The purpose of this article is to summarize the research literature pertinent to the evaluation and treatment of unilateral neglect as it pertains to potential investigations by occupational therapists. In an earlier review of unilateral neglect (Van Deusen, Fox, 1983) I dealt with the clinical literature and the older studies and included implications for occupational therapy practice. The present article incorporates findings reported in the past 5 years and suggests avenues for research related to patients' function.

The term unilateral neglect denotes a deficit affecting the body half and/or extrapersonal space contralateral to the site of a brain lesion. Depending on the theoretical perspective, unilateral neglect has been labeled hemineglect, spatial neglect, extinction, imperception, hemi-inattention, unilateral spatial agnosia, or visuospatial agnosia (Gianutsos, Glosser, Elbaum, & Vroman, 1983). It should not be confused with hemianopsia, a specific visual field defect, although the presence of this condition may amplify the deficit of unilateral neglect (Gianutsos et al., 1983; Heilman, Valenstein, & Watson, 1985). That hemianopsia is not synonymous with unilateral neglect is supported by the fact that these two conditions do not always occur together and also by the results from a study of 5 subjects with unilateral neglect in which movement of a line bisection task into the perceived right hemispace improved performance as opposed to requiring mere head movements (Heilman, Bowers, & Watson, 1983).

Unilateral neglect is a serious rehabilitation problem because of its association with deficits in reading, writing, arithmetic, and various basic self-care skills (Anderson, 1971; Denes, Semenza, Stoppa, & Lis, 1982; Kinsella & Ford, 1980; Lawson, 1962; Lorenze & Cancro, 1962; Wade, Langton, Hewer, Skillebeck, & David, 1985). Two studies indicated that having unilateral neglect was a major predictor of poor recovery in terms of activities of daily living in patients with right hemisphere lesions (Denes et al., 1982; Kinsella & Ford, 1980). Furthermore, unilateral neglect is not a transitory problem. Denes et al. (1982) found that 7 of 8 patients with left neglect had retained the problem at 6-month follow-up. Although Colombo, de Renzi, and Gentilini (1982–1983) in their 10-month follow-up study found that only a few subjects had failed to improve at all, most still did retain some minor signs of unilateral neglect.

Evaluation

Clinical procedures for the evaluation of unilateral neglect include having the patient copy or draw figures, carry out pegboard and puzzle activities, bisect lines, do cancellation tasks, and identify or move body
parts on command. Diagnosis of left-side neglect is made if the patient consistently fails to fully complete the left part of activities or tasks (Van Deusen Fox, 1983). Based on these clinical procedures, more rigorous tests of unilateral neglect have been developed.

The Instruments

In 1976, Colombo, deRenzi, and Faglioni reported a set of "space exploration" tests with more precision than was typical with tests of that period. At a time when test data from control subjects were usually not collected, these authors reported cut-off scores based on the data of 50 control subjects. Among their instruments was a ball and hole test for which a box 105 cm long and 45 cm high was used. Fifteen holes were placed to the left and 15 to the right. Subjects inserted balls in these holes with and without the use of vision. Although formal validity and reliability studies were not conducted, parts of Colombo et al.'s battery did discriminate between subjects with brain damage and the control subjects.

At this time, reports of computerized key taps for the evaluation of unilateral neglect began to appear in the literature. Chedru (1976) used an imbalance score from 200 random taps to evaluate unilateral neglect. This method discriminated unilateral neglect subjects with right-hemisphere damage who did not have field defects from other subjects when their vision was occluded. Unlike those with unilateral neglect, the subjects with left-hemisphere damage and the control subjects produced symmetrically balanced keyboard taps.

