be particularly beneficial for some persons with brain damage; particularly persons lacking abstract reasoning. Direct training substantially decreases the amount of abstract thinking that is required. The client learns the appropriate skill for that specific situation.

In contrast, therapists employing a remedial approach to treatment, attempt to improve abilities by specifically correcting the underlying cause of the problem. According to Toglia (1991), remedial techniques seek to improve abilities in functional tasks by identifying the specific component of perception that is impaired. The therapist may determine that the person has UN. Therapy activities are provided to retrain the impaired component (attention due to a hypoactive right hemisphere, for example) with the expectation that improvements will generalize to other activities in which the same component underlies performance (Neistadt,

1988). A therapist using the remedial approach hopes that treatment of the underlying deficit will result in improved performance in a number of activities requiring that ability.

There is debate about the relative merits of rehabilitative versus remedial approaches. Ultimately, a therapist chooses one form of treatment over another according to the nature of the problem, his comfort with remedial and rehabilitative approaches, his philosophies and experiences regarding occupation, his knowledge base, and the needs of each individual patient.

Hemisphere Stimulation

Several treatment strategies have been developed and tested based on the attention theories of Kinsbourne (1993) and Heilman, Watson, and Valenstein (1993). Both theories have informed studies that attempt to ameliorate UN by manipulating either the type or location of stimuli.

According to Heilman, Watson, and Valenstein (1993), damage to the right hemisphere results in a hypoactive right hemisphere. They suggested that perceptual activities would minimize neglect. This will occur because perceptual activities demand right hemisphere processing. Right hemisphere processing boosts the activity level of the right hemisphere. On the other hand, activities that demand interpretation of verbal information will exacerbate UN. Verbal tasks would activate the left hemisphere, increase the imbalance, and intensify UN symptoms. This information has been used to design treatment strategies for persons with UN.

Heilman and Watson (1978) used a cancellation task to test the above theory. Subjects with UN canceled out figures on a cancellation sheet composed of either letters or geometric shapes. They surmised that the sheet with the letters would stimulate the left hemisphere whereas the geometric figures would stimulate the right hemisphere. Their findings were

consistent with their theory; subjects demonstrated less neglect when canceling the geometric forms.

Robertson and North (1992) discovered that wiggling the left fingers in the left hemispace (both acts require right hemisphere processes) improved performance on a cancellation task. In a later study (1994), they again, found that left hand movements resulted in a reduction in UN, but that benefit could be eliminated if bilateral hand movement occurred. In contrast Hjaltason and Tegner (1997) found no difference in performance on a line bisection test when subjects used their right hand or a pointing device attached to their head, and argue that hand use alone does not influence neglect. Hommel et al. (1990) found improvements on copying task accuracy when subjects with UN listened to music or white noise (presumed right hemisphere activities) during those tasks. Vallar and colleagues (1995) used transcutaneous electrical stimulation to deliver passive tactile stimuli to subjects with left UN. They found stimulation to the left neck (or hand and neck) improved performance on cancellation tasks whereas stimulation to right neck worsened performance.

People with UN do not perform poorly on all tasks requiring them to locate a stimulus. In fact, Ladavas, Petronio and Umiltà (1990) found that patients with left UN outperform controls (with no visual attention deficits) on tasks requiring finding stimuli in the right visual field. These findings suggest that a stimulus on the right “captures” the attention of someone with left UN.

If the presence of stimuli in the right hemifield captures attention, then reducing the amount of stimuli in the right should decrease the severity of UN. Mark, Kooistra, and Heilman (1988) discovered that patients with left UN performed better on a line cancellation task when the targets were erased as opposed to being marked with a pencil. They hypothesized that erasing

the targets reduced the amount of stimuli received by the right hemisphere and enabled the subject to attend to targets in the left hemifield. Hjaltason and Tegner (1992) found similar results using an illuminated line bisection task. The subjects' ability to determine the midline of an LED display line improved by 43% when they viewed the line in darkness compared to normal illumination. The authors suggested that the darkened condition removed extraneous visual stimuli from the right hemispace, thereby enabling the subjects to more easily disengage their attention from the right and direct it leftward.

Cermak, Trombly, Hausser and Tiernan (1991) conducted an investigation, expressly to analyze the effectiveness of occupational therapy treatments based on the hypoactive hemisphere hypothesis. They compared the performance of subjects with UN following a series of treatments designed to stimulate either the left or right hemisphere. The results did not support the theory. Right hemisphere stimulating did not consistently decrease UN and left hemisphere activities did not consistently worsen task performance. The authors suggested that the theory might not be at fault. The tasks chosen to facilitate right and left hemisphere processing may have not been effective, and the alternating treatment design used in the study may have canceled any significant beneficial effects before they were evident. They urged further research in this area.

A 1992 study by Butter and Kirsch yielded more positive results. They examined the effects of monocular eye patching and transient visual stimulation on accuracy in a line bisection task. They argued that both patching the eye ipsilateral to the lesion, and providing transient visual stimuli to the contralateral eye can activate the right hemisphere via the superior colliculus. The authors argued that transient visual stimuli are a powerful activator of the superior colliculus. In an earlier study, Butter, Kirsch, and Reeves (1990) demonstrated that

visual stimuli presented to the neglected side of a person with UN, resulted in a substantial decrease in the severity of UN. This effect was equally effective even if the subjects had a hemianopsia and did not report seeing the stimuli. The authors suggested that the stimulus had an unconscious involuntary effect on attention and oriented it to the neglected side.

The rationale for ipsilateral eye patching is based on studies, that indicate that the superior colliculus receives its input from the retina of the contralateral eye (Hubel, Levay, & Weisel as cited in Butter & Kirsh, 1992). Patching the right eye will decrease the amount of stimuli detected by the left superior colliculus. The right superior colliculus will receive relatively more stimuli than the left, correcting the previous imbalance. This will enable the person with UN to orient more easily to visual stimuli on the left.

Results indicated a substantial and significant improvement on line bisection using each of the procedures. Subjects with the greatest neglect benefited the most when the two treatments were combined (a mean reduction of UN by 61.4 percent). Butter and Kirsch (1992) urged using eye patching and visual stimulation as part of a treatment to improve patients function in ADL. An eye patch can be worn during ADL and does not require the patient learn new scanning strategies.

Arai, Ohi, Sasaki, Nobuto, and Tanaka (1997) investigated the impact of decreasing the amount of visual stimuli in the right visual field on left UN. The authors used a tint to prevent 90% of the visible light from penetrating the right half of each lens. The tint, in effect, reduced the amount of visual stimuli in the right hemifield relative to the left hemifield. Although the results were mixed, four of the 10 subjects demonstrated improvement on line bisection tasks when wearing the glasses. One subject wore the specially designed glasses during ADL. He not

only stopped colliding into objects when wearing the glasses, but also maintained this improvement once the glasses were removed.

The glasses may have had several possible effects. Decreasing the amount of light coming from the right hemifield, decreased the input to the light and motion receptors on right temporal retina and the left nasal retina. In turn, a relatively greater amount of visual stimuli was available from the left hemifield (the lenses were clear). This higher level of sensory input resulted in increased stimulation of sensory receptors in the left nasal and right temporal retina. This increased activity was transferred along the visual pathways to the visual cortex, resulting in increased stimulation of the right hemisphere relative to the left hemisphere. The disparity in sensory input may have been sufficient to enable the right hemisphere to overcome inhibition of the left hemisphere. The authors also suggested that the glasses might have effectively limited stimulation of the left superior colliculus. The left superior colliculus was no longer able to inhibit the right superior colliculus, thereby permitting more attention to left space.

Overall, the theories of Heilman, Watson, and Valenstein (1993) and Kinsbourne (1993) have generated intervention strategies that suggest improvement on tests of UN. Unfortunately, frequently the results were mixed, suggesting that one type of treatment will not work for all persons. Furthermore, the vast majority of these treatments occurred in highly controlled and artificial settings. The subjects were asked to perform only simple pencil and paper tests during which a treatment was applied. Although an intervention may have demonstrated positive results under such conditions, the ability for those same interventions to be of benefit in a clinical situation where the patient experiences a barrage of uncontrolled stimuli, remains unanswered. Furthermore it remains to be seen whether any benefits seen in the test situation transfer to ADL.

Cueing

During rehabilitation, therapists frequently utilize cues to assist a patient to complete a task. Cues provide feedback and draw attention to aspects of the task that a patient has forgotten or is unaware of (Trombly, 1995). The descriptions and definitions of cues vary according to author, discipline, and theoretical perspective.

Toglia (Trombly, 1995) describes semantic cues, analysis cues, repetition cues and perceptual cues. A less sophisticated (but no less useful) classification provides three basic groupings: verbal, physical, and environmental. A suggestion to "look to the left" is an example of a verbal cue. Physical cueing includes pointing to an object or physically guiding the patient. Physical cues do not require that the therapist make contact with the patient's body, only that the therapist uses his or her body. Therapists will also use environmental cues to facilitate learning. Colored lines indicating the edge of a piece of paper, arrows showing direction, pictures identifying contents of drawers, and thoughtfully positioning meaningful objects to facilitate memory are all examples of environmental cues.

Cues are used during both remedial and functional training sessions. Therapists use cues intentionally, and monitor the number, frequency and type of cues a patient requires for success. Each of these factors can affect whether a task is accomplished and learning takes place.

Several attempts have been made to determine if cueing is an effective method of rehabilitation for persons with UN. Riddoch and Humphreys (1983) found performance on a line bisection task improved when a letter was placed to the left of the line to be bisected. The letter, an environmental cue, enabled the subjects to determine whether they had scanned to the very left of the line. On the basis of their results, Riddoch and Humphreys urged clinicians to

utilize cues in their treatments. They proposed that cueing decreases UN and leads to accelerated recovery.

Unfortunately, Riddoch and Humphrey's (1983) statements were not supported by their research. They did not investigate whether their subjects' ability to look to the left improved on measures other than the line bisection task. There was no attempt to measure whether a concomitant improvement occurred in ADL. Moreover, the ability of the subjects to spontaneously use the cue on the paper is in question. The researchers indicated that the positive effect occurred only when subjects were forced to attend to and report the left side cue. It appears that cueing was beneficial, but only with verbal or physical reminders (cues) to use the environmental cue. The subjects used the environmental cue only when prompted. This study does not provide support for the use of purely environmental cues, nor does it indicate that UN is decreased for anything other than line bisection. It does indicate that purely environmental cues are an ineffective means of treatment for someone with UN and must be coupled with verbal and or physical cueing techniques to be of benefit.

Lennon (1994) studied the effects of visual and tactile cueing on a number of functional tasks. The subject's UN responded differently to each of the treatments. The subject's ability to read and perform cancellation tasks improved spontaneously, whereas motor neglect and spatial awareness (treated using tactile cueing, motor repetition, weight-bearing, and visual cueing) did not respond to the treatment techniques. A red line was used as a cue to teach the subject how to correctly navigate a pre-arranged obstacle course with his wheelchair. Neglect (as measured by the number of obstacles the subject bumped into) improved as a result of the treatment. Unfortunately, the author reports that this improvement did not generalize to other conditions (eg. home, outdoors). The lack of transfer of wheelchair navigation skills to areas other than the

obstacle course does not indicate that the rehabilitation of impairment using a functional approach is inappropriate; rather it emphasizes the need for the therapist to be cognizant of the absolute specificity of this type of training.

Lennon (1994) suggested that the subject's differential responses to the treatments and lack of generalizability support the view that UN is composed of multiple components. For this reason a number of different treatments using different theories may be necessary to tackle the many deficits labeled UN.

Halligan, Donegan and Marshall (1992) compared the relative effectiveness of a variety of cues on the ability of a person with UN to perform a line bisection task. The researchers used cueing techniques that would be familiar to most therapists. The cues included 1) premarked crosses to the left of the line used as an anchor for visual attention, 2) the therapist marking the left side of the line in front of the subject 3) passive stimulation to the left arm during the task 4) asking the subject to position his right arm to the left of the line before beginning the task 5) having the subject mark a cross to the left of the line before commencing the task 6) having the experimenter move the pen along the stimulus and asking the subject to indicate when the midpoint was reached. This condition was repeated for both a right to left direction and a left to right direction.

Two of the above cueing conditions were superior to the rest in terms of increasing the subjects' accuracy. They were: (a) the condition that required the subject to mark the very left of the line with a cross prior to determining midpoint; and (b) the condition in which the experimenter traced the line with pen (left to right direction) and the subject was instructed to indicate verbally when the bisection point was reached.

Although the Halligan, Donegan and Marshall (1992) study suggests that some forms of cueing may be superior to others, it does not indicate that cueing is a highly effective means of rehabilitation. Even when cues resulted in a major improvement on the line bisection accuracy, the effects of the strongest cue were lost if a mere 5-10 second delay existed between cue and task. Although cueing did cause an improvement on the patient's ability to consider stimuli in the neglected hemispace, once the prompt was withdrawn the ability was lost. The authors stated that the results confirmed the view that passive cueing produces no long-term carryover of improvement when the cues are withdrawn. If the benefits of cueing are lost after a 10 second delay, the authors rightfully argue that clinicians cannot assume that improvements in scanning ability via cueing will automatically generalize to other untrained tasks.

Overall, studies of cueing have yielded mixed results. Improvements are limited to the immediate task and the potency of cues are of a very short duration. Most results indicate that once the cue is withdrawn, (i.e., guidance of the therapist) the subject is unable to spontaneously direct his or her attention to the left. Seron, Deloche, and Coyette (1989) analyzed the results of several studies and concluded that cueing does not produce long-term changes or generalization to other tasks.

Although these studies, by and large, do not support the use of cueing, their results should be interpreted cautiously. The studies utilized very short testing and training periods. Halligan, Donegan, and Marshall (1992), for example, studied their subject's responses over a one-week interval. During this time only some of the conditions were repeated. This condition does not replicate the intensive daily therapy given by occupational therapists to persons hospitalized due to stroke. Antonucci et al., (1995) suggested that the relatively short training periods used to study treatment effectiveness may be the cause for poor generalization and inconsistent results. It

is reasonable to question whether results might have been different if the training period had lasted over several weeks rather than one or two trials.

These studies have also been criticized for addressing only the voluntary aspects of attention. A cue that indicates where the subject should direct his or her attention is a central or voluntary cue (Ladavas, Menghini, & Umiltà, 1994). Verbal instructions to look to the left, or arrows drawn on a page pointing left are examples of voluntary cues. The subject must voluntarily move his or her attention. An involuntary cue (peripheral cue) is a salient environmental stimulus that automatically pulls attention in its direction. A flashing red light in the periphery of a person's visual field that causes an automatic attention shift is an involuntary cue. The person did not have to consciously decide to direct his or her attention toward it.

Several authors have argued that UN maybe a result of breakdown in either the automatic or voluntary orienting system; or both systems (Ladavas, Menghini, & Umiltà, 1994; Riddoch & Humphreys, 1994). Riddoch and Humphreys contend that their subject's ability to utilize the therapist's verbal direction, but inability to spontaneously use the visual marker indicates the presence of two systems. The verbal guidance resulted in a voluntary orienting of attention to the left, whereas the visual marker demanded automatic attention shifts. They suggest that each system required a different type of treatment.

Mental Imagery

A 1997 study by Smania, Bazoli, Piva, and Guidetti examined the effectiveness of visuomotor imagery training on UN. They selected two subjects with UN and provided them with visual and motor imagery retraining over a period of several weeks. The authors argued that

although there was compelling evidence that representational deficits contribute to UN, no research had been conducted to expressly treat those deficits.

The subjects were tested three times: before the treatment period began, at its conclusion, and after a six month delay. The subjects demonstrated significant improvement on functional tests following the intervention and maintained this result six months after the training period had concluded. Unfortunately, because the subjects were receiving ongoing rehabilitation at the time of their inclusion in the study, and only pre and post intervention measures were used, the improvement in function can not be attributed to the intervention alone.

Computer Scanning

Researchers have attempted to directly assess the impact of visual scanning treatment on UN. Paul (1996) used computer activities to improve visual scanning. After four weeks of treatment using a software program designed for perceptual retraining, the three subjects demonstrated improvements in scanning performance on letter cancellation and line bisection tests. Unfortunately, the study did not utilize an adequate experimental design, tested only pre and post-training, did not control for spontaneous recovery and the effect of concurrent therapies, and did not explore transfer to functional tasks.

Ross (1992) used a single subject design to study the efficacy of a computer training program for visual scanning, and compare improvements made on the computer scanning program with a functional grocery shelf scanning task. All three subjects improved their scanning performance on the computer program. Unfortunately, these new skills did not transfer to the functional grocery shelf task. Ross speculated that the visual-motor demands of the computer task were insufficient to train people to make the scanning movements necessary for

many ADL. The relatively small size of the computer screen required scanning across only a restricted portion of the visual field. Computer training situations typically require that the subject use only the central twenty degrees of the available visual field (Bouska & Galloway cited in King, 1992), whereas items on the grocery shelf scanning task were placed as far as 75 degrees on each side of midline.

King (1993) investigated the efficacy of using a large screen to train persons with UN on a computer scanning program. The study involved 21 subjects who were evaluated on the basis of UN test scores using the large screen. The subjects took part in a 30 minute treatment session that required tracking objects projected on the screen. Post treatment test results indicated a statistically significant improvement on scores following the treatment session. Unfortunately, the study did not investigate whether treatment effects were retained, or if there were any corresponding improvements in the subjects' ability to perform ADL.

Video Feedback

Soderback, Bengtsson, Ginsburg, and Eckholm (1992) used video recordings of their subjects completing a homemaking activity to provide them with performance feedback. In general, the use of video resulted in a decrease in neglect behaviors during both the homemaking activity and a concurrent line cancellation task. Unfortunately the authors did not examine other activities to determine if there existed a concurrent decrease in neglect behaviors and generalization to other ADL had occurred.

Effectiveness of Treatments for UN

Robertson (1994) reviewed the literature and concluded that although several studies indicated positive effects on neglect due to therapy, the gains cannot be interpreted as effective treatment. Robertson believes that any therapy deemed effective must meet two criteria: The effects must be lasting and must generalize to situations other than the test situation. To date, positive effects are seen only for tasks which very closely replicate the training condition, and the skills do not appear to generalize to other cognitive perceptual tasks or activities of daily living (Butter & Kirsch, 1992; Robertson 1994). When generalization does occur it is evident only for tasks that are similar to the training task (Lennon, 1994).

Lin (1996) analyzed the results of 31 studies that used hemispheric activation as the theoretical basis for treatment. He described these treatments as "rationally based remedial treatments"(p. 508) that target the underlying function. Meta-analyses produced a mean effect r of .77 for group designs and a overall mean r of .89 for studies that used single subject design methodology. Overall these results are impressive and indicate that measures of UN decreased following the intervention. Limb activation studies produced a larger effect than studies that used lateralized tasks or controlled sensory stimulation as their treatment. The results suggest a positive immediate impact due to hemisphere stimulation, however the functional potential for these techniques remains unproved. Unfortunately, as noted by Lin only two of the 31 studies included in the meta-analysis included functional tests of ADL.

Lin (1996) also compared the effectiveness of remedial and rehabilitative approaches to treatment for UN. He produced evidence from earlier studies that could support each side of the debate. He suggested that the studies used treatments based on the principles of behavior therapy (eg. visual scanning training), and therefore, may not have targeted the underlying deficit. The

same observation can be made of the studies cited by Robertson (1994) upon which he based his conclusions regarding the effectiveness of UN treatments. Remedial therapies require treatment of the underlying deficit for any lasting change to occur and the continuing debate surrounding the mechanisms of UN suggests that in many instances the underlying deficit is not fully understood.

At this time, the superiority of either the remedial or rehabilitative treatment approach has not been established. Neistadt (1988) urged continued research to determine the effectiveness of occupational therapy treatment for perceptual deficits. She cited several weaknesses in the research that need to be remedied before any conclusions can be made. These included poor definitions of the exact perceptual disorder being addressed, lack of a standardized measure of ADL status, and stimulus parameters during treatment which were poorly defined. She reported that the researchers used ADL measures developed at their own institutions, used only parts of standardized assessments, or did not use any rating scale but rather utilized narrative descriptions of ADL performance. Lastly, poorly defined stimulus parameters do not allow therapists systematically replicate treatments for their patients.

To be added to this list, is the relative lack of research that simply asks, given changes on pencil and paper tests of UN, is there a concomitant change in the performance of functional activities? Has the research utilizing remedial treatments truly tapped into the underlying deficit? Given the status of UN assessments, and the number of theories being debated as possible explanations, is it possible for therapists to precisely identify the underlying deficits that are creating UN in their patients and prescribe an appropriate remedially based treatment?

Generalizability

Robertson (1994) has criticized the effectiveness of most UN treatments because they only rarely provided skills that could be applied in contexts other than the treatment condition. Although therapists working with persons with severe cognitive disability might argue that that situation-specific skills are necessary and valuable, Robertson's criticism underscores the importance many clinicians and educators place on the generalization of skills.

Although very few studies were able to document changes in ADL resulting from treatment, Antonucci et al. (1995) is a notable exception. They reported that subjects with UN that took part in an eight week remedially based treatment program, were able to apply new scanning skills to tasks other than those encountered in the treatment session. The investigators attributed their subjects' ability to generalize these skills to the duration of the treatment. They argued that factors such as the length of time a patient is treated, and the structure of that treatment, are more important to recovery from UN than the length of time since the CVA. Their review of earlier research revealed that for generalization to occur, a minimum training period of five to eight weeks is required. Previous research that had suggested that gains were limited to situations similar to the treatment condition were a result of training periods of only one or two weeks. The authors believe that the subject needs time to become aware of his impairment and develop methods to overcome the problem.

New Directions

The evidence from right hemisphere stimulation studies is promising. Arai and colleagues (1997) used hemispatial glasses to minimize input to the left hemisphere. The glasses led to an

improvement on line bisection in some of the subjects and a dramatic functional improvement in the one subject who wore the glasses during ADL.

The authors provided a number of possible explanations for their results. They suggested their study was similar to Mark and colleagues (1988) target erasing task and Hjaltason and Tegner's (1992) illuminated line bisection task. All three interventions reduced the amount of stimuli in the right hemifield, thereby increasing the subjects' ability to detect visual stimuli in the left hemifield. They also argued that treatments that used eye patching to decrease stimuli (Butter & Kirsch, 1992) are theoretically compatible with their own. However, of the two techniques, hemispatial sunglasses are more effective at reducing stimulation to the left superior colliculus.

Perhaps, most importantly, Arai and colleagues (1997) proposed "forced use" of the neglected hemifield to explain their results. In doing so, they introduced the concept of "forced use" to the UN literature. Although not widely used, forced use has been shown to be a highly effective intervention for overcoming chronic upper extremity hemiplegia following CVA (Taub et al., 1993; Wolf, Lecraw, Barton, & Jann, 1989). In those studies, the subjects' were provided with a sling to restrain their unaffected (strong) arm. The subjects were instructed to wear the restraint for several hours each day and use the weak arm to perform their normal daily activities. The subjects were "forced" to use their weak arm when they normally would have compensated during difficult tasks by using the stronger more dextrous extremity. Compared to subjects who received concurrent traditional therapy for hemiplegia (exercise etc.), the subjects in the experimental condition (forced use) made rapid, dramatic, and lasting gains. In fact, results were incredibly robust: There was no overlap between the two groups.

Although these findings were exciting, they were not readily applicable to persons with cognitive or perceptual deficits. Most clinicians will readily recognize when a person may be over-using the strong limb at the expense of improved function in the weaker limb. Further, methods to restrict the use of the strong arm are easily devised. It is a different matter entirely when the function being over used is an automatic perceptual or cognitive process. How does the clinician restrain or decrease activity in the area of the brain that processes right hemifield visual stimuli?

Arai et al. (1997) may have elegantly solved this problem by altering the amount of light that strikes different areas of the retina. Typically, when a stimulus (light) strikes the retina, the sensory input is transmitted along the visual pathways to the brain for processing (see figure 1A). Visual stimuli (light, shape) from the right visual field enters each eye (Snell, 1992). It strikes the left temporal and right nasal retina where it is relayed along the visual pathway to the left hemisphere of the brain for final processing. Note that although the stimuli entered both eyes, the final destination was the left hemisphere. The pathway for stimuli arising from the left visual field is the same but on the opposite side. Visual stimuli from the left visual field enters each eye.

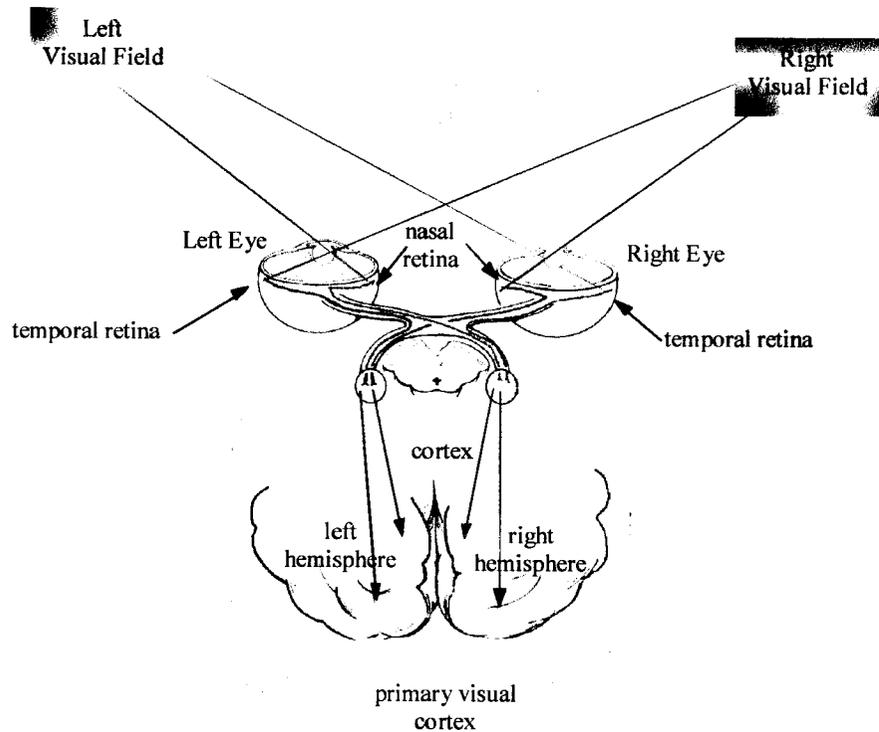


Figure 1(a)

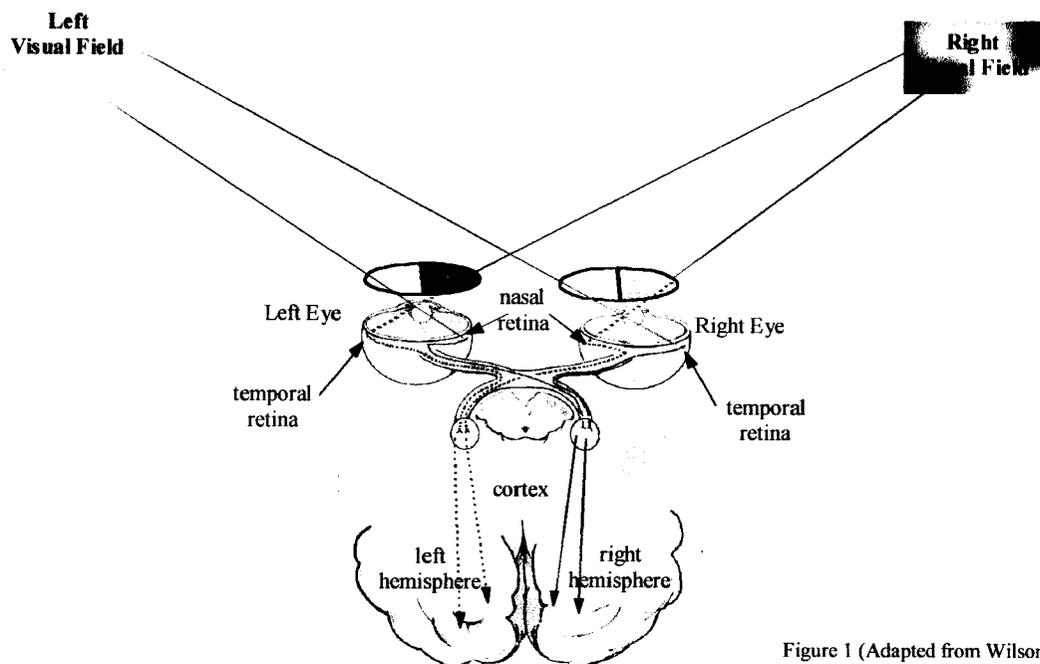


Figure 1(b)

Figure 1 (Adapted from Wilson, Pauwels, Akesson, & Stewart, 1988)

Figure 1. The Pathway for Visual Information. The light enters the eye and strikes the opposite side of the retina. Note that although each eye receives information from both the right and left visual field, each side of the cortex receives stimuli from only one visual field. The left hemisphere processes visual images from the right visual field, whereas the right hemisphere processes images from the left visual field. Figure 1(b) diagram depicts the manner in which glasses with the right side of each lens darkened decreases the amount of stimuli to the left hemisphere of the brain.

The right temporal and left nasal retina transmits this information to the right hemisphere of the brain.

Arai and colleagues (1997) created glasses in which the left half of each lens was tinted. The dark (tinted) area of the lens decreased the amount of light penetrating the lens by 90%. Figure 1B illustrates the effect of the glasses. Light from the left visual field could freely enter each eye and be transmitted along the pathway described earlier. In contrast, much of the light from the right visual field was prevented from entering the eye by tinted portion of the lens. The left temporal and right nasal retina were masked by the tinted area of the lens, and hence, received less sensory input than the right temporal and left nasal retina. As a consequence, relatively less visual information was sent for processing to the right hemisphere of the brain than the left hemisphere. There was an excess of left visual field information relative to right visual field information. The increased saliency of visual stimuli on the left and the relative lack of visual stimuli may have enabled the subjects to more easily attend to the left.

The results can be explained using “forced use” theory. The tinted lens prevented (or effectively restrained) processing by the intact hemisphere. By restraining left hemisphere activity, the glasses forced the subject to use the right hemisphere to direct attention. Use of the right hemisphere enabled the subjects to process more visual stimuli originating in the left visual field. This suggests that the capacity of the right hemisphere to direct attention was not lost, but rather masked when the left hemisphere dominated attention processing.

The findings reported by Arai et al. (1997) were similar to those reported in the forced use studies. Subjects, who did respond, did so immediately, suggesting latent ability. The glasses decreased visual neglect in persons with chronic (post-acute phase) UN. When one person with chronic UN wore the glasses constantly for one week, he no longer bumped into objects when

walking: The benefits were maintained even after the glasses were removed. Similar to the “forced use study” (Taub et al., 1993) the benefits of wearing the glasses were immediate, seen in persons with a chronic impairment, and reportedly, long lasting.

