Visual Neglect in ADHD Students

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A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in the Department of

Psychological Foundations in Education

We accept this dissertation as conforming to the required standard

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ABSTRACT

Unilateral Visual Neglect was measured in 12 Attention Deficit Disorder, Hyperactive elementary boys aged 8-12 years old, and 27 classroom derived boys also aged 8-12. Previous studies have suggested greater numbers of omission errors on the left side of the page in atttention deficit disorder. This study compared a carefully diagnosed group of hyperactives to a classroom sample of boys to see if this type of error is particular to the ADD with H dimension of attention. The Behavioural Inattention Test (Thames Valley Test Company, (1987) series of conventional subtests, was used. This test is commonly used to detect neglect in stroke victims. Tests involve line bisection, line crossing, star and letter cancellation, representational drawing and copying of drawings. No significant differences between the two groups were found on non-parametric statistical testing of the results of four comparisons: total test score, total errors, left sided errors, right sided errors.. Some differences between the groups were noted, but scores realized were very close to the ceiling and few errors were made. It was concluded that the BIT test is not especially suitable for testing neglect in this population.

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Acknowledgements

I want to thank the members of my doctoral commmittee for their encouragement, time spent answering my questions, and for their unfailingly thoughtful and caring manner.

Many people helped with advice in various stages of the research, including Charles Otaneimi, Alysson Hadwind, Monica Standell, Reo Audette, and Aaron Pauliuk.

In Delta School District, I wish to thank the principals, teachers and students in many schools who participated Stan Auerbach, Kathy Guild, Peter Molloy, Sue Purcell and Peter Yang, as well as Gwen, Wendy and Monique from the District Special Programs office were instrumental in helping this study to proceed.

Rick Diamond, my husband, whose loving kindness, inner child jokes, and belief in our vision helped me to complete this. Roxanne Hopkins, for numerous efforts on my behalf. Lesley Hames and Claire Hopkins, especially, listened to almost daily accounts of my progress and my frustrations. Many family members and friends encouraged me along the way. Thank you all.

CHAPTER 1. INTRODUCTION

Unilateral-Visual-Neglect in ADHD Students

Is Visual Neglect a Problem for ADHD Students?

Two previous papers have found a connection between visual neglect and Attention Deficit Disorder (ADD) in young people. These small studies used a letter cancellation task with students, and measured omission error performance, either in comparison to controls, or, within-subject in placebo and medicated conditions. The purpose of the present study is to extend previous research through careful selection and description of the students involved, by limiting the study group to students with a diagnosis of attention deficit disorder with hyperactivity (ADHD) and by administering a more extensive and widely accepted test battery than previously used. It is not yet known whether neglect might apply to both ADD and ADHD subjects, or only to one subgroup. The present study was selected to investigate only ADHD subjects. It includes a letter cancellation test, similar, but not identical to those used in two previous studies which reported an association between the two syndromes.

Neglect is an impairment of spatial and/or motor cognition, frequently the result of stroke or lesions, especially to the right hemisphere or parietal lobes, which result in contralateral deficits in processing of stimuli. Two papers which have found a link between ADD or ADHD and neglect form the rationale for this study. The study will see if unilateral visual neglect is present in ADHD students. This study will help to isolate the subject population susceptible to neglect. Neglect may possibly be related to right hemisphere damage; and since this has also been suggested for ADHD, it is plausible that neglect could be found in association with Attention Deficit (ADD) populations.

This study uses a well established test battery, the Behavioural Inattention Test (Thames Valley Test Company, 1987) to investigate neglect in classroom children aged 8-12. This test is used to identify neglect, most frequently found in older stroke victims. In neglect, one side of the page (often the left) is not processed past a perceptual level; which is indicated by omission errors on the left side of the tests.

The postulated relationship of neglect and ADHD is relatively new in the study of the specific problems experienced by Attention-Deficit-Disorder populations. Issues in the theoretical basis of attention are explored in the literature review for possible associations of ADHD and neglect. Previous studies of neglect and ADD have not investigated the theoretical basis in attention, to see if such an association makes sense. This is the intent of the literature review chapter.