Line bisection has been used clinically for decades to evaluate patients for unilateral neglect. Recently, several studies have documented the reliability and validity of this tool. Schenkenberg, Bradford, and Ajax (1980) designed a paper and pencil, line bisection test having two practice lines and six horizontal lines, 100 to 200 mm in length. Six lines each were placed to the left, right, and center on the page. Rotation of the paper created a comparable alternate form as tested with 38 normal subjects. This line bisection test was evaluated with 20 subjects who had diffuse cerebral damage, 20 subjects each who had left and right cerebral hemisphere damage, and 20 control subjects. The line bisection test clearly differentiated the subjects with right-brain lesions, 90% of whom had unilateral neglect, from the other groups. Harlowe and 1 (Van Deusen and Harlowe, 1987) also supported the construct validity of the Schenkenberg test by establishing an association between it and a second test purported to measure unilateral neglect. However, Downing (1986) found no relationship between a computerized line bisection test and the Schenkenberg test. Apparently, the computerized version was not measuring the same construct as the Schenkenberg test.

The reliability of the Schenkenberg tool has also been examined. The test's authors reported test-retest coefficients from \( r = .84 \) to \( .93 \) (Schenkenberg et al., 1980). Because unilateral neglect is frequently seen in elderly occupational therapy patients and the mean age of the control subjects in the Schenkenberg study was 49 years, I provided normative data from 93 elderly subjects with a mean age of 70.5 years (Van Deusen, 1983). Measures of skewness and kurtosis showed data to be symmetrical but more peaked than for a normal distribution. The test-retest reliability coefficient for left-placed lines was only moderate at \( r = .68 \). Downing (1986) also obtained a moderate \( (r = .60) \) test-retest coefficient with her 40 elderly well subjects' left-placed lines.

Unsatisfied with the tools available for unilateral neglect evaluation, Gianutsos et al. (1983) developed more sensitive tests. Their Search-A-Word (SAW) and Speeded Reading of Word Lists (SRWL) are speeded, verbal instruments suitable for literate, English-speaking patients having no verbal language dysfunction. The SAW compares search times for left-versus right-side identification of word targets on standard size paper containing a number of letter arrays. SRWL involves computerized speeded word reading in three parts.

Four scores can be obtained from SRWL: anchoring errors, scanning effectiveness, proportion of success with side-placed versus center-placed words, and a periphery monitoring score. Data were obtained for control subjects and for subjects with brain damage. Construct validity was supported both by test scores distinguishing subjects with right-side brain injury from other subjects, and by means of a factor analysis. Two factors were clearly identified: left spatial hemi-imperception and lateral eye movement efficiency, that is, efficient eye function in scanning stimuli. Two foveal imperception factors were less clear. These authors emphasized that research was needed to relate these test results to functional activities.

Because they believed an everyday skills test would provide more comprehensive and appropriate information for developing rehabilitation programs for patients than do conventional tests, Wilson, Cockburn, and Halligan (1987) developed a behavioral skills test of visuospatial neglect. Items involved simulated meal eating, use of telephone, telling time, copying an address, and map reading. Errors on this skills test were significantly related to errors on conventional clinical tests such as copying drawings and letter cancellation. There was 82% agreement between medical unilateral neglect diagnoses in hospi-
Therapy aimed at increasing the function of unilateral tests. Test-retest (alternate form) reliability was $r = .83$, and interrater agreement was 100%. The authors are refining the scoring for this test, which is of particular relevance to occupational therapy.

**Implications for Research**

Although the instruments reported to measure unilateral neglect need further research support, it is apparent that some tools are currently available. These tools can be used in occupational therapy studies as further data on reliability and validity are collected.

Since a major need in occupational therapy research is for studies relating these instruments to functional activities of all types, I am making some suggestions regarding the kind of questions that could be studied: Is there a high association between scores on the SAW and SRWL and ability to select items from all sides of a hospital tray? From all shelves of a supermarket? Do scores on the ball and hole test relate to grooming or dressing success? Do patients who can appropriately plant seeds and weed gardens perform better on the Line Bisection Test than those who frequently miss the left side in their gardening pursuits? Is there a high correlation between defective left-sided performance on randomly assigned items and inability to perform well in a clerical job tryout? How does performance on skill items of Wilson’s test (Wilson, Cockburn, & Halligan) relate to other kinds of daily living functions?