Each of the attention- based theories can be used to explain the results. Heilman (Heilman, Watson, & Valenstein, 1993) could argue that the increased input to the right hemisphere, relative to the left hemisphere, boosted its overall activity level. This enabled it to better perform the left spatial tasks he believes it was designed to do. Kinsbourne (1987, 1993) might argue that the increased sensory input to the right hemisphere allowed it to inhibit previously unchecked left hemisphere processes. Earlier it was discussed that Posner (1987) views the right hemisphere as critical to the disengage function of attention. By decreasing the amount of visual stimuli in the right visual field relative to the left visual field, the subject is more able to disengage from stimuli on the right. In this way, Arai and colleagues (1997) results are similar to those of Mark, Kooistra, and Heilman (1988) where the subjects’ ability to detect targets on a cancellation sheet improved when the targets were erased (not marked) when they were located. Further, the increased stimuli in the left visual field relative to the right visual field, results in greater activity in the right hemisphere relative to the left hemisphere. This increased activity level may improve the subject’s ability to disengage his attention overall.

One particular advantage of the glasses that Arai and colleagues (1997) did not discuss in their study is the ease with which the glasses can be incorporated into treatment. The person can wear the glasses in a number of settings and during a variety of tasks with different demands. Given the absence of proven lasting treatment for UN (Halligan, Donegan, & Marshall, 1992) and the likelihood that a number of impairments have been conflated under one term (Halligan & Marshall, 1994), Lin proposed “...the concurrent use of therapeutic maneuvers...” (1996, p. 512).

A combined approach could include right hemisphere activation techniques during ADL (Arai et al., 1997) with activities in peripersonal and extrapersonal space. Should the glasses serve to enhance the ability to detect objects to the left, the variety of conditions under which they can be utilized may promote learning and generalization. The glasses can be worn during remedial activities and ADL, thus providing the patient with sufficient time and multiple contexts to learn and apply the new skills.

Single Subject Designs

Kinsella and colleagues (1995) caution against large group testing to determine treatment efficacy with UN. There are likely a number of discrete impairments that fall under the rubric of UN (Halligan & Marshall, 1994). It is inappropriate to treat all forms of UN in the same manner as different deficits may underlie what is frequently seen as a single problem. For this reason, single case analysis is recommended.

Single subject designs enable researchers to make inferences about the effectiveness of an intervention with only one or a few subjects (Ottenbacher, 1986). This is possible because, unlike large group designs, single subject designs require repeated measures of one or more dependent variables while the independent variable is systematically applied, withdrawn, or altered. Data are systematically and repeatedly collected during a baseline phase prior to the commencement of the intervention. The results of the pretreatment performance are used for comparison against the results obtained during intervention. In this way, the subject serves as his or her own control.

Within single subject design methodology, there is an experimental design that utilizes a multiple baseline design with an embedded withdrawal (Kazdin, 1982). The multiple baseline

design begins with a baseline phase during which the dependent variable is repeatedly measured and no new intervention is provided. The baseline phase (A) permits the researcher to predict future performance if conditions remain the same (Kazdin, 1982). In the intervention phase (B) the independent variable is introduced, and the dependent variable continues to be assessed. The researcher must determine if the performance seen during the baseline condition remained the same during the intervention phase. A change in performance suggests a relationship between the independent variable and the dependent variable. However, a change in behavior (if any) cannot yet be confidently attributed to the independent variable. History, maturation, or learning could produce the effect.

A multiple baseline design across behaviors provides a lagged introduction of the treatment to several behaviors (Kazdin, 1982). This design allows investigators to determine if a change in performance that occurred when the treatment was applied to one behavior, could be replicated across other behaviors. In a multiple baseline design, threats to internal validity are weakened by the repeated demonstration of the effect of the independent variable across different behaviors. Multiple baseline designs allow a researcher to determine the effect of an intervention when the behavior will not reverse due to learning.

In addition, the embedded withdrawal design further protects against history or maturation as a threat to internal validity. The internal validity of a study is strengthened if an embedded reversal design is used, and the subject's performance on the dependent measures can return to baseline levels after the intervention is withdrawn. The researcher can conclude (with a high degree certainty) that change in performance on the dependent variable is a consequence of the independent variable (Barlow & Hersen, 1984).

The systematic application and withdrawal of treatment is an excellent way to determine if changes in performance are related to treatment. One criticism of this design is that it is ethically questionable to withdraw a treatment that is demonstrating beneficial effects. According to Barlow and Hersen (1984), the use of an A-B-A-B design, prevents this criticism. The reversal phase need not be lengthy, and the subject who has demonstrated positive effects, is able to end the study with treatment.

According to Barlow and Hersen (1984), baseline and experimental conditions should be continued until stability in the data is established, provided the number of data points in each phase are relatively equal. However, they recognized that time limitations and ethical considerations preclude many investigators from employing exceedingly long phases. They also argue that researchers conducting new research are justified in departing from the standard rules regarding length of phases.

CHAPTER III - METHODS

The purpose of this research was to test the efficacy of hemispatial sunglasses (HSG) as a treatment for unilateral neglect. Two separate study designs were used. The first study was descriptive in nature and replicated many of the features of Arai and colleagues (1997). It explored whether glasses shaded on the non-neglected side led to an improvement on pencil and paper assessments in 13 persons with unilateral neglect.

The second study investigated whether a person who had demonstrated an improvement on the shape cancellation task when wearing HSG, would demonstrate similar improvements during ADL. A multiple baseline design with an embedded reversal across three behaviors was used to investigate the effect of the glasses on unilateral neglect during ADL.

This chapter describes the methods that were used to conduct each of the studies, beginning with the initial descriptive study. An outline of the procedures that were used to identify and select suitable subjects is provided. The chapter then describes the independent variable (the glasses), the dependent variables (line bisection and shape cancellation) and information pertaining to their validity and reliability. The manner in which the data from this first study is analyzed is also reviewed.

The chapter then discusses the methods used in the second study. It reviews the criteria for participation. The dependent variables; shape cancellation (Mesulam, 1985), enlarged shape cancellation, a shelf scanning task, mobility, room look about, the Behavioral Inattention Test (Wilson, Cockburn, & Halligan, 1987), and an ADL questionnaire, are described along with pertinent information relating to instrument reliability and validity. A detailed description of the study design (multiple baseline across three behaviors with an embedded withdrawal) is included. A timeline is provided to illustrate the length of each of the phases. This chapter concludes with a review of the methods that were used to collect and analyze the data.

The study was conducted from April of 1999 through May of 2000.

Study One

Subjects

Subjects were chosen from persons receiving occupational therapy services at Vancouver General Hospital (VGH), BC Rehabilitation, and Lion's Gate Hospital. A convenience sampling technique was employed. Therapists at those sites referred clients they believed met the following general inclusion criteria.

- Diagnosis of right CVA (confirmed by CT)
- Able to understand and follow simple verbal instructions
- Evidence of significant visual neglect (determined by therapist or physician)
- Able to tolerate 45 minute treatment session
- Right hand dominant
- No other concurrent neurological diagnosis (i.e. Parkinson's disease, dementia)
- Greater than two weeks post CVA

Candidates with a severe visual acuity or known visual field deficit were excluded from the study.

The investigator provided potential subjects with a general description of the study and the type of the information required (location of lesion, and time since stroke). Informed consent was obtained.

Setting

Subjects were tested at the facility in which they were staying. Eight subjects were tested in a private occupational therapy treatment room at VGH, two subjects were tested in a private

office in the BC Rehabilitation occupational therapy department, and one subject was tested in the occupational therapy department at Lion's Gate Hospital.

Confidentiality of Data

To maintain confidentiality, all documentation pertaining to the subjects' performance on measures used code numbers only. Documentation was kept either at the home of the investigator, or in a locked drawer in the Department of Rehabilitation Services at Vancouver General Hospital.

Independent Variable

The independent variable was the wearing of hemispatial glasses (HSG). Three different types of hemispatial glasses were constructed. The glasses were constructed by applying to three pairs of clear plastic protective eye frames: 1) clear magic tape¹; 2) a tinted film² permitting only 28% visible light transmission (VLT); or 3) a tinted film permitting eight percent VLT. The glasses are standard laboratory eyewear manufactured by Johnson and Johnson Medical Inc³.

The subject was asked to look directly ahead at the investigator while wearing the eye frames. The investigator noted the location of the pupil in each eye and applied the film (or tape) to the glasses from mid pupil to the right edge of the lens on each eye. This effectively blocked the light from the right visual field to each of the eyes (see photograph appendix A). The glasses were customized to each wearer.

¹ 810 D Scotch Brand

² Llumar Film is a thin sheet of plastic used to tint car windshields. PT05gh blocks 92% of visible light and PT 22gh blocks 72% of visible light (other strengths are available). This type of film is available from most windshield retailers.

³ Style number Z87 length 4.

Dependent Variables

Line bisection

Although there are several different versions of the line bisection test (Arai et al. 1997, Marsh & Kersel, 1993; Schenkenberg, Bradford, & Ajax, 1980), each of the tests asks the subject to determine the midpoint of several lines of different length. Subjects were seated at a table. A sheet of paper (8.5 x 11) with twenty horizontal lines of different lengths (see appendix B, figure B2) was placed midline directly in front of the subject and secured to the table by a piece of tape. The line at the top of the page was used to demonstrate the test procedure to the subject. This line was not used in data analysis. The remaining 18 lines fall into three sets of six lines; each set containing a line of 100mm, 120mm, 140mm, 160mm, 180mm and 200mm in length. A set is defined by where it is located on the page (left, center or right). The sheet can be rotated 180 degrees to provide an alternate but comparable form.

Each of the subjects received the same instructions. (1) Please cut each line in half by drawing a mark through it as close to its midpoint as possible. (2) Do not skip any of the lines. (3) You have two minutes to complete this task. If you finish early let me know.

The line bisection test was scored by using the formula below:

$$\text{Percent deviation} = \frac{\text{measured left and center half} - \text{true half}}{\text{true half}} \times 100$$

The distance in millimeters that the subject's midpoint for a given line deviated from its true center was calculated for each line. The scores for each of the left and center lines were averaged, providing a single percent deviation score for the entire sheet. Although subjects were instructed to bisect each line, calculations were performed only for the central and left lines. No measurements were taken from the six lines that extend to the farthest right of the page.

According to Schenkenberg, Bradford, and Ajax (1980), lines on the right side of the page do not differentiate persons with neglect from controls whereas persons with right hemisphere

damage demonstrated (on average) a rightward displacement of greater than 10%, while the control group was within two percent of true midpoint. The number of lines missed were recorded as the authors found that only persons with right hemisphere damage missed two or more lines.

Shape cancellation

The shape cancellation test is a subtest of Tests of Directed Attention and Memory (Mesulam, 1985). It consists of 60 target stimuli interspersed among other randomly positioned geometric figures on a page 8.5 x 11.0 inches (see appendix B, figure B1). Each side of the page contains 30 targets.

The sheet was placed on a table directly in front of the subject. The subject was instructed to locate and cross out all the target items on the sheet. The subject was permitted two minutes to complete the task. The time taken to complete the task; and the number of targets left and right of center that the subject located were recorded

Procedure

Each subject was tested in a single session. The entire session lasted no longer than 45 minutes. The subjects first completed the line bisection and shape cancellation test wearing clear frames. They then repeated the tests wearing each of the experimental frames. The three different frames were given in random order. The alternate form of the line bisection test (flipped 180 degrees) was used for the second and fourth assessment. At the end of the session, the subject was asked to repeat each test (line bisection and shape cancellation) once again wearing the clear frames. Each subject performed both the line bisection and figure cancellation tests five times.

Reliability and Validity

Both line bisection and shape cancellation tests were used to measure neglect. Each of these tests is a recognized assessment tool, and has been used for many years.

According to Kinsella et al. (1995) line bisection has a detection rate of 38 %, test-retest reliability of 0.64 and correlates with behavioral ratings of neglect ($r = 0.48$). Using a procedure similar to the one in this study, Schenkenberg et al. (1980) established a test-retest reliability coefficient of between 0.84 and 0.93 and inter-rater reliability correlation of 0.99.

Kinsella and colleagues (1995) found that when measures of neglect are compared, Mesulam's (1985), shape cancellation is the most reliable and sensitive of the pencil and paper measures. The test yielded a general detection rate (among persons with a CVA) of 43% and test retest reliability of 0.84.

No inter-rater reliability studies were conducted in Study One. The tests are well recognized, objectively scored, and have been shown to have high test-retest reliability.

Data Analysis

The results of this study are descriptive. A table format is used to compare the subjects' scores in each of the conditions. Individual and group scores are analyzed for response to the independent variable.

Study Two

Subject

Participation in the second study was based on a subject's response to the hemispatial glasses (HSG) in the first study. The subject had to demonstrate an improvement on the measures while wearing at least one type of the HSG. Specifically, acceptance in the second study was contingent on four of five therapists (blinded to condition) reporting a clinically significant difference on the test sheets.

Subject #7 demonstrated a clinically significant difference (improvement) when performing the cancellation tasks while wearing the opaque tape version of the HSG. Clinical significance was established by occupational therapists who viewed the test sheets and were blind to the condition. The subject demonstrated a clinically significant improvement on both line bisection and shape cancellation when wearing the opaque tape form of the HSG. Five of the five occupational therapists reported a significant difference between the clear glasses and the hemispatial tape condition.

A summary of the research and potential time commitment required was provided to the potential subject. Informed consent was obtained. The subject was assured she would receive regularly scheduled therapy sessions in addition to the HSG.

Setting

The research was conducted at BC Rehabilitation in the department of occupational therapy. The occupational therapy treatment area and a private office were used.

Study Design and Procedures

The primary objective of this study was to investigate the effects of wearing HSG on three activities of daily living (ADL): shelf scanning, mobility, and general room scanning⁴. The study design was a multiple baseline with an embedded withdrawal across three behaviors in a single subject (refer to figure 2). The subject's performance on the dependent variables was measured continuously while the use of the independent variable, HSG, was applied first to the shelf scanning task (on day 7), second the mobility task (on day 11), and third the room look about task (on day 17). The lagged application of the treatment to the three behaviors served as a method of experimental control. To further clarify whether changes in performance were a result of the treatment; the treatment condition was applied and reversed twice for shelf scanning, applied twice and reversed once for room look about, and applied once and reversed once for mobility.

A second objective of this study was to investigate possible carryover effects from wearing HSG glasses for an extended time each day. Carryover effects were assessed on the three target areas of ADL (shelf scanning, mobility, and room look about) and two additional measures; shape cancellation, and enlarged shape cancellation. The carryover effects were assessed by including a final nine day phase when the HSG glasses were worn four hours each day, but not when performance on the dependent measures was taken. The subject recorded the time of day she wore the glasses, the length of time she wore the glasses and the activity she was performing while wearing them.

During the baseline phase, the subject wore her own prescription glasses for all

⁴ The study initially intended to assess feeding, mobility and shelf scanning. On day 1 the subject did not demonstrate any observable neglect during feeding, therefore, "room look about" was substituted.

measures⁵. The lenses were clear and did not affect her vision or perception. She performed each of the following tasks daily: shape cancellation, enlarged shape cancellation, shelf scanning, mobility and room look about. During the treatment phase the subject wore her own glasses, but the right half of each lens (from mid pupil) was covered with the opaque tape.

⁵ The subject found wearing two sets of glasses slightly uncomfortable. She stated that she would prefer to wear only her prescription glasses and have them altered for the HS effect. It was decided that the subject's own glasses could be altered using the same technique as the lab glasses without compromising the HSG effect.

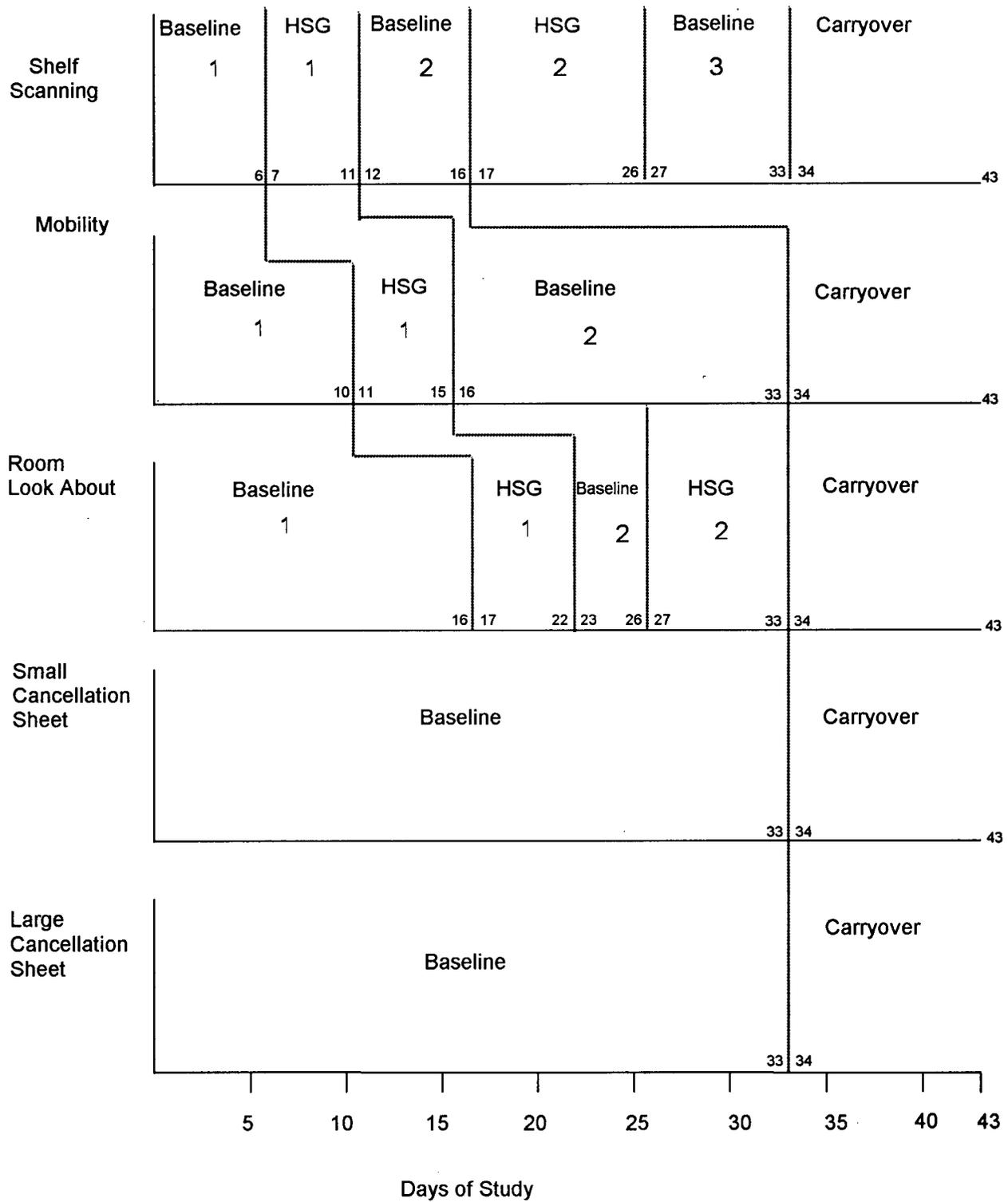


Figure 2. Outline of Multiple Baseline Design Showing Phases of each of Repeated Measure

General Features.

1. There was one subject in Study Two
2. She was tested on 43 days over eight weeks.
3. The subject performed all five activities each day and measures of her performance on those activities were taken each day.
4. On the first day of the study, all measures were in the baseline condition.
5. During baseline condition (or return to baseline condition), HSG were not worn.
6. During the treatment phase, HSG were worn.
7. The treatment phase for each activity was different. While the subject wore HSG for one activity, she did not wear it for the others.
8. The subject never wore the HS during the cancellation tasks (small and large).
9. The carryover phase began on day 34. During this time, the subject wore the glasses for four hours each day, but never during the assessments. This phase lasted for nine days.

Shelf scanning test.

On day one through six, the subject performed the shelf-scanning task with unaltered glasses. This was the first baseline condition (A1) for this task and it lasted six days.. On day 7, the first intervention phase commenced (B1) and subject began wearing the HSG while performing the shelf scanning task. The HSG glasses were worn only for that activity. HSG glasses were worn during the shelf scanning task for five days. On day

12, the glasses were withdrawn from the shelf scanning condition (back to the baseline condition –A2). The subject continued to perform the task without the HSG until day 17 when they were reintroduced as treatment and worn for the next 10 days (B2). On day 27 the glasses were removed and once again the subject completed the task for eight days without the glasses (3). The carryover phase began on day 34. The subject wore the HS glasses for 4 hours each day but not during any of the tasks. The carryover phase lasted 10 days. In all, the subject's performance on shelf scanning was tested on 43 occasions over a period of 58 days. Her performance on this task was assessed over an initial baseline phase, two intervention phases, two withdrawals (return to baseline conditions), and a carryover phase (A1-B1-A2-B2-A3-C).

Mobility.

In accordance with a multiple baseline design, the subject performed the task without HSG from day one until day 11. This first baseline phase (A) lasted for eleven days. On day 12 the intervention phase (B) for the mobility task was initiated, and the subject wore the HSG during the mobility task for the next five days. On day 17 the HSG were removed (A) and the subject continued to perform the task at each session. This return to baseline condition lasted from day 17 through to day 33. On day 34 the study entered the carryover phase (C) and the subject continued to perform the mobility task without the HSG. The design for mobility was A1-B1-A2- C.

Room look about.

The initial baseline phase for room look about commenced day one and was continued until through day 16 (A1) comprising a total of 16 days. On day 17 the HSG were introduced (B1 initial treatment) and worn for this activity through day 22. A return to baseline condition was instituted for days 23 through 26 (A2). On day 27 the subject entered a second treatment phase for this task and wore the HSG through day 33. On day 34 the subject entered the carryover phase. The design for room look about was: A1-B1-A2-B2-C.

Cancellation task (small/table top version).

The subject performed the cancellation task each day. The HSG were never worn for this task.

Cancellation task (large/wall mounted version).

The subject performed the cancellation task each day. The HSG were never worn for this task.

Independent Variable

The independent variable was the wearing of HSG. The glasses were created by applying Scotch Magic Tape to the subject's own prescription glasses. The tape was applied to both the right and left lens from mid-pupil to the right edge of the frame. The tape was removed at the end of the activity. When in baseline condition, the subject wore her own glasses with no alteration.

Dependent Variables

In study two, both pretest/posttest measures and repeated measures serve as dependent variables. The dependent variables consisted of the following measures of neglect and ADL: The Behavioral Inattention Test (Halligan, Cockburn, and Wilson, 1991, appendix C), the Subjective Neglect Questionnaire (Towle & Lincoln, 1991, appendix B, figure B3), shape cancellation (Mesulam, 1985, see appendix B, figure B1), enlarged shape cancellation (Mesulam, 1985, see appendix B, figure B4), shelf scanning task (see appendix B, figure B5), mobility (Webster et al., 1988, appendix B, figure B6) and room look about (Appendix D, figure D3). Social Validity was assessed by a series of open-ended questions (appendix B, figure B7). Refer to table 3 for a schedule of testing.

Table 3

Frequency of Tests - Dependent Variables⁶

<u>Dependent Variables</u>	<u>Type of Measure</u>	<u>Frequency</u>
BIT	Pre and post measure	Twice
SNQ	Pre and post measure	Twice
Shelf scanning test	Repeated measure	Daily
Room look about	Repeated measure	Daily
Mobility	Repeated measure	Daily
Shape cancellation (enlarged)	Repeated measure	Daily
Shape cancellation (table top)	Repeated measure	Daily
Interview	Social validity at conclusion of study	Once

Pre and Post Measures.The Behavioral Inattention Test.

The Behavioral Inattention Test (BIT) (Halligan, Cockburn, & Wilson, 1991) was administered in the first week of the study and one week after the conclusion of the study. The test was administered according to published protocol (see appendix C).

The BIT (Halligan, Cockburn, & Wilson, 1991) was developed to both address the lack of standardized testing materials for the detection of unilateral neglect and to provide information about a patient's abilities and limitations. The authors state that psychologists and occupational therapists developed the test based on item testability and relevance to everyday life. Poole and colleagues (1991) suggest that the BIT is

⁶ BIT = Behavioral Inattention Test, SNQ= Subjective Neglect Questionnaire

particularly important to OTs because it examines the impact of perceptual and cognitive deficits on daily living skills.

The test was standardized on subjects who were, on average, 2 months post CVA. The BIT has been normed and validity and reliability data are available. The test has an inter-rater reliability of .99 ($p < 0.001$), test retest reliability of .99 ($P < 0.001$), and parallel form reliability of .91 ($P < 0.001$). The authors determined the tests' validity by comparing scores on the behavioral battery with scores on conventional tests for UN (line crossing, letter cancellation, star cancellation, figure and shape copying, line bisection, and representational drawing). The correlation between the conventional tests and the behavioral tests was 0.92 ($p > 0.001$). Scores on the BIT were also compared with therapist ratings of UN and produced a correlation was 0.67 ($P < 0.001$). The authors suggest that a score of 129 or less on the conventional subtests and a composite score of 67 or less on the behavioral subtests indicates neglect. This number was determined during norming and validity studies that compared the results of 80 persons with a CVA to 50 controls without brain damage. The cut-off scores provided a UN detection rate of 37.5 %.

Subjective Neglect Questionnaire (SNQ).

The SNQ (Towle & Lincoln, 1991., see appendix B, figure B3) was administered to the subject on both the first day of the study, and one week after the study concluded. The questionnaire examines 19 potential ADL problems and asks the subject to record how frequently the problem occurred. The subject's husband also completed the questionnaire on those same days. The authors suggested that relatives or therapists complete the test, as there was a significant difference in the scores obtained by the

subjects with neglect, and the caregiver scores. The authors speculated persons with right hemisphere damage may not understand the cause of (or forget) their difficulties.

The internal consistency and test-retest reliability of the SNQ were investigated (Towle & Lincoln, 1991). Only those questions (19 of the 41 original) that gave reliable scores over a six-month period were retained. The authors suggest that the problems the subjects identified appeared to be related to UN rather than visual field deficits or severity of stroke. The SNQ correlates with star cancellation scores ($r=0.36$; $p=0.006$ one tailed test).

Repeated Measures

Cancellation task (table top version).

The subject performed this pencil and paper cancellation task each day. The cancellation sheets chosen were taken from Principles from Behavioral Neurology (Mesulam, 1985). Both the geometric (scattered version) and alphabet (scattered version) were used and chosen randomly by draw each day. The subject was seated at a desk with the sheet placed midline in front of her. The sheet was anchored to the table with a piece of tape. The subject was instructed to cross out all of the targets. She was told that she would have five minutes to complete the task and was informed when she had 30 seconds remaining. The examiner stood behind the subject and provided her with a new pencil after every 10 targets identified.

Cancellation task (enlarged version).

The subject performed this task each day. The cancellation sheets measured 48 inches wide by 36 inches high. They were enlarged forms of the tabletop assessments (Mesulam's scattered geometric and alphabet version) produced by a local printer. The

cancellation sheet was secured to the wall at a height of 72 inches. The subject was seated in her wheelchair and placed directly in front of the sheet; her knees touching the wall (appendix B, figure B4). She was instructed that she had five minutes to cross out each of the targets and that she would be notified when she had 30 seconds remaining. Selection of the geometric or alphabet version was done randomly each day by draw. The examiner stood behind the subject. The subject was provided with a new marker after each ten targets located.

Shelf scanning test.

Subject completed a shelf unit scanning test daily (Ross, 1992). The shelving unit consisted of three shelves, each 78 inches long, spaced 11 inches apart (appendix B, figure B5 for photograph and appendix D, figure D1 for scoring sheet). Each shelf held approximately 26 items at roughly equal distances from each other. Eight of the 26 items on each shelf were placed at target locations: approximately 15, 30, 45, and 60 degrees to the right and left of the central visual field. The subject sat in her wheelchair midline in front of the shelves. Her eye level was between the second and top shelf.

The examiner provided the following general instructions "I am going to give you a number of items to find on the shelves. You will have 20 seconds to look for each item. Please look for and find the object as quickly as possible. As soon as you locate the object, please point to it or describe its location. I will tell you when to stop looking and go on to the next item. Look for the bottle of shampoo now".

The subject was asked to locate the 24 items that were placed on those target locations (eight per shelf). To retain some degree of novelty in the display, every week approximately 10 new items were added to the display, while 10 others were removed.

Each day the location of all of the items was changed. The shelf was organized in advance of the subject's arrival, as was the order of the locations (target areas) in which she had to search. Each target location was assigned a number (1-24). Prior to the subject's arrival, the examiner pulled numbers out of an envelope (1-24) to determine which location would be searched for first, second, third etc. Although the subject had to find items at each of the target locations on each shelf, the order of the target locations was altered each day as was the actual items she was asked to find. In this way she was unable to anticipate where she would need to look (left or right, how far, top or bottom) and what she would be looking for. In fact, although the subject knew she was looking for items along the shelves, she never knew that the items were placed at specific target locations.

The subject was given 20 seconds to locate each item. The examiner recorded whether the item was found, the time it took and its location on the scoring sheet. When the subject was unable to find the object in 20 seconds, the examiner asked her to "Stop and begin searching for the next item."

Once each week a second examiner attended and scored the shelf scanning task. The scores of the two examiners were compared to determine interrater reliability.

Mobility.

The subject's ability to negotiate an obstacle course was assessed daily. The subject was asked to mobilize in her wheelchair to a location approximately 26 paces away. The examiner established the course and set up potential obstacles prior to the subject commencing the task. The route consisted of one right turn and one left turn.

Eight potential obstacles were placed along each side of the route. Wheelchairs, overbed tables, tables, chairs, laundry bins, stools, open cupboard doors, garbage cans and other common items served as obstacles (appendix B, figure B6). The obstacles permitted 36 inches for clearance. To eliminate learning from repeated trials, the location and order of the obstacles were different each time mobility was assessed.

The examiner stated the end location and described precisely how to get there. "You need to make your way to the kitchen sink. You will propel your chair about 15 feet down this hall and turn to your left (etc.)". Since the mobility assessment was looking for difficulties related to left neglect (and memory was not being tested) the subject could have the instructions repeated as needed, however the subject usually did not need further instruction. The examiner did not cue the subject to avoid an obstacle. The examiner remained one foot behind the subject.

The examiner recorded the number of direct hits (any contact along the frontal plane of the wheelchair) and sideswipes (any contact along the lateral surface of the wheelchair), whether these contacts were to the right or left, and the total length of time required to pass through the course. Once the subject made contact with an obstacle, she has 10 seconds to steer herself in a direction away from contact. If unable to do this within the allotted time, the examiner steered the subject so that she was one foot from the obstacle and facing to the middle of the course.

Data was collected on a drawing that represented that day's obstacle course (see appendix D, figure D2). The diagram included the location of objects, location of contacts, type of contacts, as well, time to complete the course.

Room look about.