Important features and theoretical foundations of unilateral visual neglect are investigated in the literature review. Some findings from the voluminous literature in

ADD/ADHD are related to these themes, although a review of ADD/ADHD is not included here. Attentional theory, the functions of the right hemisphere, as well as neglect and ADHD are reviewed, as well as methodology differences in the study areas. Circumstantial evidence suggests that common deficits and common mechanisms may be disrupted in both ADHD and in neglect disorders, and these are identified. However, a review of methodology used in the study of these problems by different disciplines shows that visual processing is complex and that studies are easily confounded, for instance, by field array and cue conditions. Attentional and representation theories have been proposed to account for the variety of neglect symptoms seen, and will be connected to neglect findings and right-hemisphere issues. Commonalities between ADD/ADHD and Visual Neglect include the dopamine and norepinephrine relationship (catecholamines); some neuroanatomical considerations of right-hemisphere syndrome; both groups experience similar problems with eye movements, saccades and overt/covert orienting of attention. Neglect will be related to cue-validity and gradient, and to global and focal reference frames. The role of methylphenidate, which ameliorates both neglect and ADHD symptoms, will also be addressed. How might the theoretical findings be applicable to ADD/ADHD children? A circumstantial evidence and theoretical case can be made for a relationship of the two syndromes.

Neglect and ADD/ADHD

More research is needed to establish whether neglect and ADD/ADHD co-occur. Studies to date have used only small samples. Neither neglect nor ADHD are unitary disorders and there are problems with the comparability of studies and the homogeneity of the samples. In addition, neglect can be transient and impacted by numerous task and stimulus conditions. The implications of a relationship between neglect and ADHD are important: neglect would affect classroom performance including blackboard and book work, perception of cues, and may be a possible factor in poor social performance in ADHD students.

A right hemisphere deficit has also been proposed as a factor in the attentional problems of ADD/ADHD populations. Heilman & van den Abell (1980) suggested that there is right hemisphere dominance for attention; numerous studies have verified aspects of this theory (e.g., Corbetta, 1993). Voeller (1986) found that right hemisphere deficit subjects demonstrate ADD symptoms, and Heilman, Voeller & Nadeau (1991) have questioned whether the right hemisphere frontal-striatal system is related to ADHD.

Definition of terms.

Neglect is an impairment of spatial and/or motor cognition, frequently the result of stroke or lesions, especially to the right hemisphere or parietal lobes, which result in contralateral deficits in processing of stimuli.

Several different types of neglect, including motor neglect, have been described; visual neglect is addressed here. Attention Deficit Hyperactivity Disorder is used here as defined by the DSM-IV (APA, 1994) categorization.

CHAPTER 2. LITERATURE REVIEW

The purpose of this review is to bring separately to the table relevant concepts from four areas of research: neglect, hyperactivity, right-hemisphere studies, and attention. From this it is possible to gradually construct the theoretical basis for a connection between them. Therefore, literature from each area has been separately presented. Visual attention and visual processing are related in this paper to current thinking about the attention dimension of ADHD as described in the DSM-IV (APA, 1994). By looking at a sequence of complex operations involved when a student moves from initial orienting and visual attention to cognition, one could systematically test each stage for deficits, and probably isolate a set of elements common to hyperactivity. The work of Carter et al. (1995); Swanson et al.(1991); and Guitton et al.(1985) are studies in this direction. This may help to point toward certain neurophysiological explanations for ADHD, and away from other explanations. In this context, using an established test battery for neglect in the present study helps to isolate the visual processing issues of ADHD subjects, whether significant results are found or not. We will be able to narrow down and gradually eliminate some of these areas of deficit from the ADHD profile.

Previous Studies of a Neglect-ADD/ADHD Relationship

Two studies have found direct evidence of neglect in ADD/ADHD children. Voeller and Heilman (1988) first proposed that there may be a relationship between ADD and neglect. They found that children with ADD resemble adults with inattention and neglect secondary to right hemisphere dysfunction. Their small study has not yet been replicated. Malone et al. (1994) tested ADHD children on levels of methylphenidate, finding left-sided neglect in ADHD subjects on placebo, which is reversed on medication. However, Malone et al. noted that the learning disabled children in the group accounted for most of the variance. Comorbidity and difficulty with homogeneity of samples are sources of difficulty in studying the ADD-Neglect relationship. Omission errors in written tasks and faulty processing of stimuli may be neglect related, and can have important effects on classroom performance in academic and social arenas.

The studies which have implicated neglect and ADD or ADHD have included Voeller and Heilman (1988); Malone et al.(1994); Matazow and Hynd, (1992a). All studies are suggestive of the relationship, but are not very comparable: confounds with learning disabled co-diagnoses, failure to control handedness, small sample sizes or poorly matched/small control groups, imprecise selection (or measurement) practices for the ADD/ADHD sample, or minimal testing of the neglect construct (usually operationally defined as letter cancellation) may be noted. Two of these studies are considered below.