**Therapy**

Therapy aimed at increasing the function of unilateral neglect patients can be viewed from two perspectives: changing the environment or changing the subject.

**Environmental Adaptation**

Adapting the environment has long been broached as a therapeutic possibility for unilateral neglect patients (Burt, 1970; Heilman et al., 1985). However, a retrospective study (Kelly & Ostreicher, 1985) gave little support to the notion that environmental manipulation is associated with treatment outcome for unilateral neglect patients. This study involved 39 unilateral neglect patients whose beds were positioned so that they could enjoy views or access functional equipment. Bed position was not related to length of hospitalization, recorded depression, discharge disposition, or occurrence of accidents.

In this area of environmental adaptation there is considerable room for occupational therapy research. Will a prospective study yield the same results as those reported retrospectively? If the dependent variables are more discriminating (for example a measure of subtle mood variation rather than only severe depression), will environmental manipulation affect the outcomes? Could manipulation of visual stimulation (such as photographs of loved ones on walls facing the unimpaired side) produce better results than mere facing toward an uncontrolled static view? Since occupational therapists are adaptation specialists, they are in a unique position to adapt environments for research purposes.

**Change in Patient**

Feasible approaches to therapy for change in patients exhibiting unilateral neglect are those aimed at (a) compensating for central nervous system deficits and (b) increasing central nervous system function through a neurological approach.

**The Compensatory Approach.** The rationale for this approach to therapy stems from research in learning theory. Training procedures relate to Skinnerian operant conditioning with behavior being shaped through feedback and positive reinforcement as well as to principles from other approaches to learning. As I pointed out in one of my earlier papers (Van Deusen Fox, 1983), clinical studies involving application of learning theory to the unilateral neglect patient have long been reported.

However, formal investigations of unilateral neglect patients receiving compensatory training were first emphasized during the 1970s. Diller and colleagues have reported a series of studies from the learning theory point of view (Diller & Gordon, 1981; Diller & Weinberg, 1977; Gordon et al., 1985; Weinberg et al., 1977, 1979). They studied effects of three training programs with subjects whose test results indicated presence of left-visual inattention. Diller and colleagues (Gordon et al., 1985) viewed their programming as treatment for a hierarchy of dysfunctions in the neglect syndrome. Principles basic to their training protocols were as follows (Diller & Weinberg, 1977):

1. Presentation to the left of a task sufficiently compelling to cause head turning (e.g., reading material).
2. Provision of a left-side anchoring point (e.g., vertical line), gradually eliminated.
3. Provision of verbal cues gradually reduced.
4. Guidance for even-paced environmental search (e.g., reading out loud).
5. Decrease of density of stimuli (e.g., letters, words).
Improvements observed in the Diller studies can be attributed to compensation for deficits because pre- and postexaminations in their initial study revealed no changes in neurologic status (Weinberg et al., 1977).

In their initial study (Weinberg et al., 1977), training with a scanning machine significantly differentiated between test battery scores of experimental subjects and those of control subjects. Major improvements were by subjects having the severest neglect on tasks of academic character closest to the training procedures.

The test battery included three levels of tests from primary (closest to the areas trained in the subjects) to tertiary (least related). The primary and secondary tests measured reading, arithmetic, and letter cancellation skills; the tertiary tests included tasks such as object assembly. Few significant differences between groups were observed in the performance of such tertiary tasks.

The second scanning experiment of Weinberg et al. (1979) was designed to also incorporate procedures for spatial organization and sensory awareness with the purpose of improving test scores previously not changed. The researchers' premise was that problems in sensory awareness and spatial organization are secondary to the visual neglect of space.