The subject's look around a room and "see" all of it (areas in front of her and to her sides) was tested daily. The subject (seated in her wheelchair) was asked to close her eyes. The examiner moved (or turned) the subject so that she looked out at an area she had not been just previously been facing. Care was taken to insure that the orientation provided an approximately equal number of objects to the subject's right and left. For example, a picture and doorway to the right and a basket and chair to the left.

The examiner stated, "I want you to provide me with as complete a picture as possible of the entire room in front of you (front, left and right) by describing what you see. You have one minute to do this. Do not spend time describing any one object in detail. What I want to know is that you have seen the entire room in that one minute. Begin now"

The examiner stood behind the subject with a stopwatch and sheet of paper and pencil. The examiner drew a representation of the subject and the direction she faced on the paper. Midline was established by imagining a line straight through the subject's head when she faced straight ahead. Each time the subject reported seeing an object, the examiner recorded approximately where the item was in relation to the subject on the sheet of paper (see appendix D, figure D3). For example, if the subject stated "red chair" and the chair was approximately 45 degrees to the right of the subject, the examiner wrote "45" degrees on the sheet at approximately that orientation to the drawing of the subject.

Assessor

The investigator conducted all the assessments with the following exceptions. On days 29, 30 and 31, the sessions were conducted by an alternate occupational therapist. This therapist provided the HSG and performed the assessments. The therapist was trained in the assessment procedures the previous week. This same therapist also performed the post test assessments (BIT, SNQ, and closing interview questions).

Inter-rater Agreement

An independent therapist was instructed in the assessment methods. Inter-rater reliability was calculated for each repeated measure of ADL during each phase of the study. Inter-rater reliability was calculated for 16% of the daily measures (one session each week). Inter-rater reliability for small and large shape cancellation was calculated twice. Two equations were used across the daily measures:

$$\text{Overall percent agreement} = \frac{\text{smaller score}}{\text{larger score}} \times 100 \quad \text{Exact percent agreement} = \frac{\text{agreements}}{\text{agreements} + \text{disagreements}} \times 100$$

Repeated Measures

Shelf scanning.

Once each week a second observer attended the session and scored the subject's performance on the shelf scanning. The two sets of data were compared and overall percent agreement was calculated. On three occasions exact percent agreement was calculated. Exact agreement was defined as both observers indicating that a particular object (in its assigned location) was located or not located.

Mobility.

Once each week, a second observer was present to score performance on the obstacle course. Agreement was defined as both observers recording the same number and type of contacts, as well as whether the contact was on the left or right of the course.

Room look about.

Once each week the second observer attended the session and scored the subject's performance in the same manner as the investigator. The two sets of sheets were reviewed later and the data was compared. Agreement was defined as the two investigators recording the same number of objects on the left side as reported by the subject.

Shape cancellation (small and enlarged).

During the first two weeks, the second observer re-scored the cancellation sheet. Percent agreement was calculated based on the two sets of data. Agreement occurred when both evaluators indicated that a target shape was either located or missed. For both the assessments reliability was 100%, and hence no further inter-rater reliability checks were carried out.

Data Management and Analysis

Single subject designs traditionally employ visual analysis and graphical representation to evaluate data and determine if change occurred (Ottenbacher, 1986). Only dramatic changes in performance will be visible using visual analysis (Kazdin, 1982). According to Kazdin, applied research must meet two separate criteria: The data

produced must meet experimental criterion (show an effect) and it must meet therapeutic criterion (demonstrate clinical significance). Visual analysis facilitates identifying clinically significant change, whereas trend analysis (using celeration lines) enables researchers to identify data that meets only the experimental criteria.

Data obtained from the dependent variables that were repeatedly measured are presented within a multiple baseline graph and independent graphs. This permits detailed visual analysis of the subject's response to the independent variable across each dependent variable. Performance levels are plotted along the Y-axis. Time is plotted on the X-axis. The baseline and intervention phases were analyzed for differences in level, mean, variability, and slope.

Analysis of trend was performed by applying median and mean regression lines to the data. When the change in phase resulted in a dramatic change in trend, no statistical analysis of trend was performed. At times, the change in the slope of was more subtle. When this occurred, the statistical significance of the difference between expected and the observed number of data points above and below the trend line was computed using Bloom's probability table with an alpha of 0.05 (Ottenbacher, 1986).

Social Validity Measures.

Although any measure that demonstrates a significant change in the performance of ADL, supports the social validity of the study, direct assessment of the subject's perceptions is invaluable. The subject was asked to respond to a series of questions (closing interview) concerning her experience in the study. She was asked whether she enjoyed the treatments, and saw them as relevant to her difficulties. She was also asked

whether she noticed any changes in her abilities that she attributed to the treatments. See appendix B, figure B7 for a copy of questions and responses.

CHAPTER IV-RESULTS

Study One

This study was conducted between April 1999 and June 2000. It was originally intended that 20 people with unilateral neglect would be assessed with the HSG. Subjects were recruited from Vancouver General Hospital (VGH) and G. F. Strong Rehabilitation Center. Due to low numbers of potential subjects, the search was extended to Lion's Gate Hospital. In all, only 13 people met the inclusion criteria (despite the large number of people admitted to Vancouver General Hospital with a diagnosis of acute CVA). The VGH neuroscience team experienced considerable staff turn over during that time. It is possible that new therapists were unaware of the study and might not have invited potential subjects to participate. An equally plausible explanation is that the low number of persons with unilateral neglect reflects natural fluctuations found in any population.

Population Characteristics

Table 4 provides descriptive information about each of the 13 subjects. It also indicates if there was any mention in the chart of a possible visual field loss. Although visual field problems were mentioned in relation to four of the subjects, none of the subjects had received a formal visual field test prior to the study. Unfortunately, some clinicians use the terms visual neglect and hemianopsia interchangeably. What is known about a hemianopsia is that persons with this impairment will readily compensate for their visual loss unless some other perceptual or cognitive problem exists.

Table 4

Study One: Subjects' Clinical Data

Subject	Age/Sex	Time Post CVA	CT Lesion	Hemianopsia
1	73F	4 weeks	MCA	
2	70/M	3 months	MCA	
3	74/M	7 weeks	MCA;T	b
4	66/F	4 weeks	T;BG	
5	57/M	2 weeks	BG	
6	71/M	4 weeks	MCA	
7	70/F	9 weeks	MCA	?
8	63/F	4 weeks	F,T,P,O, LN	?
9	39/M	5 months	MCA	?
10	60/M	3weeks	R caudate, lent., post.cap.int.cap	
11	53/M	7 weeks	MCA ^a	
12	63/F	2 weeks	R putamen	
13	61/F	4 months	BG, LN, minor BiP	?

Note. All CT lesion sites were on the right except where sited (subject 13)

Abbreviations: MCA, middle cerebral artery territory; BG, basal ganglia; LN, lentiform nucleus; F, frontal; T, temporal; P, parietal; O, occipital; Bi, bilateral. ^a underwent R temporal lobe resection post-CVA. ^b chart indicated possible hemianopsia, but no formal tests

Subjects' Performance on Line Bisection

Table 5 presents the results of each subject on the line bisection test. The scores represent the average percent deviation for the fourteen left and center lines. If a subject bisected a 10 cm line at 7 cm centimeters, the subject's midpoint would have deviated from true midpoint (five cm) by 40 %. The percent deviation was calculated for each of the lines and then averaged.

The clear frames were worn for the first and the final trial to capture any improvements that may be a result of learning from repeated trials. Each of the subjects (except subject 10) demonstrated a right side deviation on line bisection when they wore the clear frames. None of the subjects' midpoints fell within 2% of the actual midpoint.

Subject #10's midpoints fell to the left of center during the final clear lens condition (represented by a negative percentage). Although subject #11 began with a right side deviation of 11%, he demonstrated a left side deviation for all subsequent trials.

Subjects #1, #2, #3, #4, #7, #8, #9, #10, #11, and #13 were more accurate at determining the midpoint while wearing the HSG with 8% VLT than they were during the first clear lens condition. When the final clear lenses condition results are considered; only subjects #1, #2, #8, and #13 performed better wearing the 8% VLT HSG, and that difference is only a few percentage points.

In the 28 % VLT condition, subjects #3, #7, #9, #10, #11 were more accurate wearing the HSG than the clear lenses on the first trial. Only subjects #7, #11, and #12 maintained this benefit when their results were compared to the final clear glasses condition.

Subject # 4 refused to complete the task when wearing the taped HSG. She reported that she was unable to see anything while wearing them. The taped HSG appeared to benefit only subjects #7, #11, and #12 when their accuracy was compared to both clear lens conditions. The

Table 5

Comparison of Subjects' Performance on Line Bisection Test Across the Five Conditions.

Subject	<u>Clear lens (1)^b</u>		<u>HSG 8% VLT</u>		<u>HSG 28% VLT</u>		<u>HSG-tape</u>		<u>Clear</u>	
	<u>score^a</u>	<u>#LM</u>	<u>score</u>	<u>#LM</u>	<u>score</u>	<u>#LM</u>	<u>score</u>	<u>#LM</u>	<u>score</u>	<u>#LM</u>
1	73	11	62	11	77	13	none	13	79	12
2	79	5	74	4	85	1	73	4	78	3
3	51	6	61	9	44	6	35	7	21	7
4	50	4	45	13	53	7	refused ^c		40	4
5	6	0	4	0	11	1	12	0	14	0
6	18	11	21	5	19	1	19	6	18	1
7	32	2	23	2	15	1	25	0	18	4
8	90	9	89	9	91	8	85	4	90	2
9	37	1	25	2	27	2	30	2	20	1
10	11	0	5	0	-7	0	7	0	5	1
11	10	0	-5	1	-7	0	-2	1	-3	0
12	6	0	10	0	6	0	5	0	8	0
13	10	0	1	0	11	0	8	0	3	0

Note. Calculations were performed on only the left and center lines. ^ascore = average percent deviation that a subject's midpoints differed from the center. #LM = the number of left and central lines missed by the subject. ^bThe clear lens condition was always the first and last trial. ^cSubject stated she could not see anything.

improvement was not great. Subject #8's midpoints were 85% to the right of true midline, a 5% difference from the clear glasses. The difference in accuracy for subjects #11 and #12 was only about 1%.

Although some of the HSG resulted in increased accuracy for some of the subjects, this improvement was very small. The greatest improvements were seen in subject #2 wearing the 8% VLT HSG and tape HSG (a four and five percentage point improvement respectively); and subject #7 wearing the 28% VLT HSG (a three point difference). Although subject #1 improved by 11 percentage points when wearing the eight % VLT HSG, so few left and center lines were located that the HSG do not appear to be a significant benefit.

Interestingly, the HSG may have produced a left side deviation in two of the subjects. Although subject #10 had a right side deviation for both the first and final clear lens condition of 11% and 5%, he showed a marked left side error (minus seven percent) when wearing the 28% VLT HSG. Subject #11's midpoints deviated to the right of true midline by ten percent during the first clear lens trial. On subsequent trials, his midpoints deviated to the left by 5%, 7%, and 2% respectively. The left side deviation was maintained on the final clear lens trial.

Table 5 also displays the number of lines each subject missed. Only subject #12 and #13 did not miss any lines in any of the conditions. Subject #4 missed 4/14 lines during both clear lens trials. In the HSG conditions she missed 13 and 7 lines respectively: the greater number of misses consistent with the darker lens. Subject #6 improved dramatically. Initially he was able to identify only 3/14 lines, but improved until he missed only one line on the final trial. The order this subject performed the conditions was 1) clear glasses, 2) 8% VLT, 3) taped HSG, 4) 28% VLT, 5) clear lens. It appears the improvement was progressive. Subject #7 missed lines in both the clear trials but not when wearing the taped lenses. Overall there is no clear pattern among the subjects with respect to HSG and the number of lines located.

Subjects' Performance on Shape Cancellation

Table 6 presents results of the subjects' response to the different HSG while performing the shape cancellation task. To account for the effects of learning from repeated trials, the clear lens condition was performed as the first and last trial. Although the table displays the number of targets located on both the right and left side of the cancellation sheet, the number of targets on the left is of primary importance.

When performance on the first clear lens trial and the final clear lens trial are compared, eight subjects had improved. The improvements were, for the most part, minimal. The exception is subject #10 who initially located 22/30 targets on the left and 26/30 targets on the right. In the final condition, he located 30/30 and 28/30 targets respectively.

Subject #1 and #3 did not understand the demands of the task, or were unable to distinguish between the shapes. They crossed out a variety of different shapes with equal frequency.

The 8% VLT glasses appear to have benefited subject #8, and #9. Subject #8 was able to find 4/30 targets on the left and 27/30 targets on the right when wearing the 8% VLT glasses, compared to 0 and 14 (respectively), without. This improvement was not evident with any of the other HSG. Subject #10 also improved when wearing the 8% VLT HSG. Without the HSG (first trial) she located 22/30 objects on the left and 26/30 on the right. She was able to locate 29/30 targets on the left and 29/30 targets on the right when she wore the HSG.

In the 28% VLT HSG condition, only subject #9 was able to locate more left side targets than during the both clear lens conditions. He located 7/30 targets when wearing the HSG and 0/30 targets when wearing the clear lenses. Subject #10 maintained a score of 29/30 targets on the left.

Table 6

Comparison of Subjects' Performance on Shape Cancellation Across the Five Conditions

Subject	<u>Clear lenses (1)^a</u>		<u>HSG 8% VLT</u>		<u>HSG 28% VLT</u>		<u>HSG Tape</u>		<u>Clear lenses(5)</u>	
	targets located		targets located		targets located		targets located		targets located	
	<u>L</u>	<u>R</u>	<u>L</u>	<u>R</u>	<u>L</u>	<u>R</u>	<u>L</u>	<u>R</u>	<u>L</u>	<u>R</u>
1	N/A ^b									
2	0	15	0	21	0	18	0	13	0	16
3	N/A ^b									
4	0	15	0	8	0	10	refused		0	16
5	9	27	3	26	7	27	14	24	12	29
6	0	27	0	15	0	22	0	17	0	20
7	0	6	0	11	0	11	6	0	0	8
8	0	14	4	27	0	8	0	16	0	14
9	0	30	0	28	7	30	4	28	0	29
10	22	26	29	29	29	29	27	27	30	28
11	6	14	1	18	5	22	0	19	4	20
12	27	26	28	28	26	29	12	26	28	30
13	27	29	28	28	26	29	25	28	28	28

Note. R and L refer to the right and left sides of the cancellation sheet. There are 30 targets on each side. ^aThe clear lens condition was always the first and last trial. ^bSubject crossed out all figures on extreme right: was unable to perform task

Only subjects #7, and #9 demonstrated a significant change in performance when wearing the taped HSG. Subject #7 was unable to locate any targets to the left of center when wearing the clear lens, 8% or 28 percent VLT HSG. When wearing the tape HSG she began the test at the center of the page and worked leftward. In the other conditions, she started at the right of the page. She scored 7/30 with the tape HSG and did not maintain this ability when tested in the final clear condition. Subject #9 found 4/30 targets on the left with the taped glasses and 0/30 in the final clear condition.

Subject #4 refused (or was unable), to perform the task. After donning the taped glasses she stated that she could not "see anything." Again, this response is highly suggestive of a visual field cut. When the performance with the 8% VLT glasses is compared to the clear lenses, it appears that most subjects' ability to find left sided targets did not change significantly (by only one or two targets). The performance of subject #5 and #11 actually worsened.

In review, although most subjects were not able to find more targets on the left when wearing HSG, three subjects demonstrated significant improvements. Subject # 7 improved her ability to find objects on the left from 0% to 23% of possible targets when wearing the taped HSG. Unfortunately, she was unable to locate any items on the right side of the page in the time provided. This subject worked extremely slowly and time would have limited the total number of targets that she found on both sides of the page. This however, does not lessen importance of the dramatic change in scanning style that she demonstrated when wearing the taped lenses. Subject #8 improved from finding 0% of the left and 47% of the right targets, to finding 13% of the left and 90% of the right side targets while wearing the 8% VLT HSG. This benefit was not produced by any of the other HSG. Subject #9 located 0% of the left sided targets when wearing the clear frames, but located 23% of the targets with the 28% VLT HSG and 13% of the targets with the taped lenses. Although subject #10 improved from 22/30 on the first trial to 29/30 with

the 8% VLT HSG, he continued to score high on subsequent trials. It is unclear whether subject #10's improved performance after wearing the eight percent VLT HSG, was due to the glasses and maintained afterward, or simply the effect of learning.

No one type of HSG consistently resulted in an improvement for the subjects that did improve. As discussed earlier the greatest improvement in line bisection occurred for subject #2 wearing the eight percent VLT HSG, and subject #7 wearing the 28% VLT HSG. Subject #2 did not show any benefit from any of the HSG during the shape cancellation task. Subject #7 did not improve on shape cancellation with the 28% VLT HSG, but she did improve significantly with the taped glasses. Her line bisection scores with the taped glasses were more accurate than the first trial with the clear lenses, but not the final trial. The most dramatic improvement during shape cancellation was experienced by subject #9 wearing the 28% VLT HSG, and subject #7 wearing the taped HSG. However subject #9 did not show a corresponding improvement with any of the HSG during the line bisection task. Alternatively, subject #7 demonstrated improvements during both shape cancellation and line bisection, albeit with different HSG for each task. It could also be reasonably argued that subject #8's increased ability to find targets on the left and right side with 8% VLT HSG was a significant improvement. Subject #8 did show an improvement in line bisection with taped HSG from a 90% average deviation to an 85% deviation.

In all, the effectiveness of the glasses varied not only according to subject, but also according to task. Subject #7 was invited to participate in study #2 based on her response to the HSG. The test sheets were shown to a group of therapists as per the protocol outlined in Chapter #3. Although subject #8 and subject #9 demonstrated equally strong benefits from wearing at least one of the HSG on one of the tests, the researcher only had the means to place one subject in Study #2. Subject #7 was assessed before the others, and therefore invited first.

Study Two

Study Two employed a multiple baseline design across three behaviors with and embedded reversal across all three behaviors to explore the immediate effects of the HSG on ADL. A second objective of Study Two was to analyze possible carryover effects from wearing the HSG for an extended time each day. This was accomplished by including a final phase at the end of the study where the glasses were not worn for any of the measures. The basic design of the study and the timing of each phase change was illustrated in Figure 2.

Visual analysis was used to determine if behavioral changes of clinical significance occurred in response to manipulation of the independent variable. Semi-statistical techniques were applied to augment visual analysis.

Inter-rater Reliability

Inter-rater reliability was calculated for each repeated ADL measure during each phase of the study. The second observer was not blind to the study. The total proportion of reliability checks was 16%.

Agreement on shelf scanning was defined as each assessor reporting the same total number of objects found on the right and left sides of the shelf. Agreement was 100%. In addition, on three of the reliability checks, the assessment forms were reviewed for agreement at each of the 24 locations. Agreement was defined as both assessors reporting that the object was either found or not found at each of the locations. The assessment sheets from three of the days (days 9, 23, and 39) were analyzed (see appendix E, table E3). At each location, the data for days 9, 23, and 39 were in, respectively, 92%, 100 %, and 100% agreement. The average by location agreement is 97%.

Inter-rater reliability for the mobility test was evaluated by reviewing the score sheets of both the investigator and the independent therapist. The total number of direct hits and sideswipes on each side recorded by each of the assessors was analyzed (see appendix F, table F3). Agreement was defined as both therapists reporting the same number of direct hits and sideswipes for a given day. There was 100% agreement on 57% of the days. On 2/3 days that the therapists' scores differed, they did so by only one direct hit or sideswipe. Overall percent agreement for the combined number of contacts (direct hits and sideswipes) across the seven sessions ranged from 71% to 100%, yielding an average agreement of 88.1%.

Inter-rater reliability for room look about was evaluated by reviewing the score sheets of both the investigator and independent recorder congruence. Agreement occurred when both assessors recorded the same number of objects left of center (data in appendix G, table G4).

Inter-rater reliability for both small cancellation and large cancellation was evaluated by having a second rater re-score the cancellation sheets on day 4 and day 9. Agreement occurred when each target located by the subject was identified as located by each therapist. There was 100% agreement on the scores of the independent therapist and the investigator. Due to the objective nature of the scoring of this measure and its high reliability, no further inter-rater reliability measures were performed in the subsequent weeks.

Results

The experimental design in Study Two was a multiple baseline design across three behaviors with two embedded withdrawals in the first behavior (shelf scanning), one embedded withdrawal in each of the other two behaviors (mobility and room look about), and two concurrent non-treated measures (shape cancellation and enlarged shape cancellation). Due to the complexity of the design, the effects of the lagged introduction of the independent variable

within the multiple baseline design are analyzed first (see figure 3). This is followed by a section that analyzes the effects of the withdrawal of the independent variable separately for each behavior.

Multiple Baseline Analysis

Figure 3 illustrates the effects of wearing the HSG on the ADL tasks that were performed daily throughout Study Two, as well as the subject's performance on the two concurrent measures of shape cancellation. The effect of wearing the HSG while performing the ADL tasks was evaluated by the lagged application of the glasses (shelf scanning on day 7, mobility on day 11, and room look about on day 17). The subject never wore the HSG while performing the concurrent measures.

The subject's mean performance on shelf scanning, mobility, and room look about improved after the introduction of the HSG in the first treatment phase. However, close examination of the baseline data for each behavior indicates that, except for room look about, the change was not significant. The data during the baseline phase for both the mobility task and shelf scanning were highly variable. More importantly, the baseline data for both mobility and shelf scanning, demonstrated a trend in performance toward the desired direction. This trend towards improvement could account for the scores seen after the HSG were applied. Only the room look about task had a stable flat baseline with a significant change in level once the treatment was applied, therefore only room look about demonstrated a possible effect related to the treatment. The effects demonstrated in room look about were not replicated across either of the other two behaviors.

Figure 3 also illustrates the subject's scores on the concurrent measures. The subject never wore the HSG for the shape cancellation and enlarged shape cancellation tasks. These concurrent

measures were used to reveal the subject's natural recovery over time and indicate possible generalization or carryover effects during the extended wear phase. The data from both shape cancellation and enlarged shape cancellation over the time during which the HSG was introduced to each of the dependent measures is highly variable and also shows a trend in the desired direction. This suggests that the subject's performance on the task was improving over time without any exposure to the HSG. A more complete review of the results of the two concurrent measures is provided in an upcoming section.

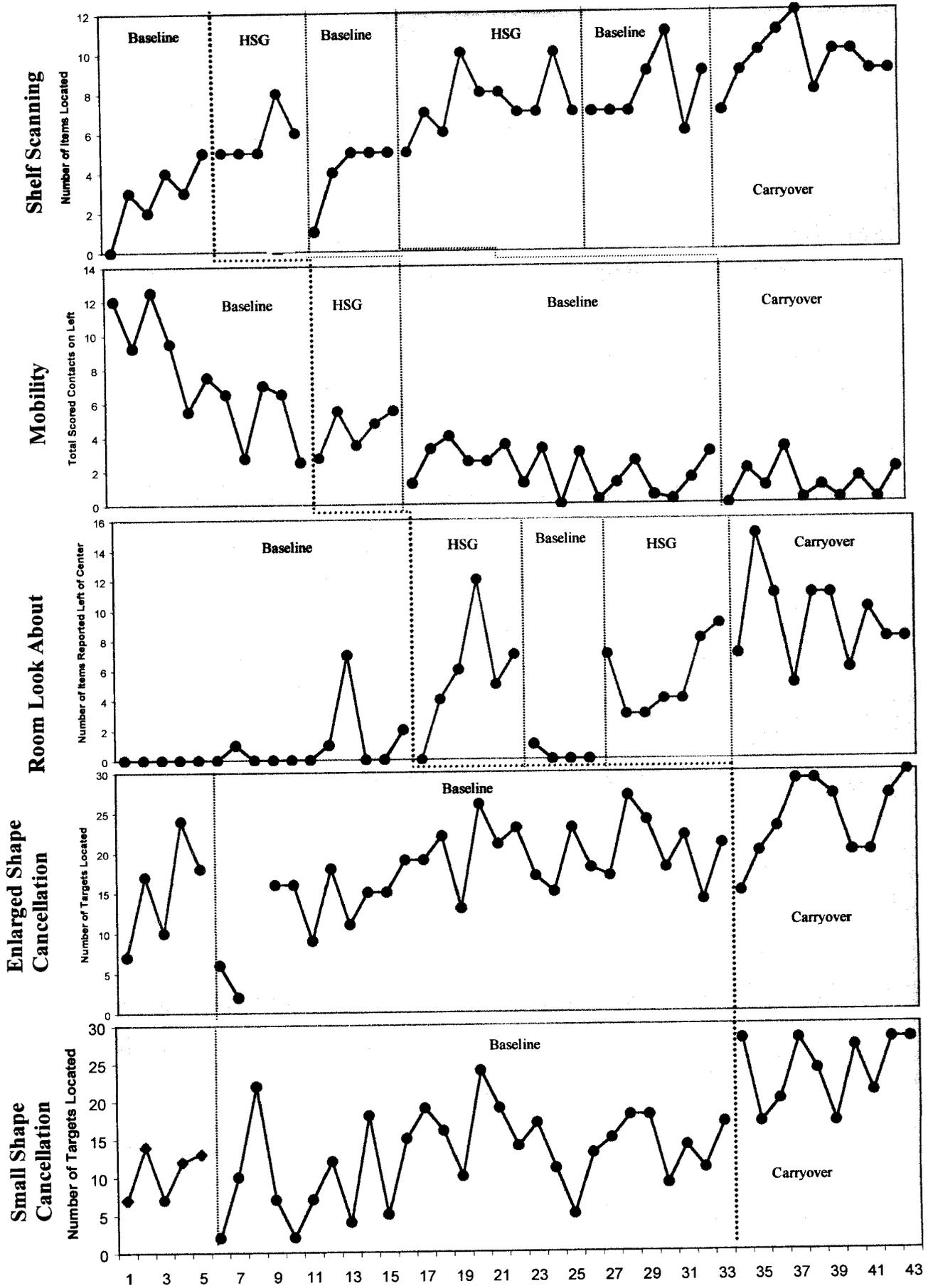


Figure 3. Multiple Baseline Design: Results of lagged introduction of HSG across behaviors.

Analysis of Withdrawals Across Each Behavior

Shelf scanning.

The effects of HSG on shelf scanning were evaluated using an initial baseline phase followed by two treatment phases, two withdrawal phases, and a final carryover phase (A1-B1-A2-B2-A3-C). Figure 4 illustrates the subject's performance on the shelf scanning activity over the course of the 43 days.

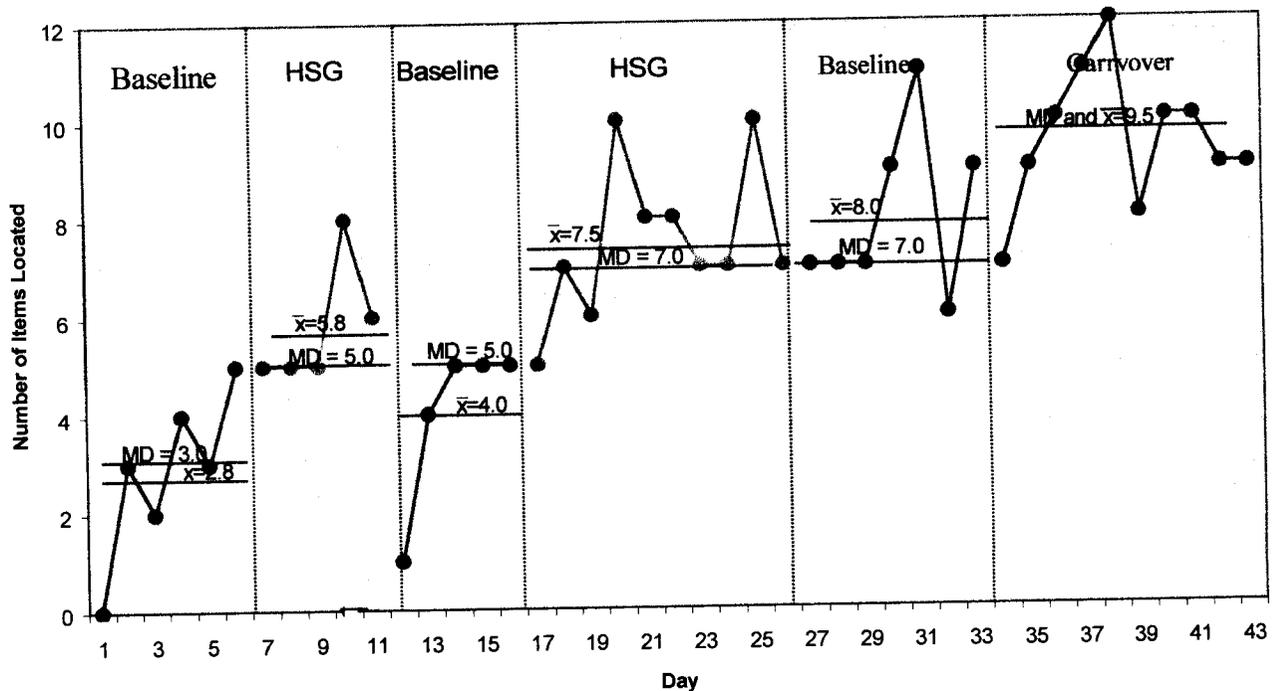


Figure 4. Shelf Scanning Task. The number of objects located on left of the shelf each day is represented. Mean and median scores have been calculated for each phase. MD = Median and \bar{x} = Mean.

The mean and median score was calculated for each phase to illustrate changes in level (see appendix E, table E1 & E2 for raw data and calculations). The subject's mean and median scores rose above baseline levels each time she entered a treatment phase. The first withdrawal of treatment (A2) resulted in a dramatic decrease in performance (level change), suggesting a

relationship between her improved scores and the HSG, however her performance rose rapidly during the second baseline phase. During the last three days of that phase her performance achieved the mean level seen in the previous HSG phase. For this reason, a second treatment phase and withdrawal phase was introduced. Although the subject's scores once again rose when treatment was implemented, her ability to find objects on the left was not diminished when the HSG were removed. The subject attained her highest scores during the carryover phase.

Although the mean and median scores appear to vary as a function of phase it is important recognize that the data in the first baseline phase are not stable. The subject's performance was improving over time. Trend lines (see figure 5) were employed to determine if the differences between the phases were a continuation of an overall trend or a response to the independent variable. The split middle method was chosen because the data set is relatively small (<10) and median slope lines are less affected by extremes than mean slope lines.