Voeller and Heilman (1988) wondered if ADD children resembled adults who have inattention and neglect secondary to right hemisphere dysfunction, and tested a small group of subjects on a letter cancellation task, as compared to controls. Whereas the subject population made more errors on the left, controls made more right sided errors. In the small sample the mean rate of errors and the standard deviation suggest that the performance of the ADD group was more erratic. The ADD group made twice as many errors. Five of seven test children made significant numbers of errors, and a left-error preponderance. One subject made many right sided errors. However, in this small sample, when the discrepant "few errors" child is omitted, the rate of errors for the left-error group is very high.

Malone et al. (1994) used a different population from that of Voeller and Heilman (1988) to test for evidence of left hemispatial neglect. Seventeen subjects diagnosed with ADHD using the DSM-III criteria and Revised Connor's rating scale (Connors, 1973) were tested on a letter cancellation task on placebo and on methylphenidate. All subjects were tested on a very similar letter cancellation task to that of Voeller and Heilman (1988b), and were tested on placebo and two individually tailored levels of methylphenidate in a double blind experiment.

ADHD children detected fewer targets on the left side of the page than on the right when on placebo, which authors attribute to partial left visual field neglect, possibly linked to right hemisphere dysfunction. More errors of omission and left-sided errors were made on placebo. Twelve of 17 children demonstrated this result. Methylphenidate at lower and higher dosages reduced the omission rate on the left side, but did not affect right sided performance.

The lower dose did not change right-sided performance for the subgroup without comorbid learning disability, but their performance improved in both directions at the higher dose. Results of the study clearly point to a need to further investigate the issue of sub-populations in ADHD, especially regarding comorbid learning disabilities.

Subjects included in the study had received a diagnosis of ADHD through the pediatric outpatient clinic, and parents also completed the Connors Scale (1973). The clarity of the actual sub-population affected by left neglect is somewhat obscured by numerous comorbid factors in the group selected, though this does not negate the main findings. Eight of 17 had learning disabilities, but these were unspecified. Seven met DSM-III-R criteria for oppositional disorder, one showed aggressive behaviour and two, anxious behaviour.

Only 4 of 17 children made commission errors, evenly lateralized. Twelve of 17 demonstrated left sided neglect on placebo and 4 of 12 right sided (2 of these were left-handed children). Ten children improved on the lower dosage of medication, making fewer left lateralized errors.

Findings of the study are that at higher dosages, more general effects are found for the group of ADHD without learning disabilities, but specific effects for the entire group at the lower dosage levels. The ADHD comorbid L.D. group showed specific improvements at both levels, and no general (no right-sided improvements). Voeller and Heilman (1988b), found that normal control children do not exhibit left sided neglect on letter cancellation tasks. Malone et al. (1994) suggest that laterality measures may be useful in future ADHD research.

Neglect

Neglect may be connected to disordered sensory input; disordered internal representations of space; disordered attention to stimuli contralateral to the site of the lesion; to, as suggested by Heilman and Valenstein (1979), loss of the orienting reflex in one hemisphere, or unilateral reduction of arousal (hypoarousal of the damaged hemisphere) (see Riddoch & Humphreys, 1983). Heilman, Valenstein and Watson (1994) postulate several types of neglect relating to the mechanisms of inattention (sensory neglect), of action and intention (motor neglect) and of representation. Neglect is not caused by primary sensory loss (Mesulam, 1981, p. 316).

Neglect may be a failure to direct attention to some locations within a representation of space (see Grabowecky et al., 1993). It might be a reduced attraction toward objects in the neglected field, or alternatively a strong hold on attention to objects and stimuli in the intact (usually ipsilateral, right) field. Neglect may be due to a degraded inner sensory representation of hemispace (Bisiach, 1979), or to damaged ability to attend either contralateral hemispace or contralateral side of an inner representation (Heilman & Valenstein, 1979, cited in Tegner & Levander, 1991). Bisiach's influential model for neglect (e.g., Bisiach et al., 1987) holds that the deficit in neglect is related to our imagery of space, or of objects; and is in our representation rather than related to perception or attention. Neglect operates on a continuum of both degree and direction of deficit. These theories imply that neglect is a deficit of attention related to the control of attention in space and is connected to task and stimuli characteristics, although exact mechanisms remain unclear.

A principal components analysis done by Kinsella et al.(1995) identified scanning of external space, and spatial representation or imagery as two factors in the Behavioural Inattention Test (BIT) (Wilson et al., 1987) battery results, whereas Halligan et al. (1989) found that six subtests in the battery all intercorrelated highly and all loaded significantly on one factor, suggesting to them that the construct of neglect is robust. Kinsella et al. (1995) argue that factors of scanning of environmental stimuli and spatial representation commonly co-occur, but can dissociate (Kinsella, 1993, 1995, cited in Kinsella, 1995).