A third training method was developed by these researchers (Gordon et al., 1985), which incorporated complex spatial perceptual tasks within the visual scanning procedure. The intent of this training was to improve performance on the more cognitively demanding tasks where a subtle left-side inattention might hinder performance. Their 4-month follow-up study used all three training modules sequentially. At rehabilitation discharge, the experimental unilateral neglect subjects differed from the control subjects on several verbal and numerical tests. They also differed in line bisection and selected spatial tasks. However, by 4 months post discharge, the control subjects had also improved so that group differences had essentially disappeared. The long-term value of this type of treatment can therefore be questioned.

Pattern of daily activities, assessed by structured interview, also showed no significant differences at 4-month follow-up. Only one minor difference was observed at discharge (amount of leisure reading).

From a practical viewpoint it might appear that the investigation based on learning principles for compensation has been fruitless. However, if a body of research stimulates others to do their own research in an area, the original research has served an important function. The recent upsurge of research literature on the treatment of perceptual and cognitive dysfunction (Carter, Howard, & O'Neil, 1983; Corrigan, Arnett, Houck, & Jackson, 1985; Scherzer, 1986; Sivak et al., 1984) speaks to the influence of the pioneer work of Diller and colleagues in stimulating research in this area. Although unilateral neglect treatment is not the major thrust, some of this research focuses partially on scanning or basic attention. Carter et al. showed a difference on a visual scanning cancellation task between trained and control acute stroke patients. One elaborate long-term project (Scherzer, 1986) used a modified Ben-Yishay model, a seven-component rehabilitation program for adults with severe head trauma. One module used throughout the entire training program included exercises to improve basic attention and visual scanning and tracking. One of the positive results of this study was in the area of attention.

Of more relevance to occupational therapy for unilateral neglect is the recent application of the compensatory approach to studies involving functional activities. Webster et al. (1984), using a single-subject design, investigated the wheelchair mobility of three unilateral neglect subjects. Their scanning task involved a large, suspended board with colored light anchors, and their training incorporated movement in wheelchairs while scanning. All three subjects improved in left-side obstacle avoidance on their wheelchair evaluation course.

This study is illustrative of research directed to occupational therapy with unilateral neglect patients. The integration of activities of daily living (ADL) training with the principles from the Diller research series can provide many avenues for studies by therapists. Does graded decrease in left-side anchoring lines, in verbal cues, and in stimuli density with appropriate feedback improve eating behaviors, dressing process, or success in personal grooming? This type of questioning can lead to many specific hypotheses appropriate for investigation by occupational therapists.

The Neurological Approach. Several neurological theories to explain unilateral neglect have been proposed (Bisiach, Luzzatti, & Perani, 1979; Heilman et al., 1985). These various theoretical positions involved sensory deficit, perceptual dysfunction, or attentional defects.

The association of parietal lobe lesions with unilateral neglect gave strong support to the positions attributing neglect to inadequate body schema, representational mapping, or spatial perception. Poppleteuer and, later, Critchley (both cited by Heilman et al., 1985) first linked unilateral neglect with attentional deficits. According to the attentional deficit adherents, clinical observations and animal research revealing unilateral neglect from lesions outside the sensory and sensory association areas made the per-
ceptual construct as the essential explanation of unilateral neglect no longer feasible (Heilman & Watson, 1977).

Several studies suggested that unilateral neglect is a defect in the neural attentional (orienting or arousal mechanism). I reviewed studies relevant to occupational therapy (Van Deusen Fox, 1983) and cited a number of papers that showed associations among structures in the cortico-limbic reticular activating loop and suggested defects in this loop as pertinent to unilateral neglect.

Results of two studies conducted by occupational therapists were also consistent with the attentional rather than the perceptual dysfunction hypothesis regarding unilateral neglect (Van Deusen Fox & Harlowe, 1984; Van Deusen, & Harlowe, 1987). In the first study a stroke evaluation battery was analyzed. Factors (theoretical variables derived from analyzing test item intercorrelations) were defined. Five measures of perception—body scheme, figure ground, position in space, spatial relations, and stereognosis—loaded (weighted) on one factor. The only other "perceptual" measure in the rotated factor pattern was the measure of unilateral neglect, and it did not load on this perceptual factor, which suggests that it is not part of a perceptual dysfunction construct. The second study showed that scores on a line bisection test correlated significantly with the stroke battery's unilateral neglect scale, but not with the perceptual ratings from this battery.