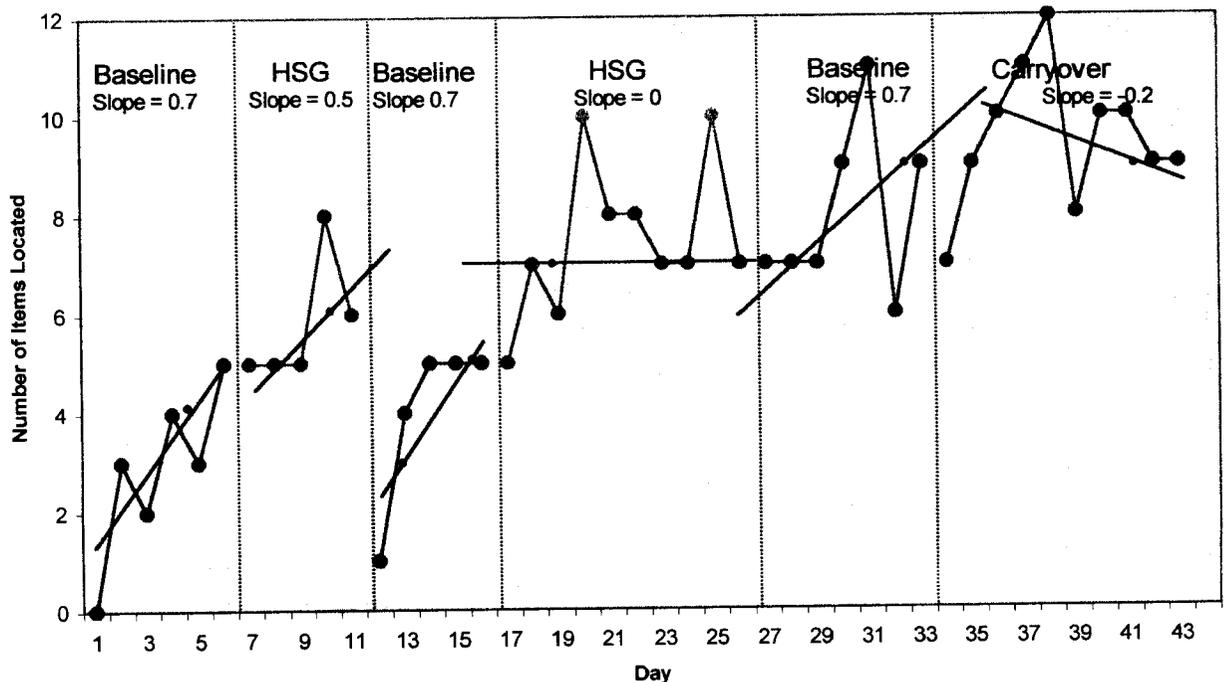


Figure 5. Shelf Scanning Task. Trend lines have been applied to each phase.

The subject's ability to locate items on the left was improving when the first treatment phase was implemented (slope⁷ = 0.7). She continued to improve at a similar rate with the HSG. Although her scores dropped during the initial days of the first withdrawal of treatment (A2), they also show an upward trend. The second treatment phase (B2) resulted in a set of scores that show no upward trend: The line is stationary. When the treatment is withdrawn (A3), her scores again rise. Although the carryover phase produced the highest average scores, this is due to an initial acceleration. When all of the scores of the final phase are considered, the subject's performance is actually deteriorating over time. Overall, the trend lines indicate that the intervention had no beneficial affect on the subject's ability to find items on her left, and her improvement is likely related to factors other than the HSG. The drop at the end of each treatment phase, and the reversal of slope observed during the carryover phase, may suggest an adverse effect from the HSG

Mobility.

The subject's response to the HSG was assessed over a baseline phase, followed by a treatment phase, a withdrawal of treatment phase, and a final carryover phase (A1-B-A2-C). Her performance was analyzed according to the number of contacts she made with obstacles to her left. Contacts with objects to her right were not included as they were extremely rare (see appendix F, table F1 & F2 for raw data).

Figure 6 displays the subject's overall performance along with her mean and median scores for each phase.

⁷ The slope for each trend line represents the rate at which points along the y-axis vary with points along the x-axis (rise over run). The value was obtained by subtracting the coordinates of any two points on the line (Freeman, Pisani, & Purves, 1978).

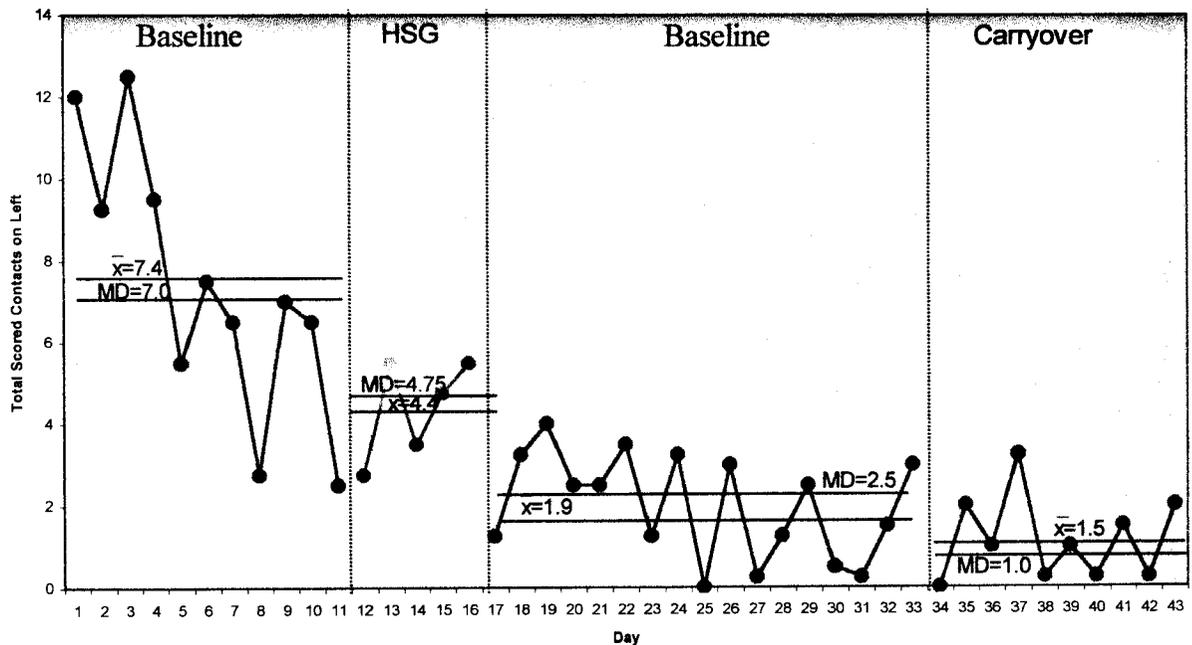


Figure 6. The Mobility Task. Scores represent the total number of contacts made by the subject with objects on the left of the obstacle course. A direct hit receives a score of 1, a sideswipe a score of .25, and a repositioning a score of 1. Mean and median scores are shown for each phase. MD = Median and \bar{x} = Mean. With each phase change there is a subsequent drop in level. The scores in the first baseline are unstable and indicate a decelerating trend.

Figure 7 represents the same data with trend lines drawn. The split middle method using median values was used. The initial baseline phase shows a strong downward trend in her scores indicating that she was improving, or decreasing the number of contacts she made on the course. During the treatment phase the slope actually reversed, suggesting that the glasses were hindering her ability. It was apparent during the test sessions that the glasses were not helpful, and therefore, a second treatment phase was not introduced. Once the treatment was stopped and the subject resumed the baseline phase, the downward trend in scores resumed. In the carryover phase the trend line is stationary. This is not unexpected. Her median number of contacts was one, and it may take some time for her to consistently produce an errorless performance.

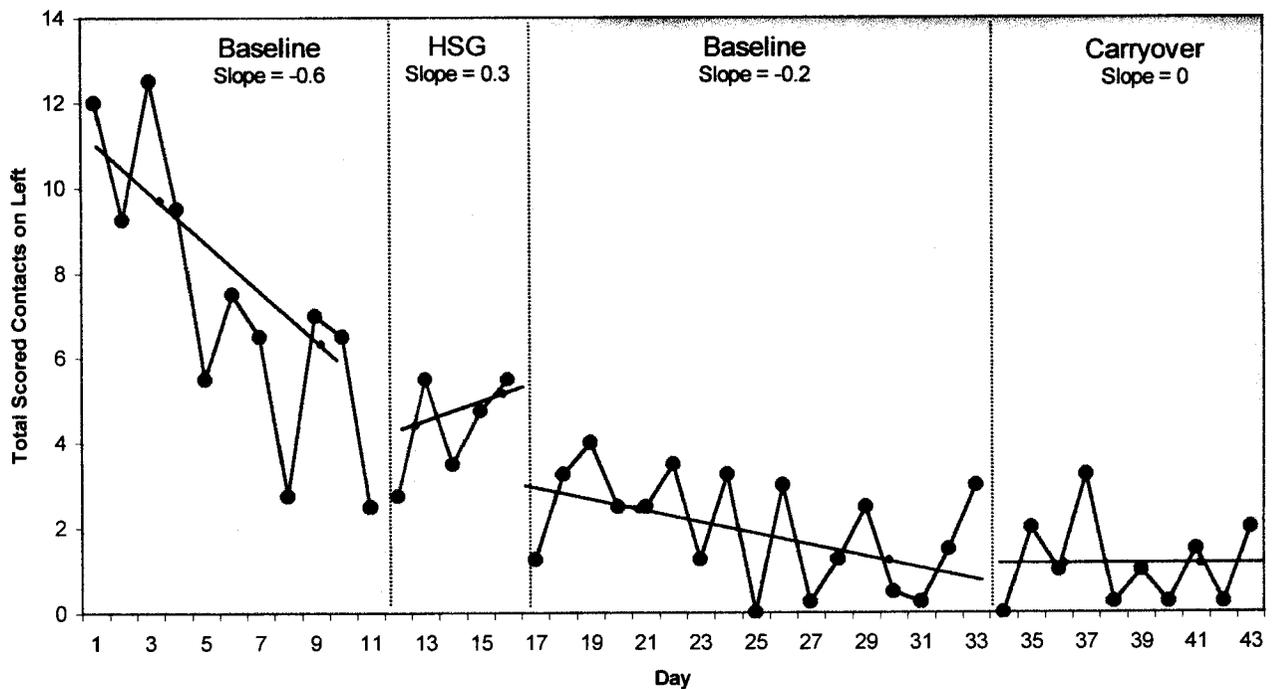


Figure 7. The Mobility Task. Scores represent the total number of contacts made by the subject. Trend lines for each phase are illustrated.

Room look about.

The investigator noticed that the subject almost always sat with her head turned to her right and her attention directed exclusively toward activities on her right. This behavior is common for persons with neglect. The object of the room look about task was to capture the frequency, duration and degree to which she would look to the left when “looking about” a large area. The number of objects she could identify, and their location in the room, was recorded during this one minute test (see appendix G, table G1 for sample score sheet). The results were analyzed for changes in mean, median and trend to determine the effect of the independent variable.

The effects of the HSG on room look about were investigated using a baseline phase, a treatment phase, a withdrawal phase, a second treatment phase, and a carryover phase (A1-B1-A2-B2-C). Figure 8 illustrates the subject’s performance on room look about across the study.

The mean and median scores for each phase are also plotted.

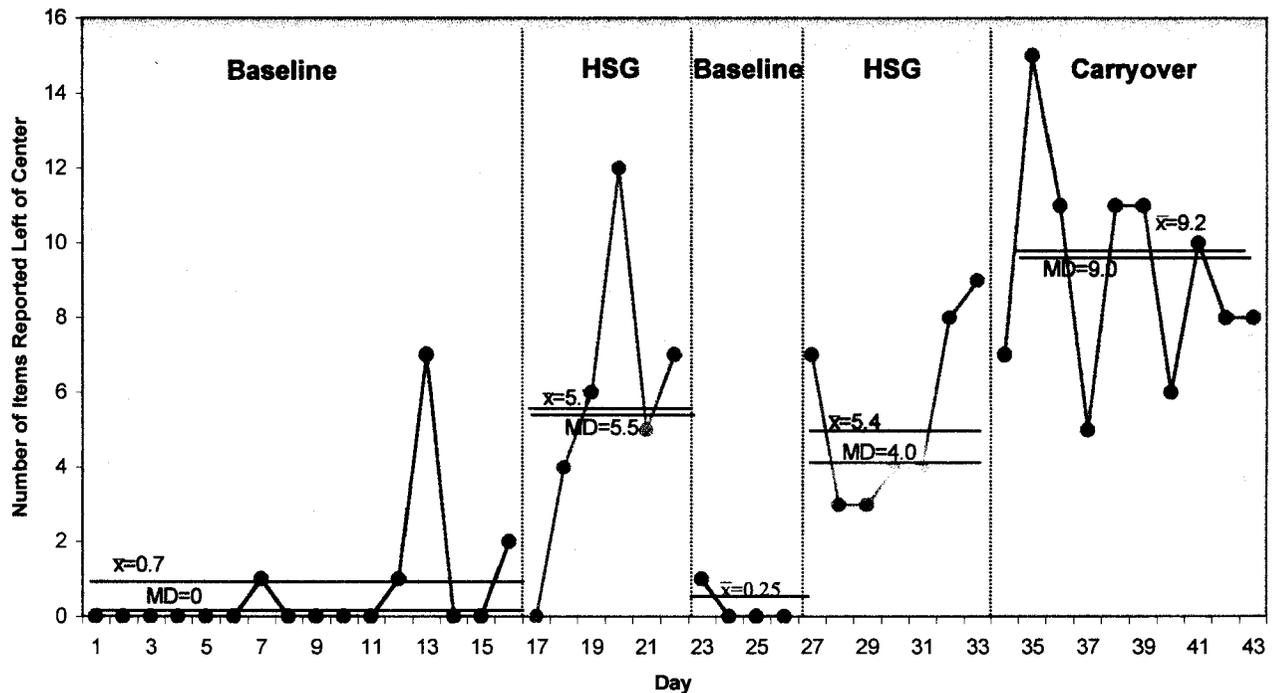


Figure 8. Room Look About Task. The number of items left of center reported by the subject are illustrated. The mean and median score for each phase is calculated. MD = Median and \bar{x} = Mean.

Figure 9 depicts the same data with trend lines indicated to capture any changes that were taking place over time. Because most of the phases have a relatively low number of data points, and there is at least one outlying (aberrant) point, trend lines were computed using median scores and the split middle method. The baseline phase was lengthy and the data stable with the exception of one outlier point. The trend line was flat, indicating no overall change was occurring in her performance. During this phase, the subject looked past center on only 25% of the days. The mean number of objects that she observed on the left side of the room was very low and the median was zero. On day 13, she performed extremely well, seeing objects on both sides of the room. Although that day's performance was unusual, it is indicative of her potential: She has an inattention to the left but no visual problems. The following day, her performance dropped to her previous level: She saw no objects on her left.

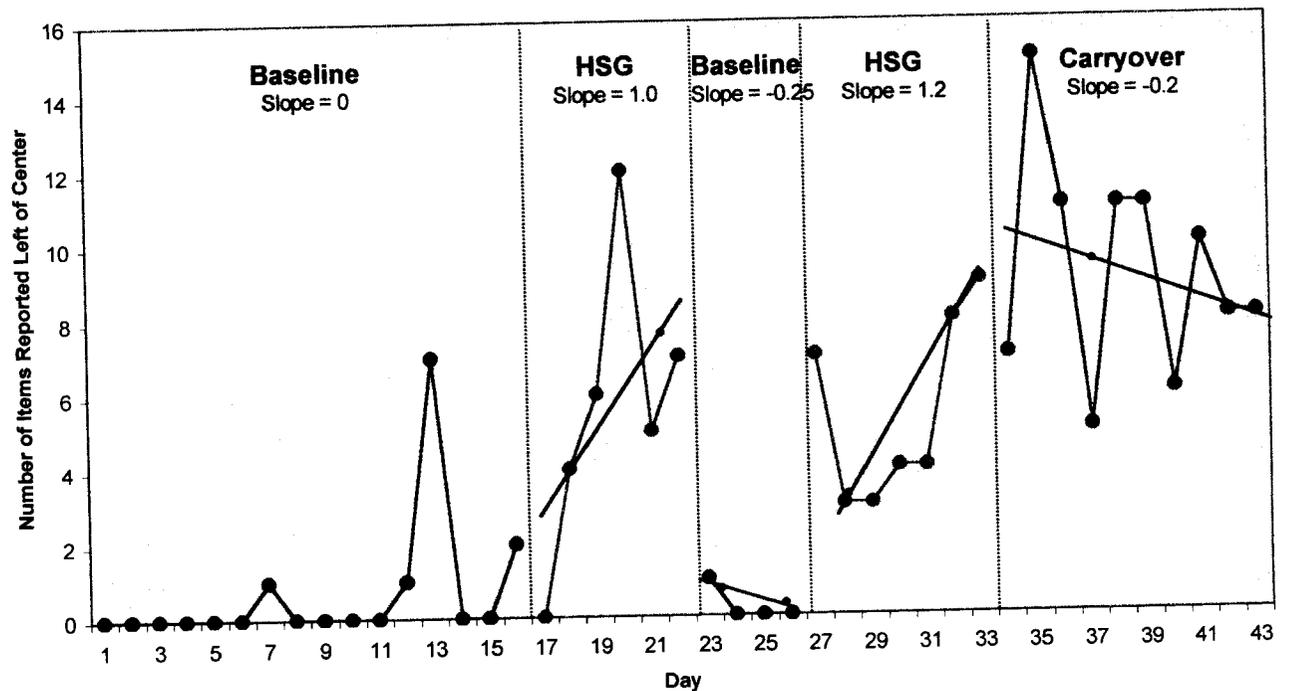


Figure 9. Room Look About Task. Trend lines drawn for each phase.

After the first day in the treatment phase, the subject's performance changed dramatically. There was a significant increase in both the number of days that she noticed objects to her left (83%) and the total number of objects that she saw (mean = 5.5). This resulted in a substantial change in level for the first treatment phase. The trend line indicated that she would continue to improve. The change in level, variability, and trend of data during this first treatment phase suggested that the subject was improving due to the HSG. Withdrawal of the HSG was required to verify the effect. If there was an association between the subject's improved performance and the HSG, removing the glasses should cause her scores to decline.

On day 23, the subject entered the second baseline phase (A2). Her scores immediately dropped to previous baseline levels. On the last three days of the phase the subject did not identify one object left of center. Since the subject's response to the withdrawal of the treatment

was so dramatic, the second baseline phase lasted only four days. For both research and ethical reasons treatment was reinitiated on day 27. Replication of the beneficial effect was required to rule out the possibility that the improvement was due to coincidence and the result of some other intervening variable. Further, it would have been unethical to withhold a potentially beneficial treatment.

The second treatment phase resulted in an immediate improvement in the subject's scores. Her mean score for the phase rose back to 5.4. Figure 8 and 9 depict the corresponding change in level and trend. These results are highly suggestive of a causal relationship between the subject's abilities on the task and the HSG.

The question that remained was whether it was necessary for the subject to constantly wear the HSG during the task to get the benefits. Would prolonged wearing of the HSG cause her to retain her improvement at room look about, even if she did not wear the glasses for the assessment? Figure 8 indicates a substantial increase in level between the last treatment phase and the carryover phase. The number of objects the subject located to her left had continued to increase to a mean of 9.2 despite the fact that she did not wear the HSG for the task.

Although figure 9 indicates a downward trend in her scores during the carryover phase, a continual increase in number is not the goal of the task. Ideally, the subject would distribute her attention equally across the room in front of her (Karnath, Niemeier, & Dichgans, 1998). She would report approximately equal numbers of items on the left and right, and those items would be represent her entire visual field.

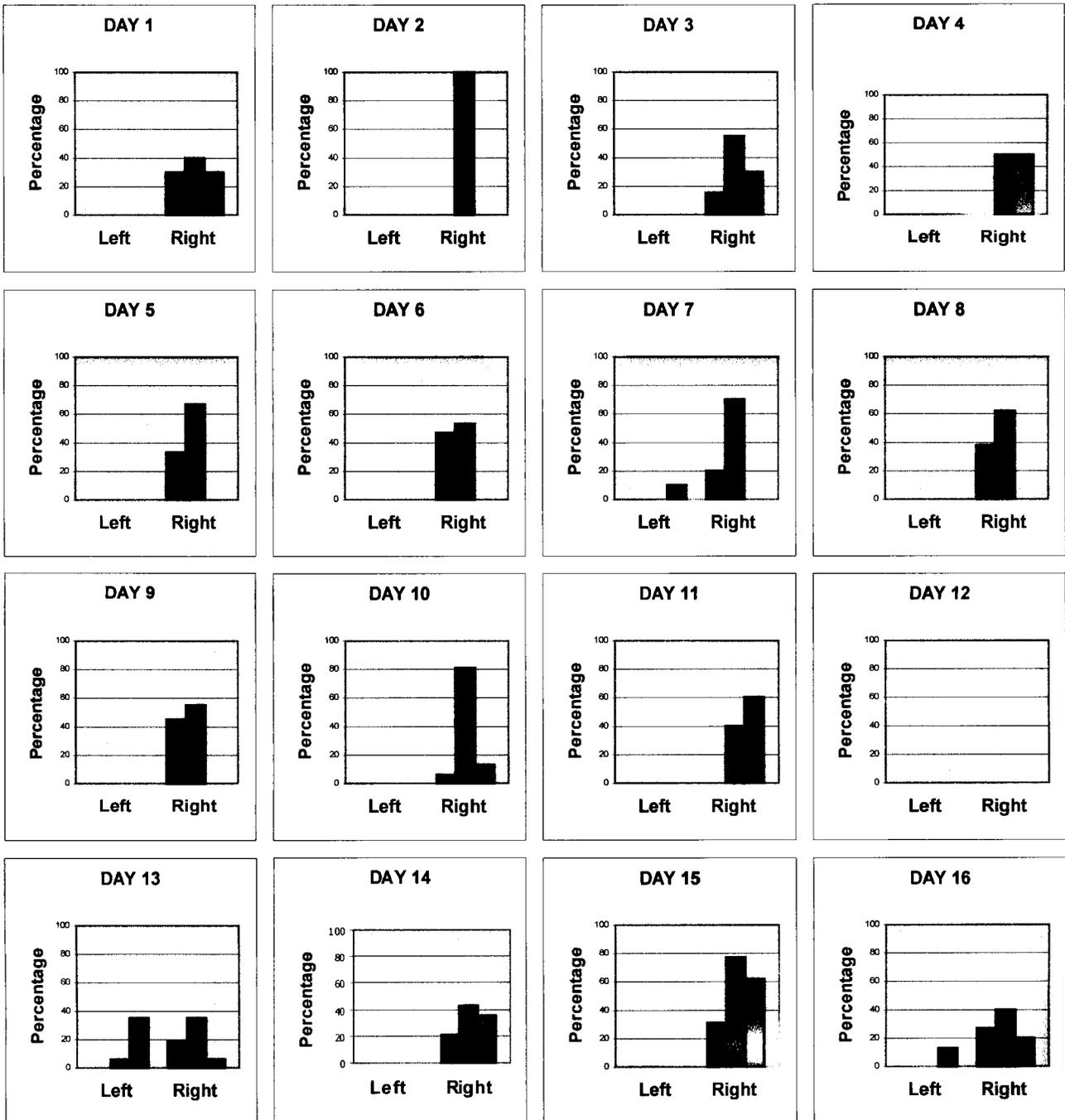
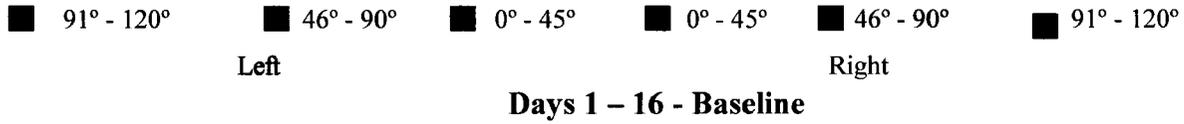
Figure 10 uses bar graphs to provide a visual representation of the location of the items reported by the subject. Each graph provides a daily account of location of the items (relative to the subject) reported that day, and what percentage of the total number of items reported by the subject for that day were in any given location. The locations of the objects were divided into the

following groups: 0-45 degrees, 46-90 degrees, and 91 to 120 degrees (to the right or left of the subject). The number of objects found in any of the six locations is represented as a proportion of the whole (see appendix G, table G2 & G3 for scores). The bar graph is provides a visual analogue of the approximate amount of attention the subject gave to each location. Given the task instructions and setup, a person without neglect should report an approximately equal number of objects in each location (with the exception of 91-120 degrees).

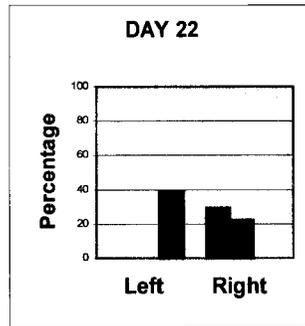
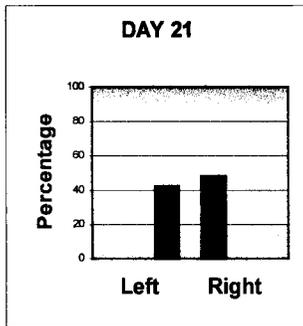
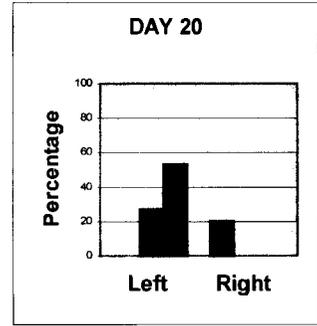
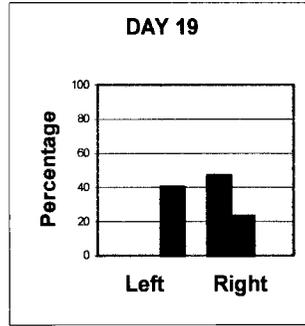
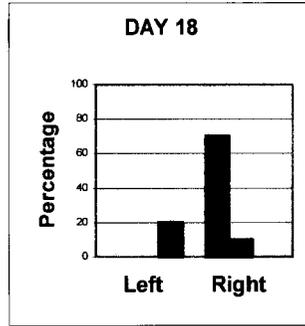
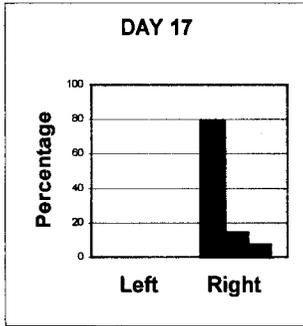
Figure 10, illustrates the relative quality or degree to which the subject scanned the left and right. Days 1 through 16 reveal that the subject not only reported objects only on her right, but that the majority of her attention was focused on the extreme right (>45 degrees from center). During the first treatment phase (days 17-22), there is a notable shift in the relative amount of attention given to each hemispace. The bar graphs for days 23-26 (second baseline phase) suggest her attention was moving progressively more rightward. When the second treatment phase resumed, the subject again identified objects to the left. On two of the seven days, her scanning included the area 46-90 degrees on her left.

Room Look About: Location of Objects Reported Proportion of objects seen across 240°

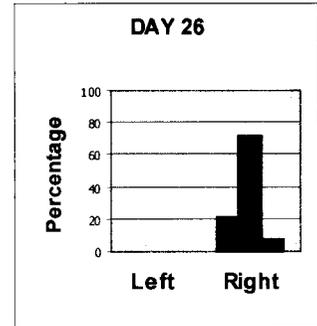
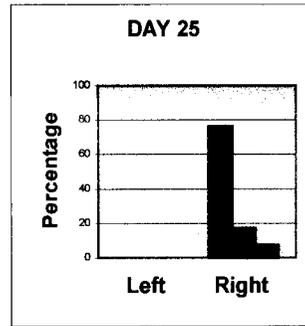
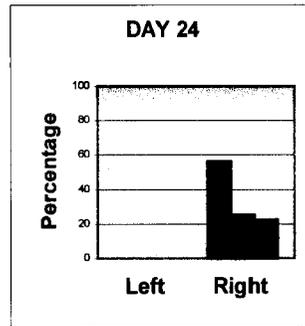
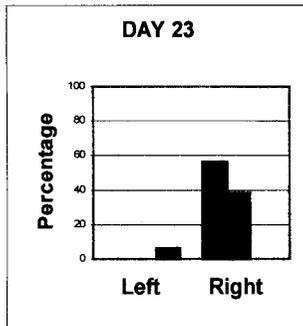
Figure 10. The graph represents the location and proportion of objects seen across 240° of visual field. The visual field is divided into right and left of center, each half field is further divided into 0° - 45°, 46° - 90°, 91° - 120°, from center. The bar graph displays the number of objects reported at a given location as a proportion of the total number of objects reported.