Neglect varies with task and stimuli characteristics. This has been widely studied in relation to perception in normal subjects, having to do with size, mass, shape, colour and other distinguishing features of targets, timing of eye movements relating to stimuli characteristics and orientation of the stimuli array in space: relative to the viewer, to other objects, and to the edge of the field. The relevance not only of the actual target, but also of the visual field wherein the cue is located is also important (see Swanson et al., 1991; Massironi et al., 1990). The reference frame (direction of orientation of vision) and the narrow-or-global window of attention may be relevant factors (see Ladavas et al, 1990; Riddoch et al., 1995). Attention has been shown, in neglect patients, to be as easily moved into neglected as into intact space in the absence of any task-relevant objects in the intact space (Robertson & Eglin, 1993).

Extinction.

It has been shown that extinction and neglect may be dissociated, thus suggesting that they are different entities, though often co-occurring (De Renzi, 1984, cited in Kinsella et al., 1995). Extinction is not a suitable marker of neglect (Kinsella et al., 1995). Reports of double dissociations suggest "...cause in equating the two disorders" (Halligan et al., 1989 citing Vallar & Perani, 1987; others). Extinction has been suggested to result from possible "deafferentation of sensory pathways and disruption of sensory association cortex"(De Renzi, 1982), as well as lesions in tertiary cortex (Mesulam, 1981, cited in Kinsella et al, 1995). Halligan et al. (1989) say that "...in extinction, failure to detect a stimulus depends on the simultaneous presentation of a second competing stimulus"...neglect of the left side of space after right brain damage is very much more common that the opposite." A contrary view is presented by Ogden (1985) who has suggested that the frequency of neglect is not different in left hemisphere damaged patients and in right hemisphere damaged ones. This is one of few discrepant findings on the issue.

Weintraub and Mesulam (1987) used a timed shape-cancellation task to assess visuospatial neglect. Neglect occurred in patients without any motor or sensory deficits and in the absence of visual extinction. They have shown that..."sensory-motor defects are not a necessary condition for the occurrence of hemispatial neglect, and extinction can be dissociated from other aspects of visuo-spatial attention" (Weintraub & Mesulam, 1987).

Attention and Neglect

Theory

How neglect occurs is not well understood. The main theories of attention related to neglect are those of Kinsbourne (1977, 1978, see Kinsbourne, 1993)- directional bias & opponent processing; of Heilman and Valenstein- defective orienting due to hypoarousal (1979; 1985); of Posner (1984; 1987)- premotor and disengagement deficit. Many theories make reference to a neural network model (eg., Mesulam, 1981; 1987), acknowledging the complexity, and distributed quality of attentional and representational processes.

Kinsbourne's (1977, 1978) "orientational bias model" proposed that each parietal lobe controls shifts of attention in contraversive direction, independent of the visual field of stimulus presentation. The left hemisphere is biased more strongly in its directional trend than is the right, requiring an equilibration process of directional biases. This idea means that left hemisphere lesions would lessen the asymmetry and right hemisphere lesions would worsen it. The emphatic rightward orienting of unilateral neglect created by hyperfunction of the left hemisphere would thus explain the prevalence of left unilateral neglect. However, Corbetta et al. (1993), in a PET study of visuospatial attention, determined that the theory of spatial attention based on hemispheric directional biases (Kinsbourne, 1977, 1978) is not supported by their study. Corbetta et al., (1993) found that superior parietal reponses were controlled, it seemed, more by visual field than by direction information. This idea accords with several recent findings that object-based (Behrman & Moscovitch, 1992), environmental, as well as body-centred coordinates are important determinants for neglect (Calvanio et al., 1987; Karnath et al., 1991), and that these can relate to the cue direction as well as the target direction (all cited by Swanson et al., 1991). Retinotopic information is probably integrated with actual or intended eye position signals by the posterior parietal cortex. For further information, see Anderson et al. (1985, 1990b) and Duhamel et al., 1992, cited by Corbetta et al., 1993, p.1220).

The issue of functional asymmetry of brain hemispheres is debated. Mesulam (1981) suggests a model for a functional asymmetry:

(1) that the right hemisphere attends to both but prefers the left;

(2) the left hemisphere attends to the contralateral right almost exclusively;

(3) more synaptic space is devoted to attentional functions in the right hemisphere than in the left (Mesulam, 1981).