Positing that unilateral neglect can occur with disruption anywhere in the cortico-limbic-reticular loop, Mesulam (1981) reviewed the relevant research literature. He suggested a function of each neural component in relation to unilateral neglect. The parietal lobes, frontal cortex, the limbic system, and reticular structures, respectively, function for internal sensory mapping, motor programming, motivation, and arousal.

One early proponent of this point of view was Kinsbourne (1977) who proposed that unilateral neglect represented an imbalance in lateral orienting tendencies. Normal subjects reflected hemispheric preference by looking to the left while solving perceptual problems and to the right while solving verbal problems. Kinsbourne suggested that the unilateral neglect patient with right brain damage is experiencing an imbalance in orienting response in favor of verbal over perceptual responses. The strong verbal stimulation from human intercommunication in a clinic setting enhances this imbalance for these patients whereas it decreases imbalance in the case of patients with left-brain lesion.

That verbal stimuli can aggravate left-side neglect and that perceptual stimuli lessen it was supported by a study of six stroke patients (Heilman & Watson, 1978). In a task involving crossing out verbal and perceptual stimuli, neglect of the left side was significantly less with the perceptual than with the verbal activity. Moreover, the use of verbal stimuli in the Diller studies (Weinberg et al., 1977) could account for the lack of neurologic changes of their subjects.

In another study (Mori & Yamadori, 1985) purported to support Kinsbourne's (1977) position, all subjects with instinctive grasp reaction (an exploratory, adaptable response, less primitive than the grasp reflex) also had left-side neglect. Mori and Yamadori interpreted this instinctive grasp reaction as a manual orienting response in accord with the imbalance posited by Kinsbourne.

Although interpreting their 1978 study results as support for Kinsbourne's (1977) position, Heilman et al. (1985) recently have noted their lack of complete agreement. Heilman and Kinsbourne share the major thesis that hemispheric imbalance of orientational tendencies is a major problem in the neglect syndrome. Whereas Kinsbourne emphasizes the imbalance due to increased stimulation of the nonlesioned side, Heilman believes damage to the neurons involved in attention, that is, decreases in the lesioned hemisphere, are responsible for imbalance.

Currently, Heilman's (1985) position is representative of one of the major neurology research-based positions on unilateral neglect. The extensive research of Heilman and colleagues has involved the neglect syndrome in animals and in people with or without brain lesions (Bowers & Heilman, 1980; Heilman, Bowers, & Watson, 1983; Heilman & Valenstein, 1979; Heilman & Van den Abeel, 1980; Watson, Valenstein, & Heilman, 1981).

Recently, Heilman et al. (1985) discussed the neglect syndrome under four categories: (a) hemi-inattention, (b) extinction, (c) akinesia, (d) hemispatial neglect. Hemi-inattention is the neglect of sensory input to the body side contralateral to the side of the brain lesion. It can involve auditory, somesthetic, or visual input and is an attentional arousal disorder induced by dysfunction in a corticolimbic reticular loop. Lesions in multiple sites in the cortex or in subcortical areas can cause hemi-inattention.

According to Heilman's view, the phenomenon of extinction of simultaneous stimulation is a limited attention situation. As the neurons involved in attention recover, minimal response is again possible to stimuli contralateral to the lesion side, but this side ceases to be the focus of attention when the ipsilateral side is stimulated at the same time.