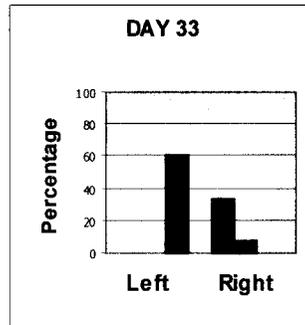
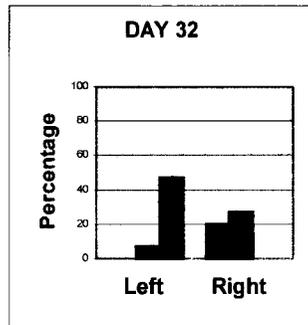
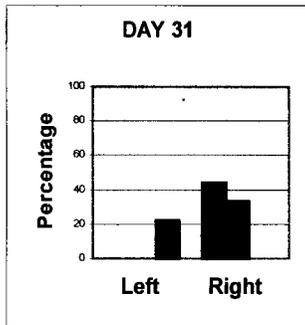
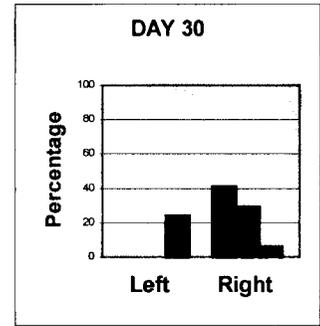
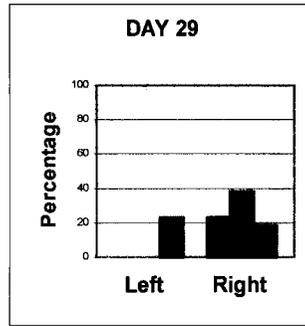
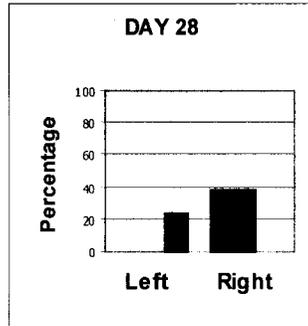
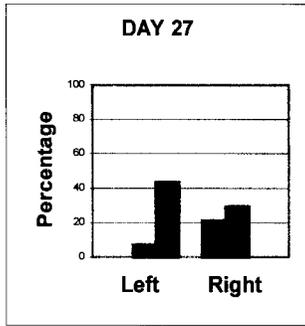
Days 17 – 22 - Treatment



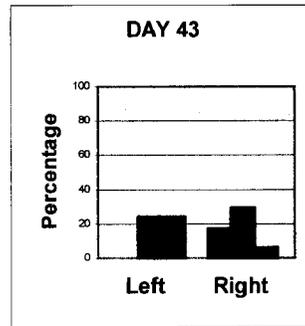
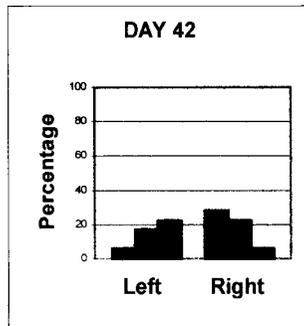
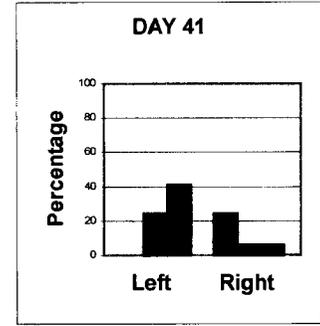
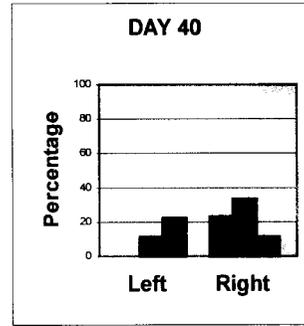
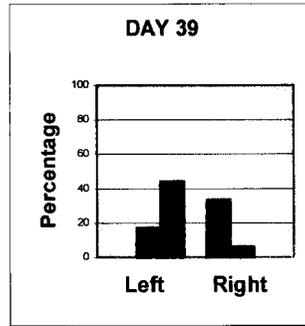
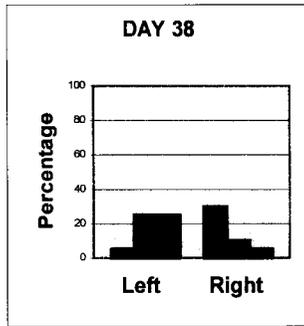
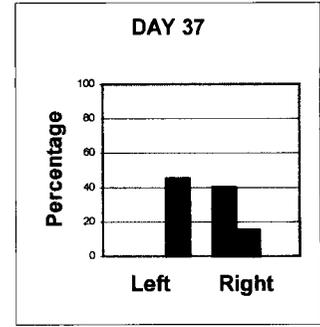
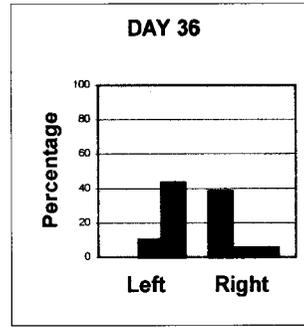
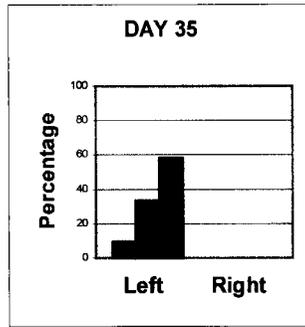
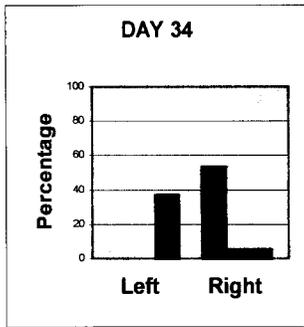
Days 23 – 26 – Baseline



Days 27 – 33 - Treatment



Days 34 – 43 - Generalization



The areas that the subject scanned during the carryover phase are important to review. It was discussed earlier that the overall level of the scores had risen during this phase, but the trend was decelerating. A decrease in the variability of the scores is also evident in the latter half of the carryover phase. The bar graphs provide further information about the subject's responses during that time.

Toward the second half of the phase (see day 39) the subject began reporting approximately equal numbers of items from each of the areas. This suggests that she became progressively more adept at directing her attention equally across the entire visual field. In terms of function and unilateral neglect, the absolute number of items located on the left is not critical. More important, is that the person can direct his or her attention to the appropriate location as needed. The data strongly suggest that the HSG were of benefit to the subject for this task. Improvement was seen during wearing of the HSG and continued through the carryover phase.

Analysis of Concurrent Tasks

Cancellation sheet (small form).

Figure 11 illustrates the two phases for the cancellation task; baseline phase (A1) and carryover phase (C). The baseline phase ran from day six through day 33. Although the subject also performed the task on days one through five, the assessment procedure was modified on day six. This was necessary because the subject spent approximately 10 minutes on each of the cancellation tasks (small and large form). The investigator observed that she identified the majority of the targets within the first few minutes, however continued to search. On day six a five minute time limit was imposed to prevent her from becoming overly fatigued and frustrated. Although figure 11 and 12 show the subject's test scores for days one through five, they were not

used in calculations.

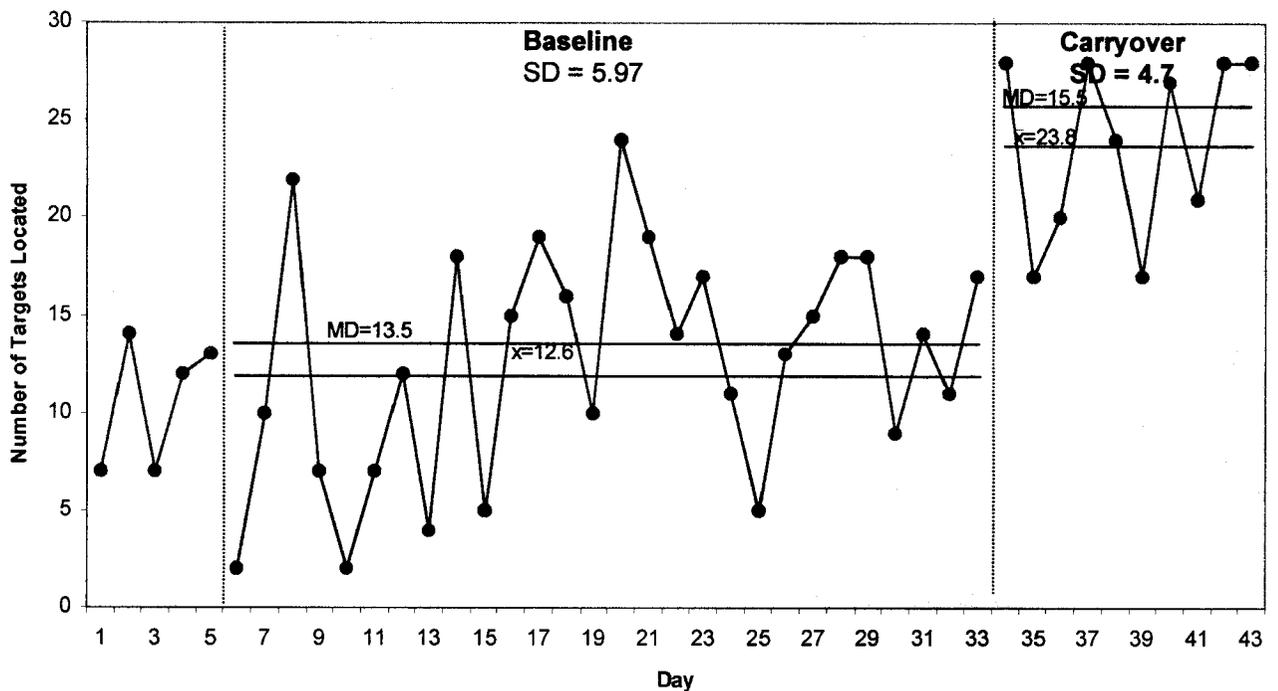


Figure 11. Cancellation Task – small version. Score represents the number of targets located out of a possible 30. Mean and median scores for each phase are calculated. MD = Median and \bar{x} = Mean. Subject's average time for completion greater than 10 minutes on days 1-5 (scores not used in tabulations). Time limit imposed commencing day 6.

The subject performed the cancellation task on each of the 43 days. She never wore the HSG for the task (see figure 3 at the beginning of- results study two-for overall design). This allowed the investigators to record, and account for, the subject's general improvement overtime. It was expected that over the next few weeks, her performance on the test would improve as a result of natural recovery, learning and the other therapies she was receiving. This information could be used for comparison to any changes that occurred in the tasks that involved the HSG. The subject entered a carryover phase for the last 10 days of the study. During that time she did not wear the HSG for any of the measures (including the cancellation tasks), but did wear the HSG for four hours each day. If the cancellation task scores were significantly different during the carryover phase than during the baseline phase, the investigators could assume that the

prolonged wearing of the HSG was having an effect. More importantly, that the effects of the HSG were generalizing to task where the HSG were never used.

Figure 11 displays the total number of targets that the subject was able to identify on the left side of the cancellation sheet (raw data appendix H1). There is a dramatic increase in level between the baseline and carryover phases. The subject's mean score during baseline was 12.6. During the carryover phase, her mean score increased to 23.8.

To determine if the difference in levels could be attributed to her general rate of recovery, a trend line (figure 12) was plotted for the baseline phase and extended into the carryover phase. Because of the substantial number of data points in the baseline phase, means regression lines were used⁷. In addition, a trend line was plotted for the carryover phase scores. The trend lines indicate that the improvement in the subject's performance during the carryover phase could not have been predicted by her baseline scores. Nine of the ten scores in the carryover phase are above the line projected by the baseline trend. The significant change strongly suggests that the prolonged wearing of the HSG during the carryover phase was having an effect on her cancellation task performance.

⁷ Microsoft Excel was used.

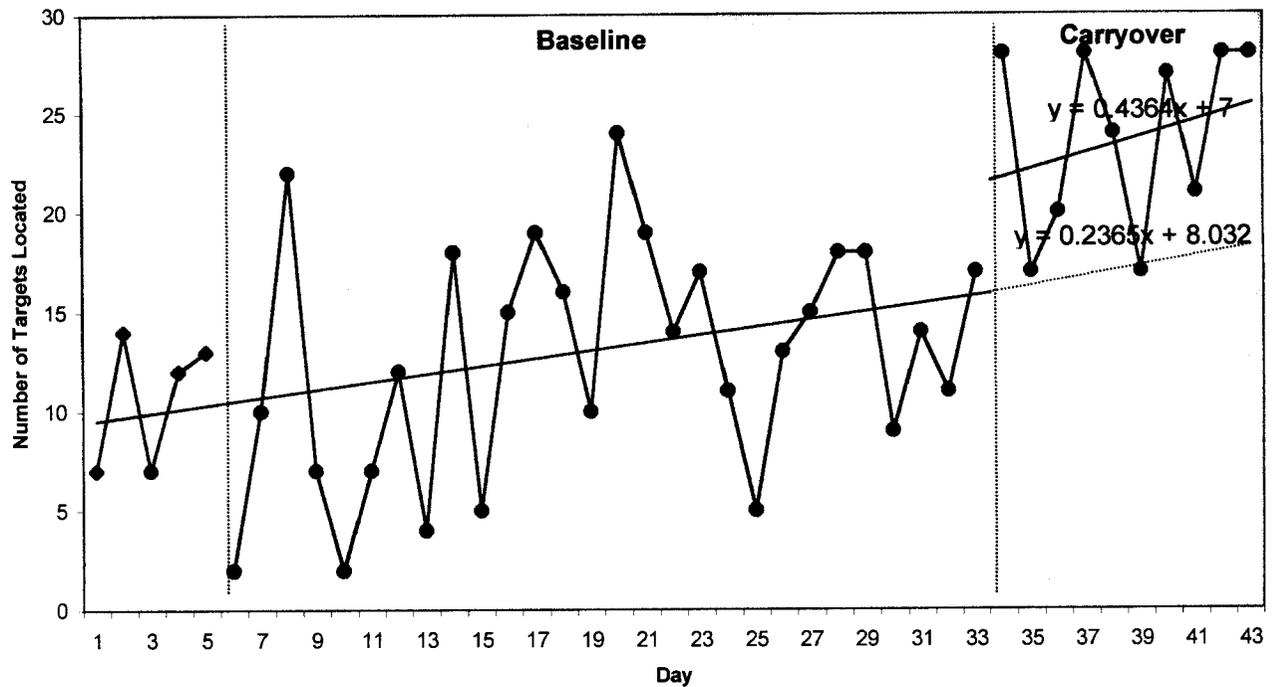


Figure 12. Cancellation Task – small version. Trend lines are applied to each phase.

One interesting observation is the extremely high variability in the subject's scores during both phases. The standard deviation and range for the baseline phase was 6.0 and 2 to 24 respectively. The same calculations were performed on the carryover phase scores providing a standard deviation of 4.7 and a range from 17-28. This cancellation task is commonly recognized in the literature as one of the most sensitive and reliable tools for the assessment of unilateral neglect. Although its reported test-retest reliability is .84 (Kinsella et al., 1995), the above results would suggest otherwise. This finding certainly limits any conclusions that can be made about a person's neglect based on this one measure

Heilman and Watson (1978) reported that some persons with neglect may perform differently on cancellation tasks that use geometric shapes as opposed to letters. For this reason, both forms of the test were given randomly, and the respective results were analyzed. Table 7

compares the subject's performance on each of the forms (see raw data appendix H). Only scores from the baseline phase were analyzed. The difference between the two means was analyzed using a two tailed t-test. The resulting t score was 0.3 (which is not significant at $P > 0.05$) indicating that there is no difference between the two versions⁹.

Table 7

Comparison of Subject's Performance on Two Versions of the Shape Cancellation Test

	<u>Geometric</u>	<u>Letters</u>
Mean	13.1	12.4
Range	2-22	2-24
Standard Deviation	6.8	5.6

Figure 13 graphically displays the subject's scores for each version of the test. Trend lines were calculated¹⁰. There is little difference between the two sets of scores.

Visual and descriptive statistical analyses clearly demonstrate how similarly she performed on each of the versions.

⁹ Microsoft Excel was used to perform the t-Test: Two sample assuming unequal variances.

¹⁰ Microsoft Excel was used to calculate means regression lines.

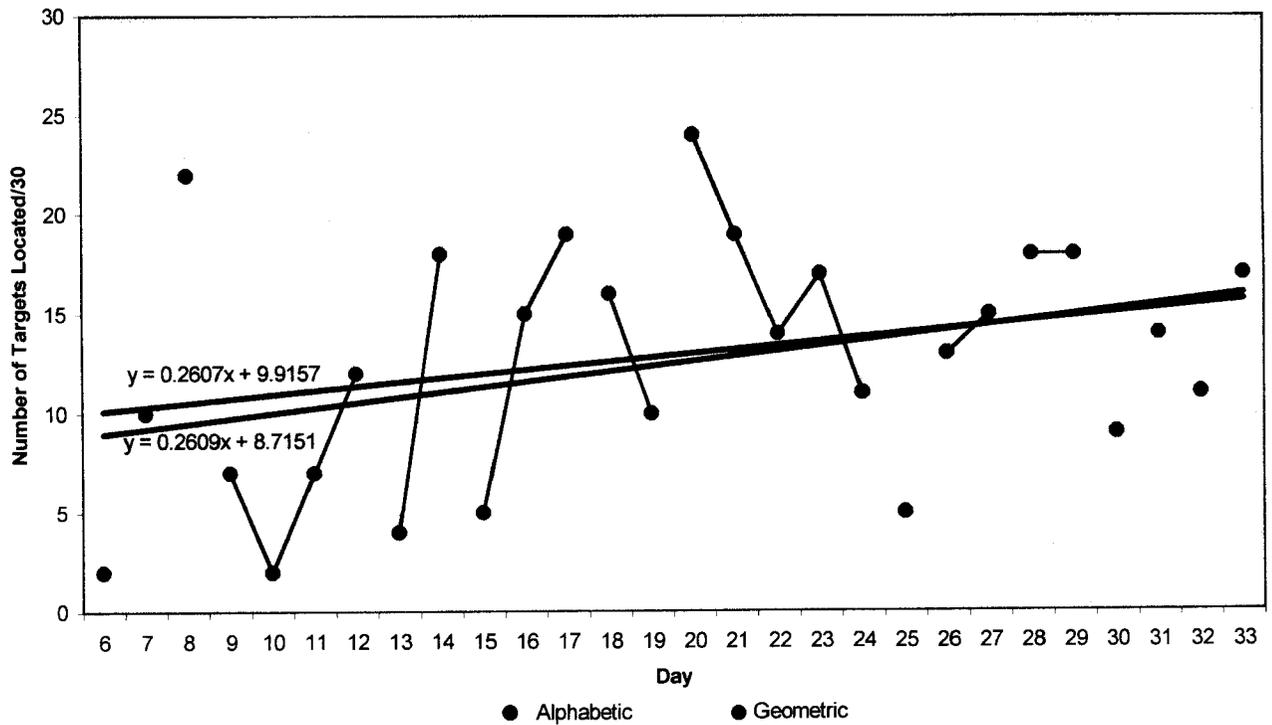


Figure 13. Comparison of Scores on the Alphabetic and Geometric Versions of the Small Cancellation Task.

Cancellation sheet (enlarged form).

The subject's performance on the enlarged form of the cancellation sheet was assessed daily throughout the study. As with the small version, HSG were never worn while performing this assessment. This allowed the test to be used to monitor changes in the subject's performance in general. A five-minute limit was imposed on the cancellation task on day six¹¹. Figures 13 and 14 display the subject's scores for each day of the study. Please note that although scores are listed for days one through five they are not used in the calculations. There is no score for day 8; the investigator forgot to provide the assessment.

¹¹ For the reasons cited during the table top version of the test.

Figure 14 displays the median and mean scores for the two phases (raw scores available in appendix I, table I1). There is a level change between the baseline scores and those achieved during the carryover phase. In fact, on the last day of testing the subject had a perfect score (30/30). The change in level between the two phases suggests a difference between the two sets of scores. There is also a fair degree of variability in the data and the subject's performance during the baseline phase appears to be improving.

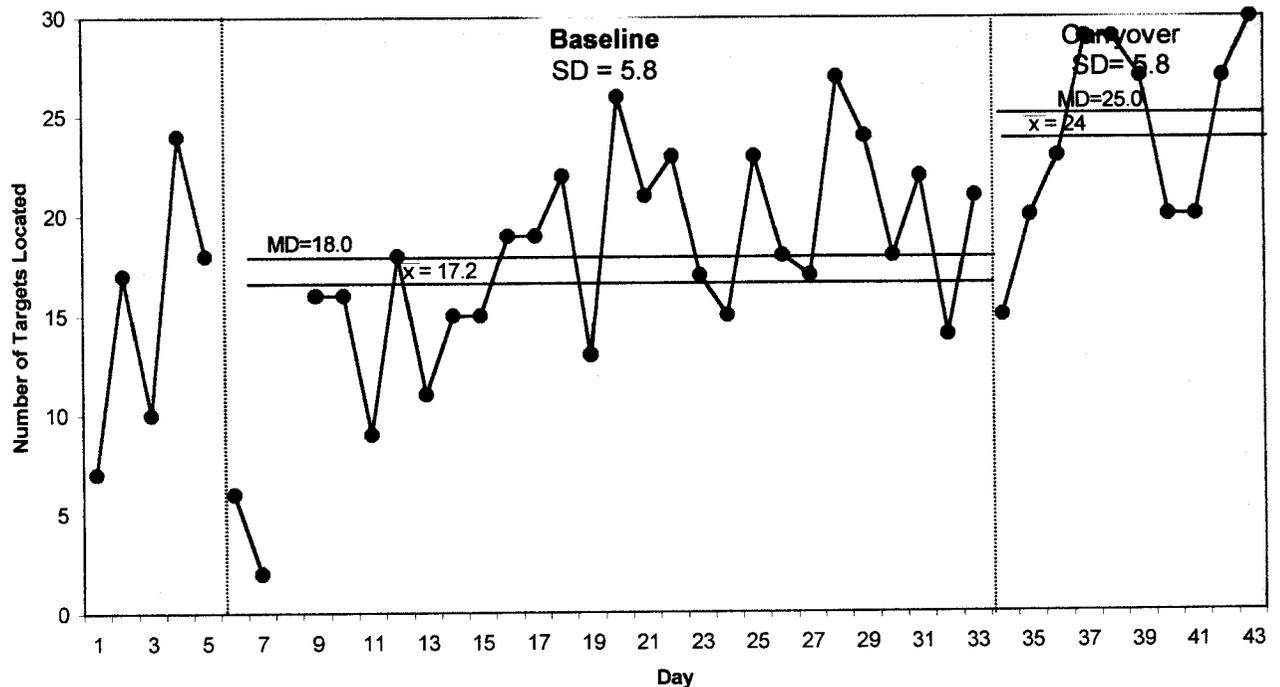


Figure 14. Cancellation Task – Enlarged Form. Comparison of subjects mean and median performance during Baseline and Carryover Phase. Total number of left side targets = 30. MD = Median and \bar{x} = Mean.

A trend line, using means regression, was calculated for the baseline data (see figure 15)¹². The trend line indicates that the scores during the carryover phase could have been predicted based on the rate of improvement seen in baseline. The subject may have achieved the same level of proficiency without the carryover phase. Wearing the HSG for an extended period of time appears to have had no effect or limited effect above and beyond the effects of general recovery.

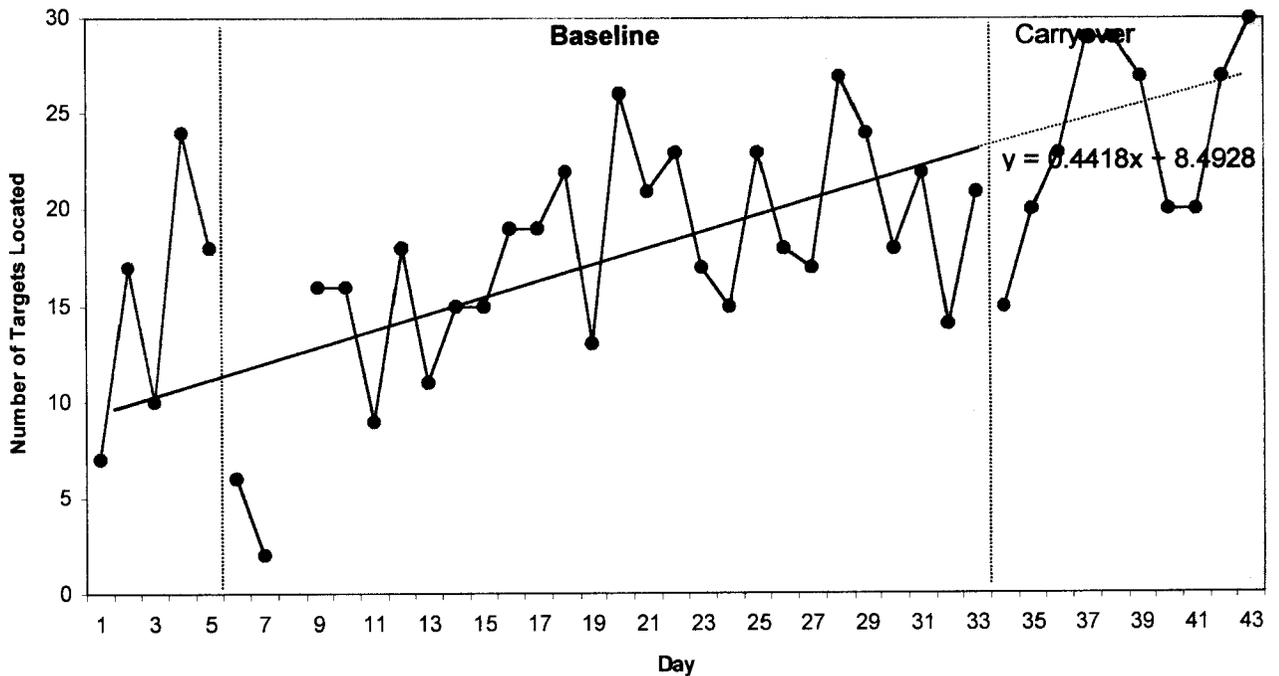


Figure 15. Cancellation Task – enlarged Form. Comparison of subject's performance during Baseline and Carryover Phase using trend lines.

The scores on the alphabet and geometric versions of the enlarged test were compared (see table 8). The subject's mean performance on the geometric version and alphabet versions are 19.2 and 15.3 respectively. A two tailed t-test was performed and yielded a t score of -1.7 ¹³. Although this score is not significant at $P > 0.05$, the t-test also indicated that this degree of

¹² Microsoft excel was used.

difference was likely to occur less than 10% of the time.

Table 8

Comparison of Subject's Performance on Two Versions of the Enlarged Shape Cancellation Test

	<u>Geometric</u>	<u>Letters</u>
Mean	19.2	15.3
Range	2-22	14-26
Standard Deviation	6.8	5.6

Figure 16 permits visual analysis of the two sets of scores. The subject's performance on each of the versions is clearly different. The trend lines¹⁴ illustrate the highly divergent nature of the data. While performance on the geometric version has stayed relatively constant, her ability to detect letters has dramatically improved.

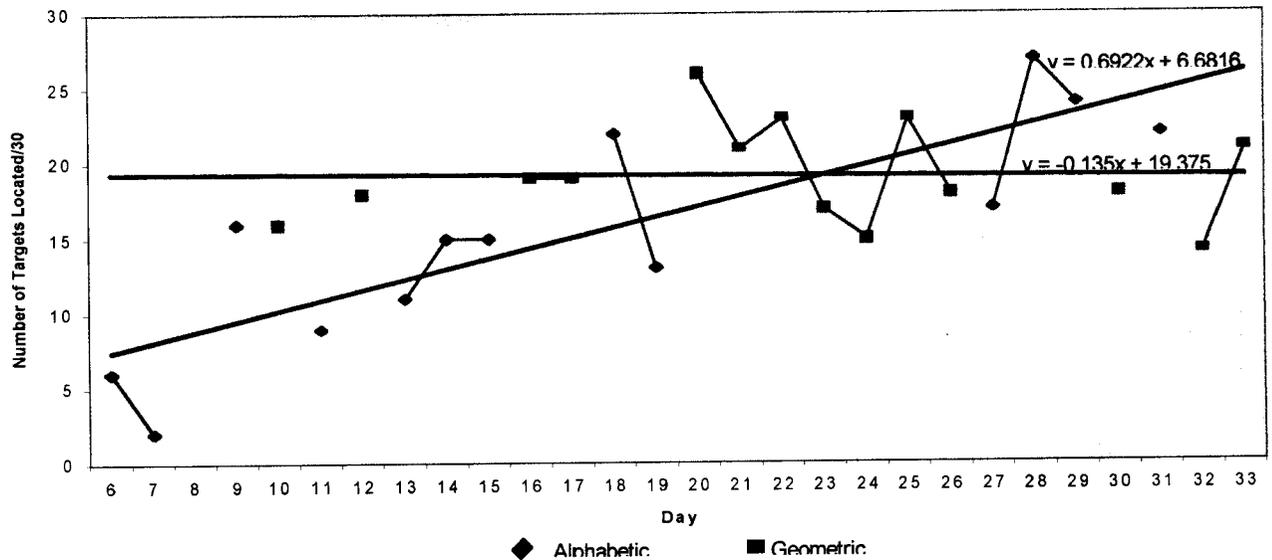


Figure 16. Comparison of Scores on Alphanumeric and Geometric Forms of Enlarged Cancellation Sheet.

¹³ Microsoft excel was used to perform a t-Test: Two sample assuming unequal variances.

¹⁴ Microsoft excel was used to calculate means regression trend lines.

Summary of Repeated Measure Results

This study used a multiple baseline design with an embedded reversal across several behaviors to explore the effects of HSG. If a treatment is highly effective (with widespread effects), each time the treatment is applied to a different behavior, that behavior will change. However, not all treatments affect all behaviors. If a behavior change occurs in one or more of the measured behaviors, a reversal (removal of the treatment), that results in a subsequent change in performance enables the researchers to attribute cause more confidently to the independent variable.

One of the first questions this study investigated was whether wearing the HSG would have any immediate effects on the subject's ability to perform the tasks. Results from the lagged introduction of the HSG and the reversal of treatment for each of those behaviors suggests that the behaviors were not affected equally by the HSG. Wearing the HSG during shelf scanning test or the obstacle course was of no benefit to the subject. In fact, the HSG may have hindered her abilities. In contrast, wearing the HSG for the room look about task seems to have been of great benefit. Based on her performance with and without the glasses, it appears she would not have made the gains she displayed, had she not worn them.

Given that the HSG were beneficial when worn during the room look about task, was wearing the HSG during the activity necessary? This question can be answered by summarizing the results of the carryover phase. During that phase, the subject wore the glasses for four hours each day but not during the tasks. The subject's performance on the room look about task continued to improve, although she no longer wore the glasses for the task. Since there was no immediate benefit from the HSG on shelf scanning or mobility, it seemed unlikely that the prolonged and distant wearing of the HSG would positively affect performance. As expected, the carryover phase had no beneficial effects on shelf scanning or mobility.

The study design also allowed the investigators to explore whether or not wearing the HSG would have effects that would generalize to tasks or behaviors that were never exposed to the glasses. The HSG were never worn for either the large or small version of the cancellation tasks. The results indicate that the prolonged but distant exposure to HSG was associated with the subject's improvement on the small (table top) version of the task. This suggests that some underlying cognitive or perceptual function was improved, and that function is used when performing the small cancellation task. Unlike the small cancellation task, there appeared to be no additional improvement on the enlarged version from wearing the HSG during the carryover phase.

The subject's response to the HSG is mixed. The glasses had both immediate and distant effect suggesting that they do not serve only as a compensatory device. The glasses may actually remediate some underlying component of visual perceptual search. That component may have been shared by both the room look about tasks and the small cancellation task. That component may not be present in the other tasks, or if it did exist, may not have been the component that was causing the greatest difficulty.

The results indicate the glasses directly and immediately benefit some activities and not others. Furthermore, the glasses appear to cause an improvement in a component of visual perceptual search that benefits some tasks and not others. Each of the activities required visual perceptual search. The results indicate that some aspect of this search was different and/or the demands of the task were different, though appearing similar.

Pre and Post Test Results

Behavioral Inattention Test

The BIT (Halligan, Cockburn, & Wilson, 1991) was used as a general pretest/ posttest

measure of improvement. It was administered in the first week of the study and two days after the final repeated measures session. The subject's pretest scores were 126/146 on the conventional tests and 44/63¹⁵ on the behavioral tests. These scores indicate neglect. Her final scores were 144/146 and 78/81 respectively. The cut-off scores for normal visual spatial perception are 130/146 and 68/81. Although her final scores would indicate the absence of UN, that was not the case. The subject continued to have difficulty with ADL as a result of her UN.

Subjective Neglect Questionnaire

The SNQ (Towle & Lincoln, 1991), was provided to both the subject and her husband as pretest and post-test measures. They filled out the forms separately. The questionnaire asks the subject to rate the frequency of 19 potential ADL problems (see appendix B, figure B3 for a copy of the test). A score of 1 (the lowest score) indicates the person experienced difficulty with that task once or less in the last month. A score of five (the highest score 5) represents difficulty with the task once or more in a day.