Heilman and Valenstein (1979) suggested that the right hemisphere programs attention bilaterally, the left attending only to the right half field, but this is not supportable, according to Kinsbourne (1993). Heilman and van den Abell (1980) postulated, as a result of their brain desynchronization studies, that the right hemisphere attends to both hemispatial fields, and the left hemisphere attends primarily to the right hemispatial field. It has been proposed that the right hemisphere is dominant in the spatial distribution of attention (Weintraub & Mesulam, 1987). It is theorized that the "neural mechanisms in the right hemisphere distribute attention throughout the extrapersonal space, while those in the left hemisphere are directed only to the contralateral right hemisphere" (see review in Weintraub & Mesulam, 1987). Normals are likely to sample the right side of space before the left, and, the rightward bias found in patients with left neglect may be an exaggerated form of the rightward bias normally found (Robertson & Eglin, 1993; see also Reuter-Lorenz et al., 1990), which would be consistent with opponent activation and hemispheric lateralisation theories (e.g., Kinsbourne, 1987). Weintraub and Mesulam (1987) noted a possible "pathological symmetry" in regional cerebral blood flow (rCBF) studies finding decreased right striatum activity. A study by Reivich et al.(1983) demonstrated that, in response to tasks in auditory and visual modalities, regional cerebral glucose metabolism increases significantly in the right inferior parietal lobule. This happens regardless of the hemispace stimulated. Weintraub and Mesulam say that these experiments infer that the right hemisphere is involved in the distribution of attention within both sides of space (Weintraub & Mesulam, 1987). Deutsch et al. (1987) found that attention demanding tasks involve right frontal activation, in their survey of 121 regional cerebral blood flow studies that represented a variety of test conditions. In their study of rCBF in rehabilitation of visuospatial neglect, increased perfusion of the left anterior area correlated with recovery for neglect patients, and was also inversely correlated with left-right cerebellum asymmetry (Pantano et al., 1992).

Kushner et al. (1988) suggested that in humans, the right hemisphere may be specialized for visual processing, based on asymmetries noticed in visual stimulation tasks, on positron emission tomography (PET) studies of metabolism in the prefrontal and inferior parietal cortex. Weintraub and Mesulam (1987) say that "...it is becoming exceedingly clear that right cerebral dominance for directed attention is as strongly established as is left cerebral dominance for language-related tasks" (see also Kolb and Whishaw, 1990, p.590).

<u>Neurophysiology of attention.</u>

Colby (1991) In his review of the neuroanatomy and neurophysiology of attention, has pointed out that attention is a distributed process, wherein sensory response to an external stimulus is often enhanced by directing attention to it. Enhancement is "spatially selective for neurons in many areas and explicitly eye movement related in most. Attention directed toward the internal representation of a stimulus may be associated with a prolongation of neural activity... Competition between left and right brain structures in the control of attention is common."

Structures on opposite sides of the brain that are responsible for directing attention to the two sides of space have demonstrated mutual inhibitory interactions in some studies (for instance, between the two superior colliculi (Infante & Leiva, 1986, cited by Colby, 1991). Imbalanced competition between right and left brain structures appears to be pivotal in some disorders of attention (Watson et al., 1978; Kinsbourne, 1987); in humans there is evidence for right hemisphere lateralization of attentional processing (Heilman, Van Den Abell, 1980; Voeller, 1986).

Also, the discharge rate of noradrenaline cells responding to sensory stimulation has been shown to increase during orienting behaviour as a function of stimulus novelty (Clark et al., 1989, cites Foote et al., 1975; Watabe et al., 1982). They also noted that the noradrenergic cells of the locus coeruleus act during stimulus orientation to tune the responsiveness of related cortical cells to that stimulus (Clark et al., 1989, cites Foote et al., 1987; Oades, 1985).

Left brain structures normally control rightward eye movements and the right brain controls leftward eye movements, stimulation at equivalent sites on the two sides results in cancellation of the horizontal components of the individual eye movements (Robinson & Fuchs, 1969), whereas stimulation at non-equivalent sites produces an averaged eye movement (Schiller & Sandell, 1983, all cited by Colby, 1991). Stein (1992), and Corbetta et al. (1993) have investigated these mechanisms. Egocentric spatial relationships are represented in the brain in the posterior parietal cortex (PPC), where the cells of PPC areas receive limbic system motivational projections, limb, body, head and oculomotor signals and inputs from sensory systems (visual, auditory, vestibular and somasthetic). Increased discharges are noticed when either there is movement toward or attention directed to a sensory target. Sensory inattention and neglect are found with PPC lesions (Stein, 1992).

According to Stein (1992), the PPC does not so much map object locations in space but rather is a distributed network that coordinates and translates sensory and motor coordinate references from one system to another, probably based on attention"... which selectively enhances the synapses needed for making a particular sensory comparison or aiming a particular movement" (Stein, 1992).

Distinguishing visuo-spatial and motor neglect.