A factor analysis of an occupational therapy battery (Fraser & Turton, 1986) gave only partial support to this idea of extinction as limited attention. Weight-
showed that very few subjects with brain damage exhibited extinction—an assumption not supported by the data. They suggested that if extinction is tested the implications drawn from Heilman’s position on extinction. They suggested that if extinction is limited attention and attention a general function, then extinction should be multimodal. DeRenzi et al. showed that very few subjects with brain damage exhibited both auditory and visual extinction. If extinction is a recovery phase of hemi-inattention, then all unilateral neglect subjects should eventually show extinction—an assumption not supported by the data. Furthermore, the implication that the incidence pattern of unilateral neglect and extinction should be similar was also not supported; DeRenzi et al. (1984) found no significant difference in incidence of extinction between subjects with right and left brain damage. Whether or not extinction is an aspect of unilateral neglect remains unclear.

Heilman et al. (1985) described the neglect syndrome as incorporating intentional as well as attentional deficits. Akinesthesia is a nonmotor deficit in starting a movement and involves lesions of the frontal lobe as well as sensory association, and limbic or reticular areas. Activities requiring bilateral limb motion may overcome this intentional deficit as may eliciting cognitive control.

The last category of Heilman’s (1985) neglect syndrome is hemispatial neglect. Neglect of space contralateral to the side of the brain lesion is an intentional (as opposed to attentional) defect. According to the Heilman position, the intention to act in that hemispace left of midline has been lost by the patient with right-brain damage. These researchers interpreted their pointing study (Heilman et al., 1983) as support for this intentional as opposed to an attentional point of view. This study found that subjects with right-brain damage as opposed to left-brain damage or normal controls showed less ability to accurately point to space at arms’ length directly in front of the sternum. Since success in this task required neither visual perception nor memory, poor performance was attributed to failure of intention to address the space.

Heilman et al. (1985) concluded that the right brain controls the intention to act in both sides of space whereas the left brain is limited to control of the right. Thus, if the right brain is damaged, there may be loss of intention to act in left space.

In summary, Heilman’s group considers the neglect observed with brain damage to involve deficits in attention to sensory input contralateral to the side of the lesion as well as a limited attention recovery phase (extinction). Unilateral neglect also comprises deficits in the intention to move the limb or to address the space contralateral to the lesion site.

Because of current theories regarding adult brain plasticity with their implications that rehabilitation can be effective (Bac-y-Rita, 1981; Moore, 1986), it is realistic to research therapy aimed at reestablishing lost nervous system functions. The neurological research regarding unilateral neglect suggests many avenues for research in occupational therapy.

Based on Kinsbourne’s (1977) ideas, therapists can experiment with nonverbal perceptual activities addressing attentional dysfunction. For example, in a soundproof room to shut out stimuli from routine conversation, the subjects in the experimental group could orient their head and right hand to the far left to construct large toys of multishaped parts for a children’s ward. These perceptual stimuli should lessen neglect if data are congruent with the research previously cited.

An attentional-deficit point of view of unilateral neglect can lead to research evaluating the effect of input directed toward the reticular activating system. The reticular neurons are multimodal, responding to cutaneous, proprioceptive, vestibular, visual, and auditory inputs. Of particular relevance are novel stimuli (Hobson & Brazier, 1980). It would seem theoretically pertinent for occupational therapists to investigate the effects on unilateral neglect of activities providing novel somatic and visual inputs to the subjects.

Two approaches might be tried for the experimental treatment directed toward intention dysfunction. Investigating the effects of bilateral activities on the increased ability to initiate movement with the involved limb is a “natural” for occupational therapists. Teaching the subject with left neglect to cognitively cue the start of a motion or to address left hemispace is another approach that readily lends itself to occupational therapy research. Whether or not such cognitive initiation effects changes in the central nervous system, rather than merely compensating for damage, could be investigated in collaboration with a neurologist. Collaborative research in other areas is also recommended.

Conclusion

This article presented a review of the recent research related to the evaluation and treatment of the unilat-
ural neglect observed in many patients with right hemisphere lesions. Appropriate areas for occupational therapy research are studies relating evaluation tools to functional criteria, adapting the environment, or investigating functional improvement through compensatory or neurologically based therapy.

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