Table 9 outlines the pretest and posttest scores for the subject and her husband. The subject responded to 11 of the 19 questions during the pretest¹⁶. The subject gave herself an average score of 1.45 on the 11 questions. The only ADL she reported having regular difficulty with were reading and crosswords. Her husband scored her abilities quite differently. He provided responses for 12 of the questions and his average score was 3.8. This score indicates difficulties with those ADL once or greater each week. While the subject had reported rarely having difficulty seeing a person on one side of the room (score 1), her husband reported that this occurred at least once or more a day (score 5).

On the post-test, the scores had changed. The subject responded to each of the 19

¹⁵ The behavioral portion was scored out of 63. Two of the sub-tests were not available.

¹⁶ Several questions pertained to ADLs that the subject did not yet encounter, such as outdoor navigation.

questions, likely a result of her increased experience performing ADL. She gave herself and overall score of 28. Her average score is 1.5. This is not a substantial change since the first assessment. Her husband responded to 9 of the questions, with a total score of 20. His new average rating is 2.2, suggesting that he believes ADL are becoming easier. While the subject's scores have not changed, they are closer to her husband's. One exception was an item exploring the frequency with which a person has difficulty finding items when eating (salt etc.). The subject gave this item the lowest score while her husband reported that it occurred weekly, but not daily (second highest score of 4).

Table 9

Scores on the Subjective Neglect Questionnaire

	<u>Pretest</u>	<u>Average Rating</u>	<u>Post Test</u>	<u>Average Rating</u>
Subject	16/11	1.5	28/19	1.5
Husband	43/12	3.6	20/9	2.2

Note. The numbers above represent the total score over the number of questions answered. There are 19 questions on the test.

The authors of the questionnaire report that it has utility as treatment planning tool. In this study, although the subject's perceptions about her abilities were important, they were not accurate. This is likely largely due to the nature of unilateral neglect. If the subject did not see someone standing next to herself (one of the questions), it is unlikely that she will weight it heavily as a problem. This type of difficulty is more readily recognized by persons around the stroke survivor. This explanation is supported by the study's findings.

Social Validity Measures

According to Wolf (1978) social validity is an important mechanism for determining the value of human behavioral studies. Many studies can demonstrate a response in a human as a result of some factor being manipulated, but social validity requires the researcher to ask if the changes were “really important changes”. Kazdin (1982) believes that social validity reflects the degree to which a treatment and its outcome is important to the larger community.

There are three of levels of social validity (Wolf, 1978). The first level requires the goal of the research to be in accordance with what society wants. It is doubtful that anyone would argue against the value of rehabilitation for persons who have sustained a stroke. Moreover, when improvement is observed on ADL rather than specific puzzles or tests, the research has greater social validity (Ottenbacher, 1986). This study was conceived and designed with the idea that improvement on ADL was critical to the success of the HSG. That the subject is now able to fully visually explore her environment is of great functional significance.

Wolf (1978) also stated that the appropriateness of the treatments needed to be considered. Are they acceptable? Although the subject reported that the HSG tickled (loose bits of tape), they were in no way noxious. They could easily be removed if necessary and the subject reported no problems when she wore them for the longer time frame.

The final criterion that must be met is one of consumer satisfaction. Are the effects of importance? This study solicited the subject’s opinion about the effectiveness of the glasses (see appendix B, figure B7 for a complete copy). She was asked six questions about the experiment in general, and the HSG. The subject reported that she believed it was the practice of scanning that was beneficial. She reported especially enjoying the shelf scanning task and found the small

cancellation task monotonous.

The subject's belief that practice (not the HSG) was what benefitted her is easily explained. Practicing the ADL likely did benefit her. Although the HSG had no effect with the shelf scanning and mobility, she did improve on those measures. Second, at no time during the study, did the subject receive feedback about her performance from the investigator. She would have been unaware of right side bias she demonstrated during the room look about without the glasses. Unlike the shelf scanning task, where the subject was aware that she failed to locate an item, the room look about task provided no feedback about her performance. She also would have been unaware of the marked change in her performance when she donned the HSG. Once the study concluded, the investigator reviewed the results with the subject¹². Given the nature of unilateral neglect, it would be difficult for someone to appreciate improvement on a task, if they were unaware of their difficulty in the first place. It is therefore not surprising that she did not see the HSG as beneficial.

In her closing interview, the subject commented on how much she enjoyed the ADL measures. It was this aspect of the study that she found beneficial. That the tasks were meaningful was evident in her closing interview. She mentioned several times each week, how much she enjoyed the ADL tasks, how relevant they were to her life. This may be in part why the subject remained extremely motivated throughout the course of the study. She was always on time (or early), absent on only one occasion (was ill, came to the session but could not participate), and would attend on weekends if her schedule permitted. In the end, the subject's own comments are most telling. They underscore the value of incorporating ADL into research and the inherent social validity it provides.

¹² The investigator felt that the subject should know that the glasses may be of some benefit so that she could make the choice on her own about continuing to wear them.

CHAPTER V - DISCUSSION

Study One: Findings

Study One was designed to answer the question of whether hemispatial glasses worn by persons with UN would produce an immediate effect on their ability to perform shape cancellation and line bisection tests. Approximately 23% of the subjects showed an immediate benefit from HSG when they performed pencil and paper measures of neglect. These results are consistent with those of Arai et al. (1997). Although those researchers reported improvement in 30-40% of their subjects (depending on the assessment), the criteria for improvement are more rigorous in this study. Unlike Arai and colleagues, a final clear glasses condition was included to identify improvement in scores that may be a result of learning effect. A change in performance was only considered to be a result of the HSG, if that trial was superior to both clear lens trials. Some of the subjects in this study improved progressively, from trial one to five. Since, it is unknown if the glasses facilitated this improvement or if it was a result of learning the task, those subjects are not considered to have improved due to the HSG.

The benefits are described as small because in no case did the HSG cause a person with a moderate degree of neglect to demonstrate nearly no neglect. Although most subjects demonstrated only a slight improvement, there were exceptions. Subject #8 was unable to locate any targets on the left and only 14 on the right during both clear conditions. When he wore the 8% VLT HSG he identified four targets on the left and 27 on the right.

The study did not reveal any obvious variables to enable the clinician to discern who would and would not benefit from the HSG. When lesion sites are analyzed, no one variable emerges as a clear predictor. One might argue that more sophisticated measurement of lesion site

and concurrent impairments might enable researchers to tease out any patterns. This argument is fair. This study did review CT results, however this was done retrospectively. The reports were often not specific, frequently stating "approximate area of right middle cerebral artery". More accurate information would be available with magnetic resonance imaging and a prospective design. This said, the locations of the subjects' lesions were consistent with the literature. The majority of the subjects had experienced a right middle cerebral artery (MCA) infarct, which supplies the inferior parietal lobule; and the parietal, occipital, temporal junction (Snell, 1992). According to Watson, Valenstein, Day, and Heilman (1994) these sites are most frequently associated with neglect. Although some of the subjects with a right MCA infarct did improve with the glasses, others did not.

A person who benefitted from one of the types of HSG did not necessarily benefit from the other types. In fact, there seemed to be no relationship between the different types of glasses and the effect they had. There are no other studies comparing the relative effectiveness of different types of HSG. However, two different forms of the HSG have been used independently in efficacy studies. Arai and colleagues (1997) used a transparent tinted lens. Beis, Andre, Baumgarten and Challier (1999) compared the effectiveness of HSG to right eye patching. The HSG were constructed using a dark opaque material to cover the right half of each lens. The glasses were similar to the taped version used in this study; they did not allow an image through the lens. The authors reported that the group wearing the HSG was significantly different from the control group on the Functional Independence Measure (FIM) and a measure of right eye movements. There was no difference between the control group and the group wearing the right eye patch.

Another finding from Study One is that the benefits of wearing HSG were not only subject and glasses specific, they were also task specific. A subject who improved with a pair of HSG on the line bisection did not necessarily improve on the shape cancellation task. Subject # 7's performance on shape cancellation was enhanced only when she wore the taped HSG. During the line bisection test, the taped glasses produced the least effect, and the 8% VLT HSG were most beneficial. Subject # 8 found considerably more shapes when wearing the 8% VLT during shape cancellation but did not improve with any of the glasses on line bisection. Although Arai and colleagues (1997) did not compare different forms of the HSG they did examine the effects of the HSG on different pencil and paper assessments. They also found that when the HSG were beneficial, they did not help on all the assessments.

It has been argued that different tests of neglect may assess different aspects of this syndrome (Kinsella et al., 1995). Until recently, it was believed that line bisection and star cancellation measured the same underlying processes (Halligan & Marshall, 1998). The authors reviewed a subject who exhibited left neglect on cancellation tasks and right neglect on line bisection. They argued that locating an overt target and an imagined midpoint requires different spatial and attentional processing. The multifactorial nature of neglect, and the possibility that each of the assessments demanded different types of cognitive perceptual processing may explain why the results are mixed.

Riddoch and Humphreys (1994) suggested that attention is composed of three subsystems: stimulus driven orienting, goal directed orienting, and attentional engagement. Subject #7 improved on each of the assessments with a different type of HSG. When provided with the taped glasses she began locating targets from the center of the sheet leftward. She had previously started on the right and remained on the right. Riddoch and Humphrey's model may

explain her response. The taped glasses enabled her to begin exploring the middle of the sheet for targets because they did not allow any visual information in from the right hemifield. She did not need to overcome an inability to disengage from right side targets. Had she turned her head to the right and located the farthest right targets, she may have been unable to overcome her fixation. The line bisection task had different demands. It required her to look into the right and left hemifields to determine the middle of the line. For that reason, the tinted lens might have been superior. It permitted her to see the entire image, yet dampened the amount stimulation she received from the right relative to the left. She was therefore able to disengage from the right side and use her goal directed system to plan the target location.

It was observed that two of the subjects demonstrated a mild right neglect when given the HSG for the line bisection tasks. The development of right neglect as a result of a treatment has not been reported in the literature, however Arai and colleagues reported that the HSG resulted in diminished performance for two of their subjects. Halligan and Marshall (1998) reported that right neglect during line bisection could occur in a person with left neglect, although it is extremely rare. They believe that the disassociation suggests different processing in the two tasks. The fact that HSG can cause a right neglect may ultimately be useful for researchers and enable them to understand which element of the attention/orientation system is affected by the HSG.

The overall finding of Study One is that some people will demonstrate an immediate benefit from wearing HSG. This finding is consistent with previous research that has demonstrated the merit of minimizing the relative input to the left versus the right hemispheres (Hjaltason & Tegner, 1992; Mark, Kooistra, & Heilman, 1988; Vallar et al. 1995). Many theorists, Heilman, Watson, and Valenstein (1993); Kinsbourne (1987); and Posner (1987) have

recommended decreasing the amount of stimuli on the right to diminish neglect. That persons did benefit from the HSG, suggests they had a disruption of the attentional orienting systems, not a failure of representation.

In terms of general neglect research, the varied responses of the subjects are not surprising given the large body of evidence suggesting that neglect is the result of several discrete impairments (Halligan & Marshall, 1994). The variable response to the HSG does not support a unitary theory of neglect. The results are more easily explained by a model that suggests that neglect is a heterogeneous condition. This theory has been advanced by Halligan and Marshall (1994) with Riddoch and Humphreys (1994), Ladavas, Menghini, and Umilta (1994), and Posner and Rafal (1987) suggesting subsystems within the attention orientation framework.

Neglect can result from a breakdown in any of the attention and orienting systems. These systems work hierarchically and in parallel to achieve a fluid and prompt response to any perturbation (peripheral or internal cue) experienced by the person. That several of the subjects demonstrated no benefit from the HSG may reflect impairment of other subsystems, or a representational impairment, further evidence that UN is highly heterogeneous.

One fact that needs to be considered is the immediacy with which the HSG had their effect. This was evident in both this study and in that of Arai and colleagues (1997). That any behavioral treatment can have an instant effect implies that latent or intact abilities were being masked. Taub and colleagues (1993) have raised the possibility that many stroke impairments are the result of learning (unconscious process). There is an initial trauma to the nervous system that results in an impairment. Over time the damaged area recovers but the patient is unable to

access and use the area of the cortex where the abilities reside. This theory will be discussed further in the following section.

Study Two

Study Two was designed to determine if wearing HSG would result in changes in ADL in one subject. Many factors could cause the subject to improve; time or other therapies for instance. For this reason, the study used repeated measurement of her abilities, lagged introduction of the HSG, and repeated application and withdrawal of the HSG.

To demonstrate experimental control within a multiple baseline design across behaviors, two conditions must be met. Each time the treatment is applied to a new behavior you need to see a significant change in that behavior. You also need to replicate this change across behaviors. A significant change in behavior between baseline and initial treatment phase occurred only in room look about. Shelf scanning and mobility did not exhibit experimental control as both behaviors demonstrated decreasing UN in the baseline phase, and no significant change when the HSG were introduced. While performance on room look about changed when the intervention was applied, the change was not replicated across the other two behaviors used in the multiple baseline design. The inclusion of a withdrawal phase in each behavior allowed the researcher to further investigate possible effects of the HSG. In only one behavior (room look about) did the withdrawal design demonstrate the effects of the HSG (eg. improved in treatment phase from baseline level and return to baseline levels once the treatment was withdrawn.)

Beneficial Effects of the Hemispatial Glasses

The study demonstrated that wearing the taped HSG while performing the room look about task, improved the subject's ability to look to her left. When not wearing the HSG the subject would turn her head to the right and locate items predominantly on her right. According to Karnath, Niemeier, and Dichgans (1998) this visual orientation is typical of persons with left neglect. In fact, they report that the average gaze for persons with neglect is 40.6 degrees right of midline.

When the subject was provided with the HSG, her improvement was dramatic and relatively immediate. During the second day of wearing the HSG she was able to turn her gaze approximately 45 degrees to the left.

These results are similar to those reported by Arai and colleagues (1997). They indicated that their subject, when wearing the HSG, made an immediate improvement while walking around the room, and no longer bumped into objects on his left. In this study, when not wearing the HSG for the room look about task, the subject's gaze was predominantly to her right. This was reflected in the location of the objects that she reported. The subject demonstrated increasing symmetry of gaze throughout the carryover phase. At the conclusion of the study, her scanning behavior (during room look about) approximated that of a person with a normal gaze pattern. Karnath and colleagues (1998) reported that persons without neglect distribute their gaze symmetrically over an area extending 130 degrees (approximately) to the right and left of their body's midline. It is interesting that the subject in this study improved to a similar degree as the subject in Arai and colleagues, but on a different type of ADL. These results do not contradict their findings, but further demonstrate how the response to HSG varies as a function of the person, the type of HSG, and the task.

The final phase of the study extended wearing the HSG to four hours each day, however the HSG were not worn during measurement of the dependent variables. In order to find evidence of generalization the researcher examined performance in both the dependent measures where the HSG had been worn (ADL) and in the two concurrent measures, where the HSG had never been worn (shape cancellation). In this final phase of the study there was maintenance in shelf scanning (increase in level but decrease in trend), maintenance in mobility (decrease in level but flattening of trend), and an improvement in room look about (increase in level and reversal of trend). Although there was high variability in the room look about data, the subject's mean performance in the final phase was almost double that of the two treatment phases.

The data obtained from the subject's performance on the two concurrent measures during the final extended wear phase also suggests generalization to non-exposed behaviors. When the subject's performance on small cancellation during the baseline phase (days 1-33) is compared to the days when she was wearing the HSG four hours each day, a significant increase in both level and trend of performance during the extended wear phase is evident. The scores she achieved during the extended wear phase could not have been predicted on the basis of her improvement during those first 33 days. Although the study's design is not sufficient to conclude that generalization occurred, it does suggest this possibility.

The evidence for generalization is not as strong for the large cancellation task. While the subject's scores did improve after the long wear phase was implemented, resulting in a change in level; trend analysis indicates that the subject's performance in the final phase could have been predicted on the basis of her baseline trend.

The possibility that the extended wear phase potentially resulted in generalization to the small cancellation task, but not the enlarged cancellation task is puzzling. No research was found

to provide a reason for this difference. Therefore, the data obtained were closely examined to develop a possible explanation for this finding. The following paragraphs review the data and attempt to account for the difference. It must be remembered that these explanations are only possibilities. Overall, the findings suggest that generalization may have occurred on small shape cancellation, while similar effects were not clear on the enlarged version.

The subject's mean performance during the baseline phase for small cancellation and large cancellation were 12.6 and 17.2 respectively. Although these mean scores are quite different, her initial scores on both the tasks were very similar. This indicates that, for some reason, the subject improved more readily (and to a higher level) on large shape cancellation during those first 33 days than she did on the small cancellation sheet.

The subject's performance during the carryover phase (extended wear) was also examined. The subject's mean performance during the carryover phase for small cancellation and large cancellation was 23.8 and 24 respectively. Therefore, at the end of the study, she was able to perform small cancellation and large cancellation equally well. Overall, her performance on both of the concurrent measures was very similar at the beginning and end of the study. What was different was her performance on the large cancellation task during the baseline phase.

There are two possible explanations for the difference in performance seen on the large and small versions of shape cancellation; learning effects and ceiling effects. The subject began both the small and large cancellation task with similar scores, but rapidly improved on large cancellation, resulting in a mean score that was substantially greater than her score on small cancellation. With the exception of small cancellation, the daily measures (shelf scanning, mobility, and room look about) were performed over a large space. She improved in all of these tasks. Perhaps, repeated practice on the tasks in large space provided a learning experience that

accelerated her ability to perform the large cancellation task. For a generalization effect to be demonstrated on large cancellation there would have to be a steeper improvement than during the baseline phase. Because her performance on large cancellation may have reflected learning from other activities, her baseline phase improvements may have, in effect, hidden possible generalization effects.

A second possible explanation for the lack of a clear measure of generalization on the enlarged cancellation task is a ceiling effect. The subject's performance on both cancellation tasks demonstrates a high degree of variability across both phases. The subject's rapid improvement on enlarged cancellation during the baseline phase resulted in a trend line with a high degree of acceleration. During the final phase the subject's mean performance on the enlarged cancellation task rose to 24/30. She scored 30/30 on one day and 29/30 on two others. However, because of the continuing variability in her performance, her rate of growth did not increase. Given both the variability in performance, and the possibility that the baseline phase may have been affected by learning, producing a strongly accelerating trend during baseline, the subject would have had to achieve a score above 30 to demonstrate a slope that was visually different.

Although the study shows evidence for generalization, the design only provided association, not experimental evidence. This appreciated, the possibility that shape cancellation scores reflect generalization is a finding that deserves separate consideration. Discovery of any treatment that may have effects that carryover to unexposed activities is very exciting. From a clinical standpoint, a treatment or prosthetic that must always be worn is less likely to be accepted. This would particularly be the case with UN because people with this impairment may not fully appreciate its impact or their improvement with the HSG. Further, the HSG are

noticeable and different. It is conceivable that people would be reluctant to wear a visual device that is not aesthetically pleasing, makes "seeing" more awkward, must always be worn for that activity, and provides (as they see it) dubious benefits. The fact that HSG may have merit as a temporary training tool makes it a more viable treatment option for clinicians. Patients are much more likely to wear the HSG, even for an extended period of time, if it is viewed as training (not compensatory) device that will benefit several areas of ADL.

The possibility of carry-over effect also has considerable theoretical implications. If the HSG had helped with room look about, but only while they were being worn they would have had only a prosthetic effect. They would have been useful in much the same way as a magnifying glass is for reading small print, or a prosthetic limb is for walking; they would minimize the disability, but not remediate the impairment. However, the fact that the HSG appeared to improve the subject's ability to perform the room look about task and the small shape cancellation task during the carryover phase suggests that an underlying component of scanning was being effected. Which of the components of the visual orienting system was affected is not known. It is likely that the subject did "look around her room" while wearing the HSG. Therefore, it can be presumed that she had some degree of fairly similar direct practice. However, for the HSG to affect her ability to perform the room look about at a later time (affect across time), the change to the component or system needed to be relatively permanent. Furthermore, it is highly unlikely that the subject performed any tasks that were very similar to the shape cancellation. Especially given the evidence, that even line bisection and shape cancellation are quite different. This indicates that whatever component of visual orientation was affected, it is shared by shape cancellation and room look about.

Whether rehabilitation should focus on compensation or remediation is a subject of some controversy within the occupational therapy literature. The issues in debate were discussed earlier in this paper. It is understood that therapists would be ill advised to direct treatment exclusively at task components that have no demonstrable effect on overall performance. This said, there is increasing evidence that treatments can affect the functional reorganization of the cortex following a brain injury.

Whether or not the neural pathways implicated in UN can recover as a result of remediation based program was the focus of a recent study. Pizzamiglio, Perani, et al., (1998) studied the effects of a UN remediation program on cortical activity. The treatment consisted of eight weeks of daily reading and pencil and paper copying activities. At the end of the study the subjects demonstrated improvement on pencil and paper measures of UN and Barthel scores. The subjects' pattern of cortical activity during a left visual exploration task was analyzed by PET prior to and on completion of the eight week program. The subjects' PET activity patterns were compared to controls (no UN). Prior to rehabilitation, there was no similarity between the subjects and the controls in terms of cortical activity. The authors reported that the subjects had almost no activity in the right parietal lobe. In contrast, the post rehabilitation PET studies revealed parietal activity in the regions related to UN in all of the subjects.

The authors argue that these results demonstrate plasticity of the brain as it relates to functional gains. Recovery of left visual spatial abilities was concurrent with the recovery of right parietal function, and followed specific prescribed visual spatial tasks. Moreover, the findings cannot be attributed to spontaneous recovery, as one of the subjects had experienced his stroke 11 months prior to commencing the study.

Lack of Benefit Across Tasks

Although the HSG appeared to have caused improvements on one measure of ADL and small shape cancellation, they did not appear to be of any benefit for shelf scanning, mobility, and enlarged shape cancellation. The HSG provided no immediate benefit, nor did they affect performance when they were worn for four hours each day. This is not surprising. Although, the subject may manifest UN on all three ADL, the factor causing the difficulty might be different for each task.

Activity Analysis

The Canadian Model of Occupational Performance depicts performance of activity as dynamic person-occupation-environment interaction (Canadian Association of Occupational Therapists, 1997). Any change in the person (cognitive, affective, or physical), the task (productivity, self-care, or leisure) or the environment (social, cultural, institutional, or physical) can lead to a fundamental change in occupational performance. Although occupational therapy models are not expressly discussed in the research conducted and analyzed by researchers in the area of UN, their analyses are compatible with those models. Attention based theorists argue that even slight alterations in task demands (environment, occupation) can require a set of different processes by the person (cognitive perceptual components). To this end, Halligan and Marshall (1998) reported that even line bisection and shape cancellation, two seemingly similar pencil and paper assessments, can dissociate along different types of neglect.

What follows is a brief analysis of the ADL activities using specific perceptual processing theories to explain the results. To do this, the nature of the tasks (occupation), the physical environment, and the processes required by the subject (person) are reviewed. Although

none of the UN theorists have made reference to occupational therapy models, their use of activity analysis, assertion that UN is highly heterogeneous and varies according to person, type of activity, type of stimuli, location of stimuli etc., is highly compatible with occupational theory and models of occupational performance.

Each of the ADL tasks, though superficially similar in that they demand looking left, was quite different. Many theorists maintain that there are at least two components mediating attention (Halligan & Marshall, 1994; Ladavas, Menghini & Umilta, 1994; Riddoch & Humphreys, 1994). They contend that some form of the following two mechanisms is required for effective visual exploration; a mechanism for automatic orienting to peripheral stimuli (global recognition) and a mechanism for goal directed voluntary search. They propose that UN can result from a disruption to either or both of the processes. Shelf scanning required the subject to use both her peripheral detection system and goal directed search. Because she was looking for something specific, the greatest demand was likely on the system that performed goal directed functions. During the room look about task, she was searching for no object in particular. She allowed the peripheral detection system to largely direct her search.

The results suggest that the subject experienced damage to both the peripheral detection system and the voluntary orienting system. During room look about, the compelling visual stimuli were removed via the HSG. This enabled her to use her weak but functioning peripheral detection system to complete the task. During the shelf scanning task, the HSG would have similarly removed the right sided stimuli enabling the peripheral detection system to work. The fact that she continued to experience difficulties during the shelf scanning test suggests two things: 1) The taped HSG were not beneficial for a task where she was forced to continually re-explore the right as she moved from shelf to shelf. 2) The subject has sustained damage to the

voluntary orienting system, and although left side cues were more salient, she could not voluntarily direct her attention fully to the left. In the end, although the HSG were not universally beneficial as a treatment tool, they may have some merit for disassociating peripheral from goal directed UN.

Another ADL that did not benefit from the HSG was the mobility task. Specifically, the HSG did not increase the subject's ability to identify and avoid obstacles on the left of the obstacle course. There are several possible explanations for this. First, the task appears sufficiently different from the room look about to require different processes. The mobility task requires the subject to use automatic peripheral cue detection when she is freely exploring her environment while propelling her wheelchair, but it also requires a significant amount of voluntary goal directed orienting. This would be utilized when the subject had to visually fixate on obstacles close to her wheelchair to insure that she maneuvered around them. A second reason for the lack of benefit seen in the mobility task may be related to the significant motor element required. When a person fails to physically respond to a "seen" stimulus, this is referred to as a motor neglect (Heilman, Watson, & Valenstein, 1993). On several occasions the subject stated, "I saw that. I don't know why I hit it anyway." This suggests that motor neglect significantly impacted her performance.

Finally, and perhaps most importantly, it is necessary to point out the subject's performance on the mobility task improved rapidly without the HSG. One possible explanation for this may be that during this task she received immediate and meaningful feedback about her performance. Bumping into an object not only informed her that she was not attending, but also gave her information about where to look in the future. No feedback about success or failure was provided during the room look about task. During shelf scanning, she was aware she did not

locate an object, but did not receive any information about the location of that object. In this way she could not learn and modify her behavior.

The results suggest that no one treatment will benefit all forms of UN. This raises one important question. Given that different HSG have different effects, would another type of HSG been more beneficial for shelf scanning or mobility? This question is especially relevant to the subject in this study. She demonstrated a benefit from more than one type of the HSG. She improved on shape cancellation with the taped HSG, but demonstrated an equally significant improvement on line bisection when she wore the 28% VLT HSG. In fact, the taped HSG were the least helpful of the HSG for that task. It may be significant that the subject who made the considerable gains in mobility in Arai and colleagues study (1997), was wearing transparent tinted HSG. Perhaps a lens that allows visual information into both hemifields, while keeping the left relatively more salient, would be superior for goal directed tasks.

Application to Theory

It is generally believed that recovery from a substantial neurological injury is a lengthy process. A person would have to slowly and sequentially learn lost skills. This was not the case with the subject in this study. The benefit she experienced when wearing the HSG during room look about was relatively immediate. Once the HSG were worn for a longer period of time, her improvement not only accelerated, but also, was no longer contingent on her wearing the HSG for the task.

Forced use theory, proposed by Taub and his colleagues (1993), may explain both the immediacy of the benefit seen with HSG and the associated generalization. The researchers proposed a type of learning theory to explain similar findings in their subjects. They suggested

that people could develop learned nonuse following neurological injury. The initial injury causes loss of function. Although the nervous system begins to recover, the damaged system (in Taub's example – arm movement) remains suppressed.

Taub and his colleagues (1993) argued that dramatic rapid recovery would not be possible if the neural mechanisms for the movement were entirely lost. He believes that the person's potential is suppressed by a learned ineffective system for performing the task. The subjects in their study were placed in one of two conditions. The experimental group wore a restraint on the non-hemiplegic arm for over 90% of their waking day. They were instructed to use their weak arm for all activities unless doing so would compromise their safety. A matched control group was told that they had much more movement in their hemiplegic arm than they were using. They were instructed to use the weak arm as much as possible and were given passive range of motion exercises to perform at home. The study ran for two weeks. The subjects were tested at the beginning and end of the treatment phase on objective measurements of upper extremity function and on their ability to use the arm for ADL. The post study measures indicated no overlap between the two groups. The control group made minimal to no gains while the experimental group made dramatic improvements. Taub emphasized that the subject must practice the "new skills" repeatedly to overcome the suppression. Without forced practice in a variety of contexts, the ineffective pathways continue to take over and suppress latent abilities.

The immediate benefit that the HSG provided during room look about supports the possibility that many of the visual attention/orientation mechanisms were retained. Taub et al. (1993) argued that latent abilities were suppressed. This idea is convergent with UN theories that suggest over activity of the left hemisphere is a cause of UN (Heilman, Watson, & Valenstein, 1993). During the room look about task the HSG may have been effective because they removed

the compelling stimuli from the right visual field. This enabled the subject to use her left side attention/orienting systems that were not strong enough to override right side attention/orienting systems in the presence of right side stimuli. When the subject wore the HSG for four hours each day, the weak but more effective neural pathways were sufficiently used for the effects to be maintained and generalize. Forcing the subject to look into the left hemifield during a variety of tasks, may have in effect, retrained or strengthened the neural pathways responsible for left side orienting. This may explain the improvement seen on shape cancellation.

Recently, Beis, Andre, Baumgarten, and Challier (1999) examined the impact of wearing HSG for an extended period of time. The subjects were required to wear the glasses for 12 hours each day, in essence, more strictly applying the principle of forced use. The subjects were instructed to wear the HSG for all ADL. They reported that the subjects in the HSG condition demonstrated statistically different FIM scores and left gaze patterns when compared to the control group and persons with UN wearing a right eye patch.

Although Beis, Andre, Baumgarten, and Challier (1999) reported that their results supported the use of HSG, their data does not support this statement. The difference in the FIM scores between the three groups is not evident on their graph. Visually, the scores appear similar. While they may be statistically different, clinical significance is questionable. Overall, the benefit of the HSG appears minimal.

Although the improvements reported by Beis et al. (1999) appear questionable and very small, the present study may explain some of their findings. It was argued earlier that not all subjects benefit from the HSG, nor did they all benefit from the same type of glasses. The subjects in Beis and colleagues study were not pre-selected on the basis of a positive response to the HSG. If, at best, 30% of the UN population benefits from the HSG, and not all of them

benefit from the same type of HSG, it is possible that very few of the subjects in Beis and colleagues' study experienced an effect. Although the effect may have been potent, the standard design (control group versus experimental group) was not the most sensitive method to study HSG effectiveness. Any effects experienced by one or two subjects are lost in mean calculations.

In the end, although the research converges with the "forced use" theory, the results can be explained equally well by general theories of UN. For the past 15 years, the most prominent researchers have urged therapists to attempt therapies that decrease stimuli on the right (Heilman, Watson, & Valenstein, 1993; Kinsbourne, 1987; Posner & Rafal, 1987; Vallar et al., 1995). Unfortunately, as compelling as their clinical research was, it was difficult to apply their techniques (transelectrical stimulation, differential illumination, and right side stimuli erasure) to the person in their daily environment. HSG may be a method for achieving different levels of stimuli in a visual world that is constantly changing.