Marshall and Halligan (1994) think that neglect may improve when the (damaged) right hemisphere controls both input and output functions; implied by the finding (Kamaki et al., 1993) that severe left neglect is seen when the right hand is employed, though left hand performance is normal in patients with callosal lesions. This is consistent with Marshall and Halligan's proposal that the "right hemisphere computes a coarse, but adequate global representation that guides left hemisphere focal attention (and the right hand) when callosal connections are intact, but can only guide the left hand when the callosum is lesioned" (1994, p. 165). Corbetta et al. (1993), in PET scans of visuospatial attention, found that "primary sensorimotor cortices and SMA activations were greater when subjects responded with their left hand to ipsilateral (left field) than contralateral (right field) stimuli (shifting attention)". This relationship may *not* be an effect of stimulus hand laterality, and it remains to be studied to observe whether the asymmetry switches if the right instead of the left hand is used (Corbetta et al., 1993). The findings of Robertson & North (1994) were that single left hand movement produced the largest neglect reduction, as did left limb movements in left hemispace, but that all double hand movements abolish these gains; this, the authors theorize, may relate to amelioration of neglect with increased arm activations, possibly arousal related. This may connect to an extinction-like phenomena for motor output, which affects perceptual functioning (Robertson & North, 1994). Another study by these authors (Robertson & North, 1992) implicated the motor activity component more than the visual aspect; found that the general arousal level of the system was not the relevant factor, and that cueing modality type may be important. Several types of independent spatial reference systems which need to form a coherent map for the calibration of motor action were suggested by Rizzolatti (cited in Robertson & North, 1992). This model may help account for the variety of forms of neglect.

Shifting spatial attention: neurophysiology.

Hynd et al. (1991) implicate right hemisphere deficits in several aspects of visuo-spatial processing: visual-pattern processing- associated with the right inferior parietal-temporal area (Kushner, Rosenquist & Alavi, 1988); right posterior region for visual-spatial calculation (Diamond & Beaumont, 1972). Visuo-spatial and math deficits of ADHD children may be related to the significant variations of the posterior callosal area seen in this population (Hynd et al., 1991). Corpus callosum differences may relate to lateralised speech dominance or to gender, although the exact importance of the corpus callosum is still debated (Hynd et al., 1991).

Robinson et al. (1991) isolated posterior parietal neurons which fire as long as attention is directed *away* from a target location in spatial detection paradigms similar to those used in humans (corresponds to the Posner "disengage" stage). This process may more stongly activate in invalid trials than valid ones, though will be active in both cases (Corbetta et al.). A shift in attention involves a computation of the spatial coordinates of the next intended location, perhaps computed by superior parietal neurons." Single-unit studies have indicated that neurons in posterior parietal cortex may encode a visual location by integrating retinotopically organized visual signals with actual or intended eye position signals" (Andersen et al., 1985; 1990b; Duhamel et al., 1992, all cited in Corbetta et al., 1993).

Corbetta's study has many implications for the issues discussed here. Among the findings: that cue validity leads to faster response to stimuli, and that, in invalid cue conditions faster responses are to stimuli in the same movement direction than away; attention shifts to the periphery result in greater superior parietal and superior frontal cortex activity than central gaze maintenance, and that these regions encode visual field, not direction (Corbetta et al.). Two distinct locations in the right superior parietal lobe were localized dependent on whether attention was in right or in left visual fields. The superior parietal peripheral location activity was dependent on cognitive or sensory cues, not on overt responses, unlike that of the frontal region, which activated for the *responses* to the stimuli in selected peripheral locations. In the left superior parietal lobule, in contrast to the right, only one representation is made, for directing attention mainly to the right visual field. This asymmetry may account for the prevalence of "disengage" related deficits for spatial cueing tasks as a result of right, but not left, parietal lesions (Corbetta et al., 1993).

When investigating right brain damaged patients, faster responses were found when the target was located most to right, thus confirming Kinsbourne's (1977) theory of an imbalance in lateral orienting activity (De Renzi et al., 1989). Kinsbourne (1987) suggested that neglect could be due to the fact that "...the left cerebral hemisphere's bias toward the right hemispace is released from inhibition following right hemisphere damage." Corbetta's finding lends more toward an imbalance in the asymmetry of control for these tasks, rather than a release of inhibition. Additional confirmation of the direction of gaze and the cueing issue is available. Posner et al. (1982; 1987, cited in Ladavas et al., 1993) found that right parietal lesion patients were especially impaired in responding to left sided stimuli if their gaze was already directed to the right side. Posner et al., (1987) using response time and directional experiments in normals and those with parietal lobe lesions found that their patients "... do worse when cued to a location in either field and then given a target in the contralesional as compared to the ipsilesional direction".

Window of attention.