Pre and Post Test Findings

At the end of the study, the subject had substantially improved on the BIT (Halligan, Wilson, & Cockburn, 1991). Her score was above the cut off score for neglect, indicating that she did not have UN. However this was not the case. Although the subject had improved significantly over the two months, the investigator observed that she continued to experience difficulties related to her UN. Her shelf scanning scores, and both her and her husband's post test SNQ (Towle & Lincoln, 1991), serve as collateral evidence of her continued difficulties.

The lack of sensitivity of the BIT (Halligan, Wilson, & Cockburn, 1991) does not appear related to the cut off score. In fact, the subject's performance on all of the subtests was virtually errorless. This suggests that the BIT is not sufficiently sensitive. The subject's difficulties were

visible on the shelf scanning test and the enlarged cancellation form. Both of these measures cover a reasonably large surface area and require the subject to keep her head upright. All of the BIT subtests (conventional and behavioral) are performed on a tabletop with the subject looking down. The addition of a subtest similar to the enlarged cancellation sheet may enable the BIT to capture significant UN that manifests over larger areas. This type of measure is necessary to increase the sensitivity (and validity) of this frequently used and widely reported assessment tool. The contradiction between the BIT score and the subject's performance suggests that the BIT should not be used as the only measure of neglect.

Adventitious Findings

On average, the subject in this study displayed significantly more UN on the small version of the cancellation sheet than on the large. This finding contradicts earlier studies that suggested UN could be more severe in far space than near (Cowey, Small & Ellis, 1994). However, a recent study using line bisection demonstrated that the distance between the subject and the stimulus sheet had to exceed 400 cm for a relatively different angular displacement to occur (Cowey, Small & Ellis, 1999). There was no significant difference between tests that were at a natural reading distance (tabletop), or 100 cm from the subject. The subject in the present study was seated less than 100cm from the enlarged cancellation form. It is not known whether the different findings can -once again- be attributed to differences between shape cancellation and line bisection (Halligan & Marshall, 1994).

The difference in mean scores on the small and large versions of the test is significant for another reason. Only the small version of the test was sensitive to carryover effects from the HSG. Whether or not the enlarged version required substantively different processing than the

small version is not known. The enlarged shape cancellation test scores may have been affected by both a learning and a ceiling effect, thereby limiting its usefulness as a indicator for possible carryover effects.

Of some concern are the highly variable scores seen on the shape cancellation task. The patient's performance was evaluated on 43 days over the course of eight weeks. The author of the test described scoring and procedural information, however test-retest reliability was not provided (Mesulam, 2000). Because of this variability, a single shape cancellation score should never be used as a definitive measure of the degree of UN. The variability also has implications for assumptions that can be made from Study One scores. This will be discussed further in the study limitations section.

In 1978, Heilman and Watson compared the performance of individuals with UN on two forms of the cancellation task. They reported that the subjects were able to detect more geometric shapes than letters. They proposed that the geometric (non-verbal) targets stimulated the hypoactive right hemisphere, thereby boosting its capacity for directing attention into the left hemisphere. When the alphabetic versions of the test were used, the letters stimulated the left hemisphere and only further compounded the imbalance in activation experienced by persons with neglect. Subsequent studies (Caplan, 1985; Cermak, Trombly, Hausser, & Tiernan, 1991) were not able to replicate their results.

This study supports, in part, the findings of Heilman and Watson (1978). The subject was able to detect more targets on the geometric version of the cancellation sheet than on the letter version, however the results were not consistent. The difference between mean and median scores for geometric targets and alphabetic targets on the tabletop versions of the test was very small. The difference between the mean and median scores on the enlarged version was much

greater. Although Heilman and Watson's theory can explain why the subject was able to locate more targets on the geometric version of the test, it does not explain why the improvement was only seen on the enlarged form. Moreover, the difference between the subject's scores on the geometric and alphabetic versions (enlarged form) was not lasting. The subject's scores on the geometric version of the test remained relatively constant, whereas her score on the alphabetic version continued to improve. Toward the end of the baseline phase, her performance on the alphabetic version of the test was similar to, or exceeded, her performance on the geometric version. One could argue that she initially found more shapes than letters because the shapes stimulated her right hemisphere. As was discussed earlier, the right hemisphere directs attention to both the right and left hemispace. The letters triggered left hemisphere processing and exacerbated her UN. Over time, as she improved in general, she was able to maintain right hemisphere activation for search, even in the presence of verbal stimuli. However, this reasoning does not explain why the subject did not demonstrate the same difference in performance on the table-top version of the test. No definitive explanation for these findings can be offered at this time.

Although it appears there is some difficulty with the reliability and sensitivity of the standardized measures of UN (shape cancellation and BIT), measuring ADL holds much promise. The shelf scanning test, although contrived, proved to be a very sensitive and objective measure of UN during a goal directed search across large space.

Equally interesting, was the subject's strong preference for the ADL measures and her high degree of motivation to perform those daily tasks. She attended almost every scheduled session over the eight-week period. Although the subject may have been a highly motivated person in general, the fact that not a week went by when she did not provide an unsolicited

remark about the usefulness of the ADL measures, suggests that the activities had meaning for her.

Although the measures were developed to explore the subject's ability to attend to stimuli on the left, this ability was embedded in a recognizable daily activity. Activities that are recognizable within a given culture would have some meaning for the participant (Nelson et al., 1996). The subject would frequently state "I'm happy to try the grocery shelf test again. I need to get better at it". The grocery shelf may have resembled activities that she needed to perform in her daily life, and the meaning of that activity, in part, may have played a role in her apparent enthusiasm for the sessions. Trombly (1995) urged the profession to focus the on the use of occupation in therapies.

The findings of this study support many of the founding principles of the profession. That shape cancellation and line bisection tests assess slightly different abilities and require different processes; and that people responded differently to the same type of tasks and treatment (HSG) would be of no surprise to occupational theorists. Occupational therapists have long emphasized that performance on any task cannot be fully evaluated apart from context and that any change in the environment, activity or person leads to a change in occupational performance (Canadian Association of Occupational Therapists, 1997).

The subject's preference for the ADL tasks compared to pencil and paper measures (she reported that the pencil paper measures were monotonous), and her high motivation to complete the ADL tasks, supports the use of embedding exercise in occupations; a principle that is central to profession. The use of activity in therapy is the hallmark of occupational therapy practice, and although this study was chiefly concerned with recovery from UN, the findings underscore the importance of the principles of occupational therapy practice in research and treatment.

Study Limitations

This study has several shortcomings. The direct involvement of the investigator in almost all of the treatment and testing, the high variability in the shape cancellation scores and the small number of subjects are a few examples. There are others. It is important to disclose the study's limitations because they impact how confidently conclusions can be made about the subjects' response to the HSG (the internal validity of the study), and how readily the results should be incorporated into occupational therapy practice, (the external validity of the study). A discussion of the potential and actual limitations of this study is necessary to qualify any conclusions that are made, and direct future research. For this reason, potential limitations and the manner in which the researcher attempted to circumvent the problems by design is discussed along with limitations that could not be controlled.

Threats to Internal Validity

General threats to the internal validity of an experimental study include: history, maturation, testing, statistical regression, instrumentation, selection, and experimental bias (Ottenbacher, 1986). The advantage of the single subject multiple baseline design with embedded withdrawals is that it controls for many of these threats.

Events that occur between observations can impact scores or performance. These events are known as historical threats (Ottenbacher, 1986). Maturation refers to growth or adaptation and takes place over time. History and maturation threaten the internal validity of the study because they, not the independent variable, may be responsible for changes in a subject's behavior or performance. The use of a multiple baseline design with an embedded withdrawal

can account for these threats. The use of repeated measurement through a baseline phase allows the researchers to view the subject's performance over time, and identify whether changes are taking place. In the current study, the concurrent tasks (small and large cancellation) provided some indication of recovery across the experimental phase. The data from small and large cancellation across the first 34 days suggests gradual recovery, however because the tests were performed daily the improvement could also be explained by practice effect. A probe design (intermittent measurement) could have controlled learning from recovery from practice effect. However, if a probe design was used the researchers would not have discovered the high variability in the shape cancellation test.

In a multiple baseline study, the researcher can only state that the independent variable had an effect if, 1) scores in the treatment phase differ significantly from the baseline phase, and 2) the difference is repeated across behaviors. In the current study there was clear evidence of change from baseline to intervention only in the room look about task. While there was improvement across all behaviors from baseline to intervention, two behaviors could be explained by an improving trend in baseline. Hence, there was no replication across behaviors.

By repeatedly applying and withdrawing the independent variable, the researcher can isolate changes in performance that are related to that variable. In this way, historical threats are managed. The current study used at least one withdrawal phase for each behavior. Performance on shelf scanning reversed when the treatment was reversed but the upward trend remained and the effect was not replicated with a second reversal. Mobility actually improved during the reversal phase. Only room look about demonstrated a dramatic change in behavior when the condition was reversed.

Selection biases are a significant threat to the internal validity of group research (Kazdin,

1982). Selection biases occur when differences between groups on the dependent measure can be attributed to general differences between the groups themselves. Selection biases are not a problem for single subject designs because they do not require comparisons between different persons. This study used single subject methodology where the subject served as her own control. Her performance on the tests was compared across conditions (baseline and intervention), but not against the performance of another person, therefore selection bias is not a threat.

Unfortunately, experimental bias is a continuing concern. The investigator manipulated the independent variable and evaluated the subject on most of the measures. To monitor for bias, a second rater was used and inter-rater reliability was measured.

A potential confounding variable is an effect resulting from expectation. Due to the nature of the treatment (HSG), the subject was not blinded to phase. Moreover, she had some idea about the potential effects of the HSG. This information was necessary to obtain informed consent. It is hoped that the nature of UN, that it is not fully recognized by the person experiencing it, may mitigate any concerns about lack of subject blinding. Unfortunately, the second investigator was also not blinded to phase.

The study attempted to address measurement concerns by using both standardized measures of UN and contrived behavioral assessments. The second rater was necessary for inter-rater reliability measures, particularly for the behavioral assessments where that information was not known. Ideally exact agreement would be calculated on scored items (location by location). Unfortunately, this was only possible for shelf scanning. The mobility score sheets and room look about score sheets were not produced in a way that allowed the researcher to determine which location on one sheet corresponded to the same location on the other score sheet. Inter-

rater agreement for mobility and room look about could only be calculated for total number of objects on the right or left. In the future, room look about could be scored on sheets that illustrate the visual field with degrees already assigned. Rather than have each recorder write down the estimated area in the visual field that the object reported was located in (example, 80), the recorders would write "1" or "2" in the area assigned to 90-75 degrees right of center. The number 1 would indicate that the first item mentioned by the subject was located 90-75 degrees right of center. This would enable exact agreement on location scored.

The line bisection and shape cancellation tasks were chosen for the pencil and paper measures because they are well recognized, objective, standardized, repeatedly used (making across study comparison possible) and had reasonably strong reliability and validity. The variability of the shape cancellation scores was a surprising incidental finding. Unfortunately, this variability potentially calls into question much of the data in study one. Each subject had performed the shape cancellation test five times. On the basis of their scores their response to the HSG was determined. Most people demonstrated only minor changes, including the subject chosen for study two. If the change in her score reflected test-retest variability rather than response to the HSG, then the assumption that a person must demonstrate an immediate response to HSG to benefit from them as a treatment is false. To allay some concern about this possibility it is important to mention that the subject completely changed scanning styles with the taped HSG. She commenced her search in the middle of the page and worked left. She had done this on no other occasion. This said, the potential threat to study one conclusions is appreciated. For that reason, all discussion about identifying an appropriate candidate on the basis of this test should be tempered with caution.

Threats to External Validity

Common threats to the external validity of single subject designs include; generalizability across subjects, generalizability across setting, generalizability across measures, and generalizability across agents (Kazdin, 1982). The characteristics of the subjects in study one do not differ significantly from those of other persons with UN, and the hospitals from which the subjects were recruited are similar to many acute care and rehabilitation hospitals. This should allow the findings to be applied to similar settings and patients. Study two enabled the investigator to draw conclusions about the impact of HSG on specific ADL and the benefits of extended wearing of the HSG, however, it must be emphasized that only one subject was used in the multiple baseline design. It is possible that the subject was unique in some way. For this reason no assumptions can be made about the extent to which these results apply to other people. This study also found a significant difference in response to the treatment across measures. For this reason, generalizability across measures appears limited.

The primary investigator provided the HSG and carried out the majority of the testing. This raises questions about generalizability across agents. To offset this concern, actual interaction with the investigator was minimal and no coaching or feedback about results was provided. These measures were required to decrease any effect that personal characteristics of the researcher might have on performance.

In general, threats to the external validity of this study are managed by a conservative interpretation of the findings. The beneficial effect of the HSG on one ADL, and the finding that extended wearing of the HSG can cause the benefits to generalize to other activities was only investigated in one person. A larger number of subjects and random selection to either control or treatment group is one way of establishing external validity. Further studies are required to

determine if the results are replicable, and if so, under what conditions. For that reason, every effort was made to sufficiently operationalize the dependent variables in a manner that would permit future replication of this study. It must be remembered that the chief findings of this study were that, although HSG can lead to a decrease in UN, the response is highly individual and varies according to person, type of HSG and type of task. The study does not recommend HSG as a therapeutic tool for all persons with UN.

Closing Issues and Future Directions

This study has demonstrated that for one subject, HSG can decrease UN on a pencil and paper measure and an ADL. This finding is interesting because there are few effective treatments for this impairment and its negative impact on independence is unquestionable. The HSG used in this study were inexpensive, easy to fabricate, easy to implement, and could be used in conjunction with other treatment techniques.

The finding that HSG effects may potentially generalize to tasks when the glasses are not being worn is also interesting because few studies have identified treatment benefits that extended beyond the test situation and materials (Halligan, Donegan, & Marshal, 1992; Robertson, 1994). The optimum length of time for a person to wear the glasses has not been determined, however, based on recent studies, longer rather than shorter duration is advised.

Not all subjects may benefit from HSG. Therapists can use the methods presented in this study to determine which patients are appropriate for this type of intervention and what type of HSG are most effective for each of them. It should be noted that the subject in this study did not make large improvements on the tests when she wore the HSG. Therefore, it appears that an initial strong reaction is not required for potential benefit. In fact, subsequent research must ask

whether an initial immediate response is necessary at all. This is particularly important in view of the potential variability in shape cancellation test scores. Perhaps persons with UN that did not demonstrate an instantaneous benefit would still make gains after a long exposure.

The investigator was unable to assess the impact of the 28% VLT HSG on the subject due to methodology and resource restrictions. These HSG may have been less beneficial, more beneficial, or beneficial for different types of tasks. Therapists may want to use more than one type of HSG during treatment.

This study has raised more questions than it has answered. Future research will be required to determine if these results are replicable, and if so, identify the characteristics of persons who benefit HSG. The amount of time that a person needs to wear the HSG for maximal effect remains unknown. Whether different HSG benefit different ADL was unanswered in this study. Perhaps HSG will prove useful in unearthing different processes or fractionations of UN. Because the subject was recovering naturally over time, the baseline phases for two of the three behaviors had an improving trend. This led to some difficulty in interpretation of the effectiveness of the HSG across behaviors. Future research might explore the effectiveness of the HSG on persons with longstanding UN. This population would likely produce more stable baseline data and result in a clearer analysis of the effectiveness of the HSG across behaviors. Research with this population would also provide further insight into the forced use principle and the possibility of unmasking latent abilities.

Although the variability in the shape cancellation scores were an incidental finding, further research concerning the test's reliability would be beneficial to clinicians and researchers alike. Occupational therapists should be cautioned against using the tool as a sole indicator of the degree of neglect or the degree of recovery. Given that the ADL proved to be very sensitive to

UN, and that shape cancellation and line bisection may each demonstrate different types of UN, an assessment would not be complete without evaluation of a person's ADL and several types of pencil paper tasks.

It is hoped that this research will prove useful on many fronts. Most directly and immediately, it has implications for occupational therapy practice. It has identified a potentially promising form of treatment for an impairment that has had very few therapeutic successes. The treatment is inexpensive, easy to apply, can be used during ADL, and has potentially far-reaching effects. However, much work needs to be done. Questions about the effectiveness of this treatment remain and the conclusions need to be vigorously re-analyzed. UN remains an enigma. Ultimately, it is hoped that this research will contribute to general theory, and therefore to a fuller understanding of how humans process spatial information.

The last word in this thesis belongs to the subject in this study. Rarely a day went by when she did not provide an unsolicited compliment about the value of practicing the ADL measures. The pencil and paper tasks were a bore. This paper would be remiss if it did not emphasize this point, her point of view. The value of incorporating meaningful ADL into therapeutic techniques cannot be underestimated.

Appendix A

Hemispatial Glasses



Figure A1 Photograph of taped version of HSG

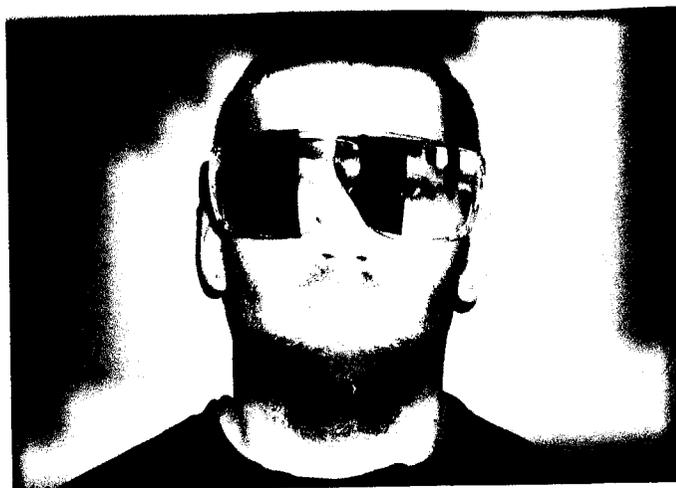


Figure A2 Photograph of 8%VLT HSG

Appendix B

Dependent Measures

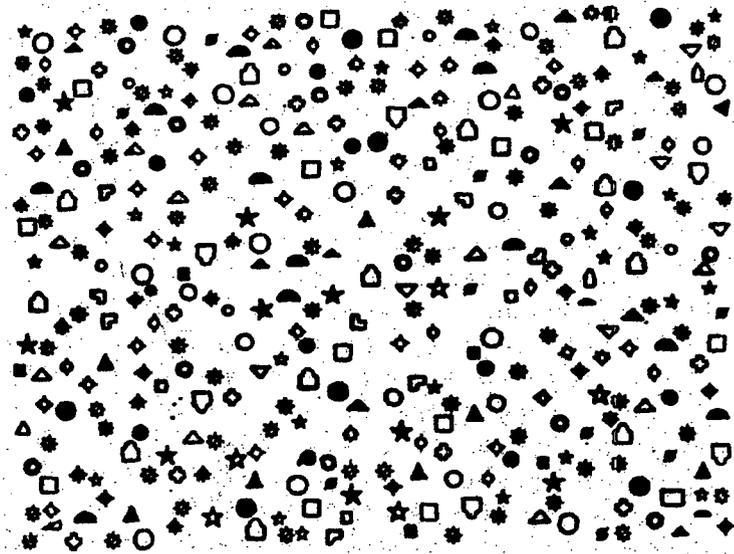


Figure B1 Shape Cancellation. Mesulam, (1985).

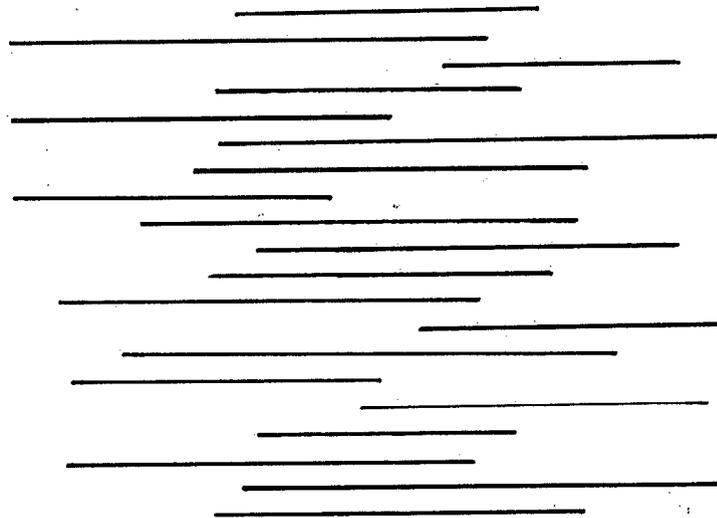


Figure B2 Line Bisection

Appendix B

Subjective Neglect Questions

Problems in everyday living (S)

Name Date

Address

Below are examples of things that happen to people in everyday life. We would like to know how often, on average, each of these has happened to over the past month. Write the appropriate letter in the box beside the item, for example, if the problem never occurs put A in the box.

People may vary from day to day but we would like an overall impression of how often these problems occurred. Please put a single letter in EVERY box and leave no blanks.

- A Once or less in the last month
- B Less than once a week
- C About once a week
- D More than once a week but not every day
- E Once or more in a day

How often has each of the following problems happened over the last month? Please write the appropriate letter by each question.

- 1. Bump into furniture
- 2. Bump into door frames
- 3. Have difficulty finding way around
- 4. Bump into walls or hedges when outside

- 5. Place only one foot on the wheelchair footplate
 - 6. Find the wheelchair veers off to one side
 - 7. Fail to notice a person standing beside you
 - 8. Misread words or miss words when reading newspaper or books
 - 9. Have difficulty seeing someone standing on one side of the room
 - 10. Have to check what you've written for mistakes
 - 11. Make errors when dialling a telephonic number
 - 12. Both legs through one hole in underwear or trousers
 - 13. When eating, have difficulty finding items such as sugar, a drink, etc. when placed to one side
 - 14. When washing or drying dishes, knock them over
 - 15. Feel you are clumsy
 - 16. Mislay toothpaste, etc., in the bathroom
 - 17. Misread time on clocks or watches
 - 18. Have problems with games, such as bingo/cards/dominos, because of difficulty seeing part of the card/piece
 - 19. Have difficulty with crosswords
- Is there a particular side you have difficulty seeing t left/right/neither/both

Figure B3 The Subjective Neglect Questionnaire (Towle, D. and Lincoln, N.B.,1991).

Appendix B

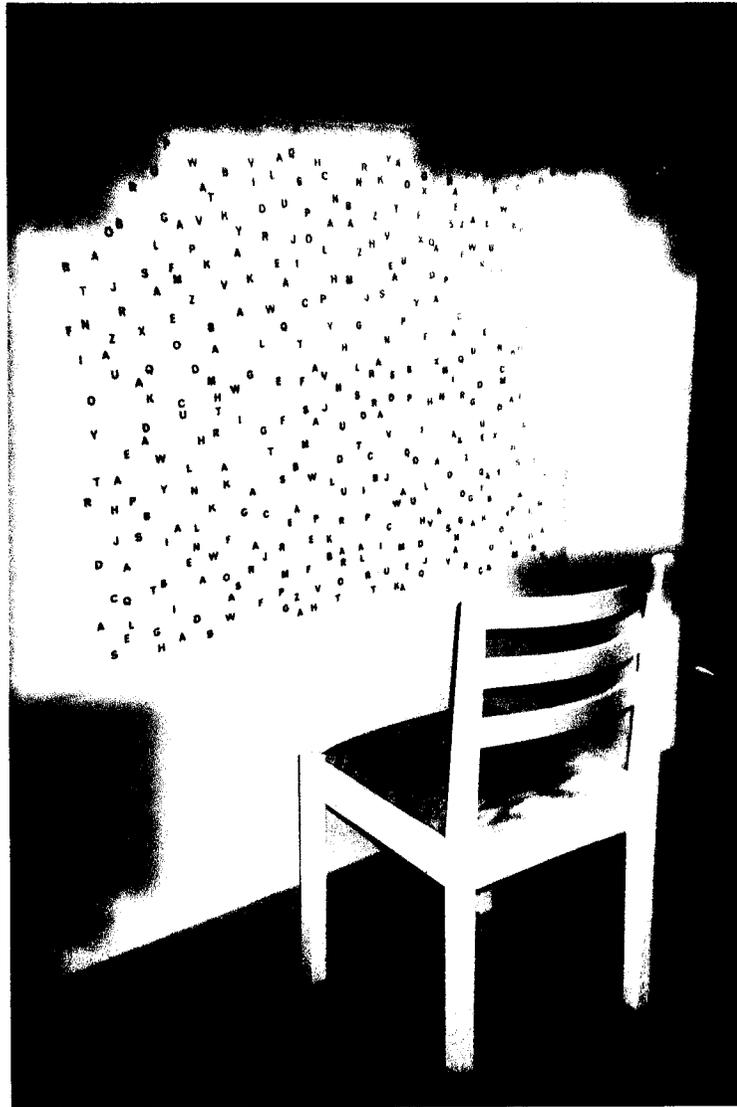
Enlarged Shape Cancellation

Figure B4 Enlarged Shape Cancellation. Mesulam (1985).

Appendix B

Shelf Scanning Task

Figure B5 Photograph of objects on shelves.

Appendix B

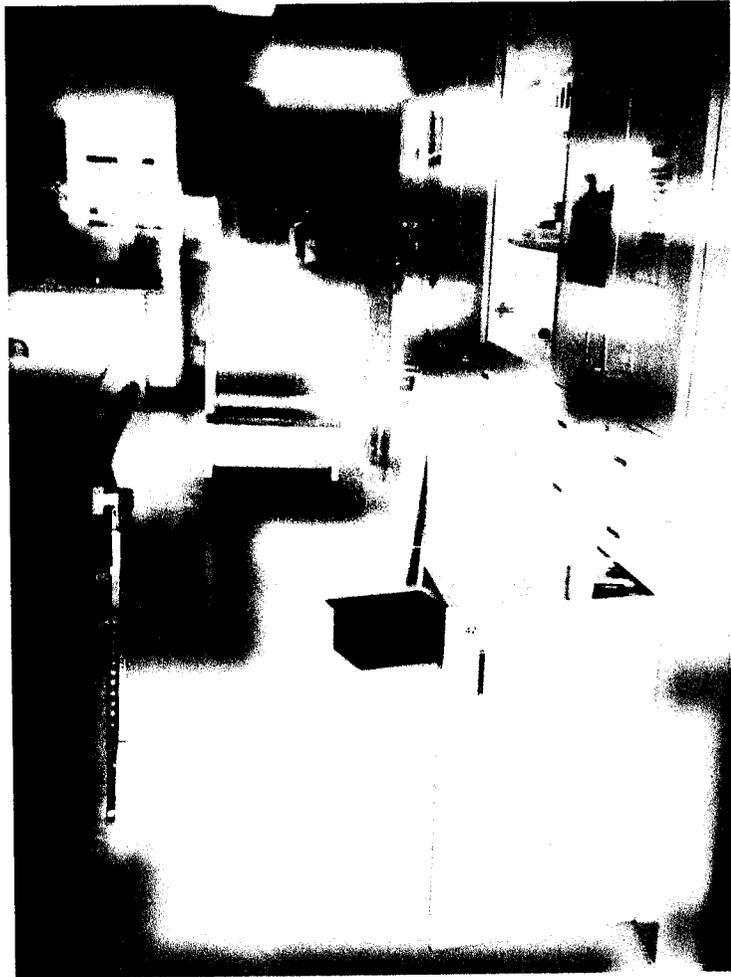
Mobility Task

Figure B6 Photograph of section of obstacle course.

Appendix B

Closing Interview Questions and Responses.**1. How do you feel about the experiment you participated in?**

I think it helped me look to the left. I'm glad I was in it. Practice using w/c was beneficial.

2. Do you think the glasses were of any benefit?

Not very much. If anything, it was repetition and reminder to look on left.

3. If not, how do you know that? What has not changed? If so, in what way (anything specific regarding ADL)?

I seemed to be able to do some of the tasks just as well using the glasses without the tape.

4. What was your experience when you put the glasses on? Did you find them bothersome in any way?

The tape tickled my face. It was annoying.

5. Was there any particular aspect of the research that you liked or disliked?

I liked scanning of the grocery shelves, monotonous especially small scan sheet.

6. Is there anything you would like me to know about your experience that might, in the future, help me when I am working with people with facing similar difficulties as you and designing therapies for them?

Repetition to remind people to look on left.

Figure B7. Closing questions and responses.

Appendix C

The Behavioral Inattention TestGeneral Information and Protocol

Behavioural inattention test

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Janet Cockburn

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Thames Valley Test Company

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Flempton

Bury St Edmunds

Suffolk

IP28 6EL

England

ISBN 0-9514322-2-2

Validation of the Behavioural inattention test

Subjects

All patients who entered Rivermead Rehabilitation Centre, Oxford, England, over an 18 month period with a presumed unilateral cerebral lesion were included in the study. Of the 125 patients thus identified, 30 were subsequently excluded because of bilateral motor weakness, apraxia, severe visual impairment, general cognitive deterioration, or severe language comprehension deficits. Those with milder language difficulties were, however, included in the study. Results from a further 15 patients who were found to have other than cerebrovascular aetiology were also excluded from the analysis. Information from the complete neurological examination of each patient on admission was taken into account when assessing them neuropsychologically. Fifty four of the remaining 80 patients had right sided lesions and 26 left sided lesions.

A control group of 50 non-brain damaged subjects was seen in order to provide normative data for the test items. These were recruited from several sources, including hospital employees, members of Oxford University subject panel,

and volunteers from community based groups.

Table 1 gives demographic details of patients and control subjects.

Table 1: Demographic details

	LCVA	SD	RCVA	SD	Total	SD	Controls	SD
Number of patients	26		54		80		50	
Mean age	54.6	12.5	57.7	8.4	56.2	10.5	58.2	13.5
Age range	19-83		33-74		19-83		22-82	
Sex	M-17/F-9		M-35/F-19		M-52/F-28		M-14/F-36	
Mean IQ	108.7	9.8	108.6	9.6	108.65	9.7	115.1	9.2
Patients with complete data	21		52		73		50	
Visual field defects	7 (27%)		24 (44%)		31 (39%)		-	

Results

The scores of the control subjects were used to establish the limits of normal performance and to allow determination of cut-off points for individual components of the test. Scores are shown in Tables 2 and 3.

Table 2: Results of 50 control subjects on conventional sub-tests

Sub-test	Maximum score	Mean score	SD	Range	Cut-off score
Line crossing	36	35.96	0.19	35-36	34
Letter cancellation	40	38.12	1.98	33-40	32
Star cancellation	54	53.72	0.54	52-54	51
Figure and shape copying	4	4.00	0.00	4	3
Line bisection	9	8.96	0.10	8-9	7
Representational drawing	3	3.00	0.00	3	2
Totals	146				129 (see page 11: A note on scoring)

Table 3: Results of 50 control subjects on behavioural sub-tests

Sub-test	Maximum score	Mean score	SD	Range
Picture scanning	9	8.38	0.75	6-9
Telephone dialling	9	8.97	0.14	8-9
Menu reading	9	9.00	0.00	9
Article reading	9	9.00	0.00	9
Telling and setting the time	9	9.00	0.00	9
Coin sorting	9	9.00	0.00	9
Address and sentence copying	9	8.90	0.10	8-9
Map navigation	9	9.00	0.00	9
Card sorting	9	9.00	0.00	9
Total	81			

Reliability

Inter-rater reliability was established by having 13 subjects scored independently but simultaneously by two raters. The correlation between both testers was 0.99 ($P < 0.001$).