The concept that neglect occurs when the attention of the subject is already directed to one location, and is either generalized and distributed or more narrowly attentive, but then must change, is relevant to both ADHD and to the understanding of neglect. Riddoch et al. (1995, p. 601) say that neglect may vary as a function of hemispheric arousal, allocation of attention (cueing becomes important), and how stimuli are read, as single or multiple objects. Multiple objects coded as an array may lead to inhibition of the left hemisphere, neglect of right space. In the case of a reading as a single object situation : such "...'zooming-in' may be produced by inhibition of the right-hemisphere attentional system by the left-hemisphere attentional system so that control is passed from a global to a more local level of analysis" (Ericksen & Yeh, 1985; Humphreys & Bruce, 1989, cited by Riddoch et al., 1995). Such activation will favour the right side of space; those with an decreased activation overall neglect on the left side of space (Riddoch et al., 1995).

Boles (1990, p. 205) has studied response times and accuracy related to asymmetry of function for task stimuli presented to LVF and RVF. Bilateral presentations are held to produce greater asymmetries than unilateral presentations, an effect present in several modalities. Boles has neatly summarized the evidence for the many hypotheses presented to explain this characteristic. Neglect of the opposite side, triggered by competition, is not, in his studies, considered as one of the main explanations for differences in processing found in bilateral displays.

Gradient.

Halligan et al. (1991, p. 292) have pointed that some patients with right hemisphere damage make ipsilesional omissions. Their study found the number of omissions, and the lateralized distribution of omissions to be correlated. They found the gradient of neglect severity to be greatest in the extreme contra-lateral hemifield and least in the extreme ipsi-lateral hemifield. This, they say, "... is consistent with the attentional bias models of Kinsbourne (1977, 1992), Rizzolatti et al. (1985), and De Renzi et al., (1989)." However, Gainotti et al. (1990) has cautioned that the same mechanisms may not govern neglect of the two sides.

Rizzolatti et al., (1987) undertook experiments measuring response times in cued and non-cued conditions to investigate why stimuli in a non-attended location are much more slowly responded to, finding that costs were incurred when stimulated and attended locations were on opposite sides of the vertical or horizontal meridian, leading them to theorize that there is a strict link between covert orienting of attention and programming explicit ocular movements. Authors say that an attentional gradient hypothesis, or one proposing attention movements at constant speed are possible explanations, whereas those of hemifield inhibition and of movement of attention over constant time are not. Attention and the programming for eye movements are closely linked. Response time was found to be faster in the same hemifield, and, when the midline does not need to be crossed. The vertical meridian is important to the cost calculations but not completely responsible for the variance (see p. 37); the hemisphere specialization explanation remains, therefore, tenable. They recommend that attentional gradient theories need to take into account the meridian effects. Authors suggest that "attention is oriented to a given point when the oculomotor programme for moving the eyes to this point is ready to be executed. Attentional cost is the time required to erase one ocular programme and prepare the next one" (Rizzolatti et al, 1987). Neglect has been found for all three dimensions of imaged and actual space (near/far and up/down as well as horizontally). (See also Koenig & Kosslyn, 1991). Kosslyn, Koenig, et al. (1989) found that subjects make categorical (on/off, left/right, above/below) judgements faster when stimuli are presented to the left cerebral hemisphere initially, and distance evaluations (2, 3mm and 1 inch) faster when stimuli are initially presented to right hemisphere. This is consistent with a similar study of Hellige and Michimata (1989) regarding categorization and distance, which found hemispheric differences for processing spatial information (see also Koenig, Reiss & Kosslyn, 1990). Bracewell et al. (1990) found that the majority of right handed subjects were found to be more accurate in directing their gaze to locations in the LVF than the RVF, suggesting that the right hemisphere may be superior to the left for oculomotor control. Braun (1992) found that a (LVF) left visual field advantage is usually associated with faster transfer from the right hemisphere to the left one and a RVF advantage with faster transfer in the opposite direction. In normals, rightward movements of attention are faster than leftward in the left visual field ", and the reverse in the right visual field" (Posner et al., 1987, p.138). This ..."favors the idea that the direction of the attention shift is at least a major difficulty caused by the parietal lesion " (p. 140). However, outward movements in detection response-times are somewhat longer in normals than are inward movements which follow far cues. Another similar study found that vertical shifts in the contralateral field and/or hemispace produced longer RT's over and above any effect of direction. Thus the hemisphere interpretation (Bowers et al., 1981) or the hemispace one (Bisiach et al., 1981; Geffen & Quinn, 1984) are more plausible (as cited by Posner et al., 1987).