Parallel form reliability was calculated by administering two alternative versions of the test to 10 subjects. Half were tested first with Version A and the others were tested first with Version B. Correlation between the two versions was 0.91 ($P < 0.001$).

Test-retest reliability was established by assessing 10 subjects on two separate occasions with a mean interval of 15 days. The two administrations of the test resulted in a correlation of 0.99 ($P < 0.001$).

Validity

The validity of the test as a measure of visual neglect was established in two ways. The first considered the relationship between scores on the behavioural battery and scores on the conventional tests for all 80 patients. The second compared the behavioural scores for each patient with the responses to a short questionnaire completed by the relevant therapist at the time of the assessment. The respective correlations were 0.92 ($P < 0.001$) and 0.67 ($P < 0.001$).

General information

A note on scoring

Testing should take place in a quiet room with the subject seated at a table. The examiner should be seated directly facing the patient. All materials should be presented on a neutral background. It is not always possible to test certain items with dysphasic and/or hemiplegic patients: some items can be adapted and relevant instructions for these items are provided. It is advisable, as with all visual perceptual tests, to ensure that visual acuity and other oculomotor aspects of vision have been taken into consideration (Gianutsos and Matheson, 1987).

All test stimuli are placed directly in front of the subject's mid-sagittal plane (see Fig. 1). The subject can move his/her head but is not allowed to move the material/stimulus.

Unless directed otherwise, individual instructions may be repeated once. In general, the instructions may be paraphrased as long as the intent of the item is not distorted. Subjects should be asked to indicate when they have completed each sub-test. All subjects should be encouraged to attempt each item.

In each sub-test the strategy is to record the number of *omissions*. Errors of *commission* and/or other types of error are noted but not scored. Such errors may indicate other perceptual/cognitive disorders and should be recorded for further investigation.

Norms for the six conventional sub-tests were established from the results of the 50 control subjects. The total score derived from performance on the conventional sub-tests is used to determine whether an individual evidences UVN. A subject was considered to have visual neglect if his/her aggregate score on the six conventional sub-tests fell below that of any control subject. The cut-off score was set at 129. Using this operational definition we found that 30 (37.5%) patient-subjects were classified as showing neglect. The characteristics of the neglecting and non-neglecting patients are shown in Table 4.

There was no significant difference between the two groups in age, IQ or time post stroke. Not surprisingly, however, fewer left hemisphere strokes showed neglect.

It is suggested that the conventional sub-tests may be used to diagnose the presence/absence of UVN, and the behavioural sub-tests used (a) to indicate the type of everyday problems likely to occur because of UVN, and (b) to guide therapists in the selection of tasks to work on in rehabilitation.

Although visual neglect is generally considered to be a failure to respond in free vision to stimuli situated on the side contralateral to a cerebral lesion, it may be documented for ipsilateral space omissions. The scoring sheet enables the construction of a profile of omissions wherever they occur. Detailed scoring instructions for each sub-test are supplied on the scoring sheet.

Figure 1

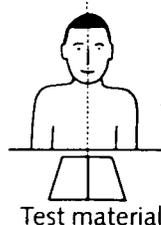


Table 4: Distribution of neglect among 80 patients

	Neglect patients	SD	Non-neglect patients	SD
Number of patients	30 (37.5%)		50 (62.5%)	
Mean age	58.2	8.3	55.8	10.76
Age range	41-72		19-83	
Sex	M-16/F-14		M-36/F-14	
Mean IQ	106.1	7.8	110.2	9.7
Number of patients with complete data	29		45	
Laterality of lesion	R 26 (87%) L 4 (13%)		R 28 (56%) L 22 (44%)	

Conventional sub-tests

1 Line crossing

Description: Subjects are presented with a page containing 40 one-inch (25 mm) long lines. The page is placed directly in front of them (see Fig. 1). The lines appear to be randomly spaced about the page but are in fact grouped into three columns containing six lines on either side of the midline.

Instructions: 'On this page we have many lines pointing in different directions. Follow my pen as I indicate these lines.' (Move pen right to left, top to bottom over all the lines on the page). 'Now with this pen, I want you to cross out all the lines which you can see on the page, like this.' (Illustrate by crossing out two of the four central lines).

Some patients may initially cross out only those lines which appear to correspond to the orientation of the example. In such cases the patient should be instructed to cross out *all* the lines irrespective of orientation.

Scoring: The total number of lines crossed is noted. The maximum is 36 (18 left, 18 right). The four lines of the central column are not scored.

2 Letter cancellation

Description: Subjects are presented with a sheet of paper containing five lines of letters (34 per line). The stimulus letters E and R are scattered randomly throughout the page. The examiner points to the letters E and R at the bottom of the stimulus sheet.

Instructions: This page contains many letters of the alphabet. Look at the page and every time you see the letter E or R cross it out with your pen.' (Illustrate by crossing out the letters E and R located at the bottom of the stimulus sheet.) 'Try not to miss any of the letters. When you have finished put your pen down.'

Scoring: The total number of crossed E's and R's is scored. The scoring template divides the page into sections for further analysis of omissions. The maximum score is 40 (20 left, 20 right).

3 Star cancellation

Description: Subjects are presented with a page containing 52 large stars, 13 randomly positioned letters and 10 short words, interspersed with 56 smaller stars.

Instructions: 'This page contains stars of different sizes. Look at the page carefully – this is a small star. Every time you see a small star, cross it out like this.' (Illustrate by crossing out the two small stars immediately above the centralising arrow on the stimulus sheet.) 'I would like you to go through this page and cross out all the small stars without missing any of them.'

Scoring: The total number of small stars cancelled is noted. The response sheet can be further divided into six sections by the scoring template for further analysis of omissions. Total number of stars is 54 (27 left, 27 right).

4 Figure and shape copying

Description: (a) The subject is instructed to copy three separate, simple drawings from the left hand column of a page. The three drawings, a star, a cube, and a daisy, are arranged vertically. They are clearly indicated to the subject.

(b) After completing the copying in task (a) the subject is required to copy a group of three geometric shapes on a separate sheet of paper. On this occasion, the contents of the page are not pointed out.

Instructions: (a) 'On the left side of the page are three simple drawings.' (Indicate all three.) 'I want you to copy all three as well as you can in these boxes over here.' (Indicate.)

(As left handed individuals or those unable to use their right hand might obscure the drawings with their left arm, they are given a second copy of the stimulus placed on the table above the stimulus sheet.)

(b) 'Copy the drawings you can see on this page.'

Scoring: The scoring of this sub-test is based on the completeness of the respective drawings (1–4). Failure to complete is defined as the omission of any major component of the drawing (examples are provided in the Appendix).

Behavioural sub-tests

1 Picture scanning

Description: The subject is presented with three large colour photographs, one at a time.

These depict:

- (1) a meal on a dish
- (2) a wash basin and toiletries
- (3) a large window flanked by sundry objects.

Each photograph has various items arranged about its midline. The subject is asked on each occasion to name and point to the main items seen in the picture. The photograph is placed directly in front of the subject (Fig. 1) and should not be moved. It is important to emphasize that all major items seen should be pointed to, especially those cases where there are two of any item (e.g. flowers, curtains).

Instructions: 'This is a picture of a ... I would like you to look at the picture carefully and then name and point to those major items you see in the picture. Do not miss any of the items and be careful to *point to and name* each item you see ... Is there anything else you can name or point to?'

(Patients with language disorders may point to various items and this will suffice to indicate that the item has been seen.)

Scoring: A record of all items mentioned is kept. Errors of identification (for example, 'cabbage' for 'lettuce' in Picture 1) are *not* scored. Only omissions are scored, indicating neglect.

2 Telephone dialling

Description: A disconnected telephone with numbered dial or push button keyboard is presented to the subject. Three cards with telephone numbers printed in large numerals are presented to the subject, one at a time. These are placed directly in front of the telephone (the telephone being in line with the subject's mid-point). The subject is instructed to dial the numbers presented.

If this sub-test is administered to subjects unfamiliar with British telephone numbers, testers may request the subject to dial a telephone extension.

Instructions: 'Here we have a telephone. Would you please dial some numbers for me.'
(Cards presented one at a time.)

Scoring: The subject's dialling sequence is recorded together with the location and number of omissions. (See scoring sheet.)

(It is not necessary for the subject to hold the receiver while dialling. On this task incorrect numbers are also scored as indicating neglect.)

6 Coin sorting

Description: The subject is presented with an array of coins (six denominations in all, three of each denomination). S/he is asked to indicate the coins according to the denomination called out. This is arranged according to a pre-set order.

Instructions: 'Here we have a selection of coins which I would like you to look at. There are three rows altogether (indicate). I am now going to call out various names of coin and I'd like you to point to the coin or coins I name. Be sure to point out all the coins of each type called out.'

Scoring: All coins identified are recorded on a score sheet. The score is based on the number of omissions. Location of omissions can be noted on the score sheet.

7 Address and sentence copying

Description: The subject is presented with a sheet of white paper and instructed to copy (a) an address, and (b) a sentence. The address and sentence are presented separately and opposite the subject's mid-line. Neither should be moved.

Instructions: 'I would like you to copy an address that I am going to place before you (place address in position). Please copy this as carefully as you can on the sheet of paper in front of you. . . . Now I'd like you to copy this short sentence, again as carefully as you can.' (Place sentence in position.)

Scoring: Use of the ampersand (&) is not acceptable and is scored as omitting two letters. The total score is calculated from the number of letters omitted.

8 Map navigation

Description: The subject is presented with a network of pathways connecting letters of the alphabet.

Instructions: 'Here we have a view of a road system. Note at each junction the letters A, B, C, D, E, F, G, H and K (indicate by pointing). I would like you to use your finger to travel between the letters on the map that I will call out to you. For example, B-A, B-C.' (Demonstrate). (The three sets of sequential directions are called out.)

Scoring: Score three points for each correctly traced route. Failure to complete segments of the route sequence incurs a deduction of one point per segment failed, down to a minimum of 0.

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Clock faces supplied by Early Learning Centre, Hawksworth, Swindon, England.

The test materials were printed by Herald Graphics, Aldermaston, Reading and John Bower Studios Ltd, Reading. The pack was manufactured by Packkids, Twyford, Reading.

Appendix D

Scoresheets

Shelf Scanning Task							
1. 1/20 <u>9</u>	2. 1/20 <u>6</u>	3. 1/20 <u>14</u>	4. 1/20 <u>1</u>	5. 1/20 <u>3</u>	6. 1/20 <u>11</u>	7. 1/20 <u>5</u>	8. 1/20 <u>7</u>
9. 1/20 <u>12</u>	10. 1/20 <u>8</u>	11. 1/20 23 <u>20</u>	12. 1/20 <u>20</u>	13. 1/20 <u>17</u>	14. 1/20 <u>22</u>	15. 1/20 <u>2</u>	16. 1/20 <u>15</u>
17. 1/20 <u>16</u>	18. 1/20 <u>21</u>	19. 1/20 <u>4</u>	20. 1/20 <u>24</u>	21. 1/20 <u>13</u>	22. 1/20 <u>19</u>	23. 1/20 <u>10</u>	24. 1/20 <u>18</u>

Date _____ Session number _____
 Objects located left _____ right _____
 Hemispatial Glasses yes no _____
 Time Left _____ Time Right _____

Figure D1 Shelf scanning score sheet. The three rows of boxes represent the three shelves (1-24). Each box corresponds to an analogous location of the shelf. The printed number in each box indicates when in the sequence that item was asked for on that day. For example, the item in location 1 (top shelf, extreme left) was the 9th item requested. The number /20 represents time taken to locate the item.

Appendix D

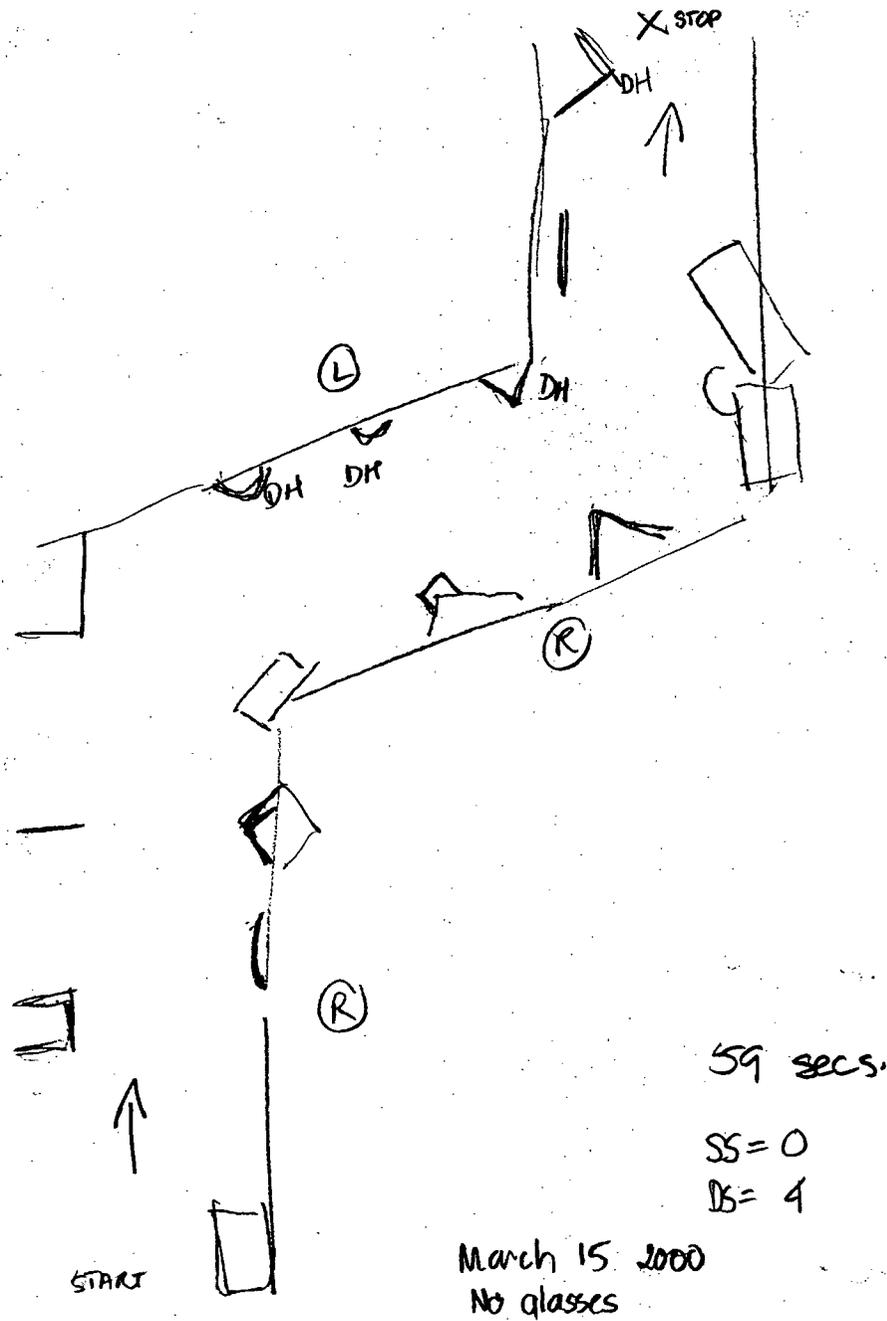
Mobility Task

Figure D2 Mobility task score sheet. The course was designed in advance and drawn on a sheet of paper. The contacts were recorded as the subject proceeded through the course.

Appendix D

Room Look about Task

Mar 23 2000
Room lookabout

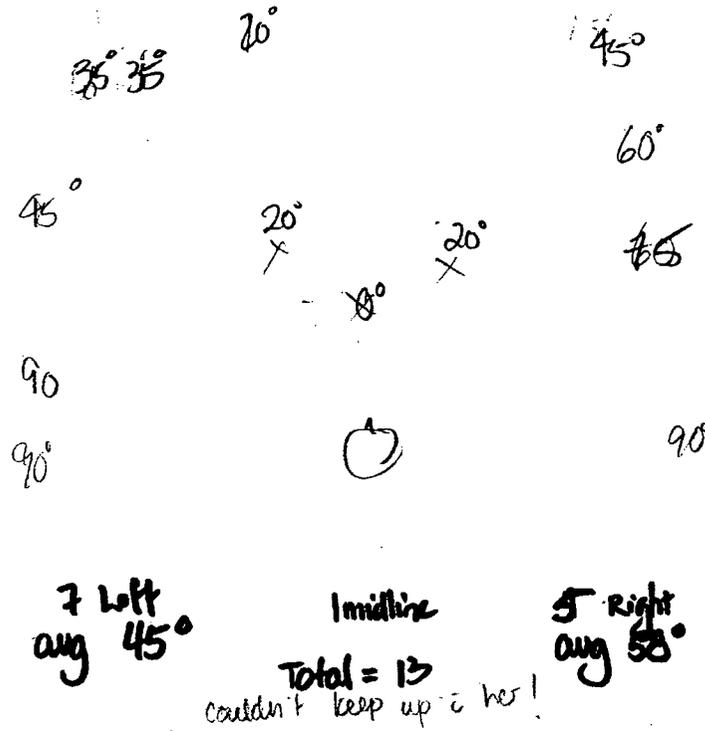


Figure D3 The numbers represent the locations of the items that were called out by the subject. The numbers are given in degrees right and left of center relative to the subject.

Appendix E
Raw Data and Calculations

Grocery Shelf Scanning Result: Raw Data					
Day	# ^a L/12	^b Time	#R/12	Time	HSG ^c (Y or N)
1	0	202	9	110	N
2	3	217	11	63	N
3	2	224	12	40	N
4	4	207	11	69	N
5	3	212	12	27	N
6	5	202	11	31	N
7	5	208	11	89	Y
8	5	172	12	36	Y
9	5	196	11	69	Y
10	8	178	12	55	Y
11	6	179	11	52	Y
12	1	224	11	35	N
13	4	199	12	36	N
14	5	189	12	37	N
15	5	202	11	34	N
16	5	179	12	69	N
17	5	176	12	43	Y
18	7	157	11	40	Y
19	6	167	11	62	Y
20	10	110	12	45	Y
21	8	141	11	44	Y
22	8	146	12	—	Y
23	7	156	12	31	Y
24	7	142	11	53	Y
25	10	135	11	77	Y
26	7	176	12	39	Y
27	7	167	12	29	N
28	7	151	12	14	N
29	7	149	11	41	N
30	9	153	12	21	N
31	11	119	12	23	N
32	6	152	12	25	N
33	9	147	12	28	N
34	7	147	12	31	N
35	9	125	12	11	N
36	10	145	12	26	N
37	11	104	12	21	N
38	12	111	12	40	N
39	8	145	12	29	N
40	10	129	12	31	N
41	10	134	2	15	N
42	9	135	12	18	N
43	9	136	12	32	N

Table E1. Note. ^aL = objects seen on left; ^b Time in seconds; ^cY/N = yes or no

Appendix E

Grocery Shelf Scanning Scores: Computations

A1) mean = 3.0	median = 3.0	slope: $2,2 \ 5,4 = 2/3 = 0.7$
B1) mean = 5.8	median = 5	slope: $8,5 \ 10,6 = 1/2 = 0.5$
A2) mean = 4.0	median = 5	slope: $12,5,3 \ 15,5,5 = 2/3 = 0.7$
B2) mean = 7.4	median = 7.0	slope: $8,7 \ 25,7 = 0/7 = 0$
A3) mean = 8.0	median = 7.0	slope: $29,7 \ 32,9 = 2/3 = 0.7$
C) mean = 9.5	median = 9.5	slope: $36,9 \ 41,10 = -1.5 = -0.2$

Table E2. Computations by phase. Slope = $\frac{\text{rise}}{\text{run}}$ or $\frac{\Delta y}{\Delta x}$

Appendix E

Self Scanning Task Inter-rater Reliability Calculations

Days	Day 9			Day 23			Day 39		
	I	SR	Agreement Y/N	I	SR	Agreement Y/N	I	SR	Agreement Y/N
1	x	x	Y	x	x	Y	x	x	Y
2	☐	☐	Y	☐	☐	Y	x	x	Y
3	☐	☐	Y	☐	☐	Y	☐	☐	Y
4	☐	☐	Y	☐	☐	Y	☐	☐	Y
5	☐	☐	Y	☐	☐	Y	☐	☐	Y
6	☐	☐	Y	☐	☐	Y	☐	☐	Y
7	☐	☐	Y	☐	☐	Y	☐	☐	Y
8	☐	☐	Y	☐	☐	Y	☐	☐	Y
9	x	x	Y	x	x	Y	x	x	Y
10	x	x	Y	☐	☐	Y	☐	☐	Y
11	☐	☐	Y	☐	☐	Y	☐	☐	Y
12	☐	x	N	☐	☐	Y	☐	☐	Y
13	☐	☐	Y	☐	☐	Y	☐	☐	Y
14	☐	☐	Y	☐	☐	Y	☐	☐	Y
15	☐	☐	Y	x	x	Y	☐	☐	Y
16	x	x	Y	☐	☐	Y	☐	☐	Y
17	x	☐	N	x	x	Y	☐	☐	Y
18	x	x	Y	x	x	Y	☐	☐	Y
19	x	x	Y	x	x	Y	x	x	Y
20	x	x	Y	☐	☐	Y	☐	☐	Y
21	☐	☐	Y	☐	☐	Y	☐	☐	Y
22	☐	☐	Y	x	x	Y	☐	☐	Y
23	☐	☐	Y	☐	☐	Y	☐	☐	Y
24	☐	☐	Y	☐	☐	Y	☐	☐	Y
	16/24	16/24	22/24	17/24	17/24	24/24	20/24	20/24	24/24
	Total Score Agreement = 100%			Total Score Agreement = 100%			Total Score Agreement = 100%		
	Location by Location Agreement = 92%			Location by Location Agreement = 100%			Location by Location Agreement = 100%		

Table E3. Note. I = Investigator, SR = Second Recorder, Agreement - Yes or No, x = object not found, ☐ = object found

Appendix F

Mobility Task

Day	Left			Total	Right			T
	#DH	#SS	#Rep		#DH	#SS	#Rep	
1	6		6	12.0	0	0		0.24
2	6	1	3	9.25				<1.00
3	12	2		12.5				2.00
4	7	6	1	9.5				1.30
5	5		2	5.5				1.20
6	7	2		7.5				
7	5		3	6.5				1.14
8	2	3		2.75				1.48
9	6	4		7.0				
10	6	2		6.5				1.16
11	2	2		2.5				2.16
12	2	3		2.75				2.23
13	5	2		5.5				1.59
14	3	2		3.5				
15	4	3		4.75				2.10
16	5	2		5.5				
17	1	1		1.25				1.25
18	3	1		3.25				
19	3	0		4.0				1.02
20	2	2		2.5				1.37
21	2	2		2.5				
22	3	2		3.5				
23	1	1		1.25				1.00
24	3	1		3.25				1.00
25	0	0		0.0				
26	3	0		3.0				
27		1		0.25				N/A
28	1	1		1.25				N/A
29	2	1		2.5				N/A
30	0	2		0.5				N/A
31	0	1		0.25				N/A
32	1	2		1.5				1.09
33	3	0		3.0				1.00
34	0	0		0.0				0.43
35	1	4		2.0				1.01
36	1	0		1.0				1.22
37	3	1		3.25				1.21
38	0	1		0.25				1.16
39	1	0		1.0				1.07
40	0	1		0.25				1.04
41	1	2		1.5				N/A
42	0	1		0.25				N/A
43	2	0		2.0				N/A

Table F1. Mobility Task Raw Data.

Appendix F
Mobility Task

Phase	Baseline 1	Treatment	Baseline 2	Generalization			
mean	7.4	4.4	1.9	1.5			
median	7.0	4.75	2.5	1.0			
slope	9.5,3	6.5,8 = 3/5	12.5,4.13	15.5,5.13 = -1/3	20.5,2.8	29.5,1.4 = 1.4/9	36,1
	41,1=0/5						

Table F2. Mobility Task Raw Data Computations

Data for Inter-rater Reliability Calculations: Mobility Task.

	Day 4		Day 9		Day 12		Day 18		Day 23		Day 33		Day 39	
	#DH	#SS	#DH	#SS	#DH	#SS	#DH	#SS	#DH	#SS	#DH	#SS	#DH	#SS
I	5	2	6	4	2	3	3	1	1	1	3	0	1	0
S.R.	5	2	7	4	6	1	3	2	1	1	4	0	1	0
Agreement:	yes		no		no		no		yes		yes		yes	
Agreement on 4/7 days = 57%														

Overall agreement for total number of contacts:

100% 91% 71% 80% 100% 75% 100%

Average overall agreement = 88.1%

Table F3. Inter-rater reliability calculations for Mobility Task., S.R. = second recorder.

Appendix G

Room Look About Data

Day	# of object left of center
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	1
13	7
14	0
15	0
16	2
17	0
18	4
19	6
20	12
21	5
22	7
23	1
24	0
25	0
26	0
27	7
28	3
29	3
30	4
31	4
32	8
33	9
34	2
35	15
36	11
37	5
38	11
39	11
40	6
41	10
42	8
43	8

Table G1. Raw data for room look about task. Scores indicate the number of objects seen left of the subject's center.

Room look about task: Total number of objects seen across 240° .

Day	<u>Left</u>			<u>Right</u>		
	120°-91°	90°-46°	45°-0°	0°-45°	46°-90°	91°-120°+
1				3	4	3
2					4	
3				2	7	4
4					7	7
5				2	4	
6				8	9	
7			1	2	7	
8				3	5	
9				5	6	
10				1	13	2
11					4	6
12						
13		1	6	3	6	1
14				3	6	5
15				4	8	1
16			2	4	6	3
17				11	2	1
18			4	14	1	
19			6	7	2	
20		4	8	3		
21			5	7		
22			7	7	4	
23			1	10	7	
24				9	4	3
25				13	3	1
26				3	10	1
27		1	6	3	4	
28			3	5	5	
29			3	3	5	2
30			4	7	5	1
31			4	8	6	
32		1	7	3	4	
33			9	5	1	
34			7	10	1	1
35	3	5	7			
36		2	9	8	1	1
37			5	4	2	
38	1	5	5	6	2	1
39		3	8	6	1	
40		2	4	5	6	2
41		4	7	4	1	1
42	1	3	4	5	4	1
43		4	4	3	5	1

Table G2. Location of number of objects identified in room according to degrees left and right of center.

Room Look About Task: Proportion of objects seen across 240°

Day	<u>Left</u>		<u>Right</u>			
	<u>120°+-91°</u>	<u>90°-46°</u>	<u>45°-0</u>	<u>0°-45°</u>	<u>46°-90°</u>	<u>91°-120°</u>
1				30%	40%	30%
2					100%	
3				15%	55%	30%
4					50%	50%
5				33%	67%	
6				47%	53%	
7			10%	20%	70%	
8				38%	62%	
9				45%	55%	
10				6%	81%	13%
11					40%	60%
12						
13		6%	35%	19%	35%	6%
14				21%	43%	36%
15				31%	62%	77%
16		13%	27%	40%	20%	
17				79%	14%	7%
18		20%	70%	10%		
19		40%	47%	23%		
20		27%	53%	20%		
21		42%	48%			
22		39%	39%	22%		
23		6%	56%	38%		
24				56%	25%	22%
25				76%	17%	7%
26				21%	71%	8%
27		7%	43%	21%	29%	
28		23%	38%	38%		
29		23%	23%	38%	19%	
30		24%	41%	29%	6%	
31		22%	44%	33%		
32		7%	47%	20%	27%	
33		60%	33%	7%		
34		37%	53%	5%	5%	
35	9%	33%	58%			
36	10%	43%	38%	5%	5%	
37		45%	40%	15%		
38	5%	25%	25%	30%	10%	5%
39	17%	44%	33%	6%		
40	11%	22%	23%	33%	11%	
41	24%	41%	24%	6%	6%	
42	6%	17%	22%	28%	22%	6%
43		24%	24%	17%	29%	6%

Table G3. Location of objects identified given a percentage of the total number.

Appendix G

Interrater Reliability Calculations/Data For Room Look About Task

	Day 4	Day 9	Day 12	Day 18	Day 23	Day 33	Day 39
I	0	0	3	4	1	9	11
SR	0	0	3	4	1	9	7
Agreement	Yes	Yes	Yes	Yes	Yes	Yes	No

Table G 4. Inter-rater reliability calculations for room look about task. Scores represent the # of items reported that were left of the subject's center. I= investigator, SR= second recorder.

Appendix H
Small Cancellation Sheet

Day	#/30	^a Version	Raw Data.			
			Day	#/30	Version	
1	7			38	24	A
2	14			39	17	A
3	7			40	27	G
4	12			41	21	G
5	13			42	28	L
6	2	G		43	28	G
7	10	A				
8	22	G				
9	7	A				
10	2	A				
11	7	A				
12	12	A				
13	4	G				
14	18	G				
15	5	A				
16	15	A				
17	19	A				
18	16	G				
19	10	G				
20	24	A				
21	19	A				
22	14	A				
23	17	A				
24	11	A				
25	5	G				
26	13	A				
27	15	A				
28	18	G				
29	18	G				
30	9	A				
31	14	G				
32	11	A				
33	17	G				
34	28	A				
35	17	G				
36	20	A				
37	28	G				

Note: ^a Randomly provided either geometric (G) version or alphabet (A) version of the cancellation sheets.

Figure H1. Number of targets located on left of sheet/30.

Appendix I
Enlarged Cancellation Sheet

<u>Day</u>	<u>#/30</u>	<u>^aVersion</u>	<u>Raw Data.</u>		<u>Version</u>
			<u>Day</u>	<u>#/30</u>	
1	7		38	29	
2	17		39	27	
3	10		40	20	
4	24		41	20	
5	18		42	27	
6	6	A	43	30	
7	2	A			
8	0 data				
9	16	A			
10	16	G			
11	9	A			
12	18	G			
13	11	A			
14	15	A			
15	15	A			
16	19	G			
17	19	G			
18	22	A			
19	13	A			
20	26	G			
21	21	G			
22	23	G			
23	17	G			
24	15	G			
25	23	G			
26	18	G			
27	17	A			
28	27	A			
29	24	A			
30	18	G			
31	22	A			
32	14	G			
33	21	G			
34	15				
35	20				
36	23				
37	29				

Note: ^a Performed either alphabet (A) or geometric figures version (G) of cancellation sheets, randomly provided.

Figure II. The number of targets located on the left of sheet/30.

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