Ladavas, Petronio and Umilta (1990) investigated the idea of either an attentional or a representational gradient in hemineglect patients, with results that indicated that gradient was not a relevant aspect. The constructs of d' (d prime), a sensitivity indicator for faster or more accurate processing of information; and, of beta (a response criterion or bias measure) finding also that these constructs also did not account for the differences in their populations. They concluded that the results were best accounted for by the global/local focus of attention concept and that of the "window of attention" (in which direction and how wide is the arena of directed attention?). Satterfield, Schell and Nicholas (1989), in a study of auditory and visual attention in ADHD boys found them slower and less accurate than controls. In attend-visual conditions they made more omission and commission errors, had longer RT's and less accuracy on d prime indices. The beta index for response criterion was also significantly lesser for ADHD's as compared to controls.

Global and local processing.

Considerable research indicates that the hemispheres process information differently, including emotionally based material. If ADD/ADHD and neglect share some common traits of deficient (possibly right-hemisphere directed) processing, a number of possible consequences could ensue. This section will link similar global processing habits in neglect and ADHD, and suggests that these may be associated, because of faulty processing when such subjects are compared to normal subjects. The global-local preference may occur across several sensory modalities, be at an executive level of processing, and, affect social relations as well as learning habits, with consequences in the emotional responsivity and reward behaviour of ADHD subjects.

Marshall and Halligan propose an extension of work done by Kinsbourne (1974) in which he distinguishes preattentive and focally attentive processes; the former, panoramic type being linked to right-hemisphere processing mechanisms, and the latter, local processing, linked with primarily left-hemisphere mechanisms (Marshall & Halligan, 1994). Kinsbourne argues that "...these hemispheres cooperate for attentional control by disposing attention in space as a balance of opposing directionalities, focus being guided by preattentive structuring of the field and attentive focusing within it in temporal sequence" (Kinsbourne, 1974, p. 279). "The notion of global precedence in the temporal sequence of processing has received considerable empirical support" (Robertson & Lamb, 1991) cited by Marshall & Halligan, 1994). Marshall and

Halligan (1994) suggest that panoramic processing may be significantly intact in left visuospatial neglect, but that the preattentive visual encoding may not direct focal attention to the spatial locations needing more local attention, which may let the intact left hemisphere prevail to some degree. Their interpretation suggests that the focal view cannot be simultaneous with the panoramic, so that the "guiding structure" disappears, even if the "spotlight" of attention can still be voluntarily moved leftward (Marshall & Halligan, 1994, p. 164). Driver et al. (1992) take a somewhat similar view, thinking that the information about an object seen preattentively is then lost when it is to go to the attentional stage. If this is the process that is also amiss in ADHD, it may help explain why complex tasks and those requiring directed attention lead to defaults in this population. Additional relevant and consistent factors include the parsing of the stimuli into object size/number, the global/focal issue as explained by a hemisphere specialization concept, the eye movement findings (abnormalities are in the later 800ms. RT interval, so are more cognitive), and the invalid cue findings in ADHD (e.g. Swanson et al., 1991; Carter et al., 1995; Pearson et al., 1995) and the interaction with task and stimuli features (such as size, angularity of figures, peripheral or central, etc.) (see also the findings of Guitton et al., 1985).

The spotlight of attention ("attentional window") relates to the size of the attentional awareness, irrespective of the eye movement. Eglin, Robertson, Knight and Brugger (1994) found that search deficits in neglect patients are dependent on the size of the visual scene. However, the issue of figure-ground segregation skills may *not* be implicated in at least some cases of visual neglect, (although it is found in ADHD) since this was found to be preserved, along with symmetry perception, in a study by Driver, Baylis and Rafal (1992). These authors imply that figures may be segregated from ground at a preattentive processing stage, and that candidate objects may then be attended to; it is at the later stage when neglect may occur. This is consistent with the idea that preattentive priming is found in neglect and that, for ADHD, attentional and cognitive load issues are implicated. The stage wherein object identification occurs is still debated (Driver et al., 1992).

Posner and Peterson (1990, p. 29) discuss tasks of alerting, orienting and detecting as part of the attentional systems. They say that each hemisphere has specialized attention functions, that perhaps the right hemisphere executes global processing and low spatial frequencies; the left, local processing and high spatial frequencies. A theorized deficit in this subsystem may contribute to the problems of neglect and/or of ADHD subjects. It may be that processing of emotion, and reward dysfunction, in ADHD may relate to dysregulation of the sensory input and blending mechanisms, perhaps consistent with the right-hemisphere deficit hypothesis. Contrast sensitivity and low spatial frequency discrimination have been investigated in hemineglect. Spinelli, Guariglia, Massironi, Pizzamiglio and Zoccolotti (1990) found that RBD subjects differed from RBD/with-neglect subjects in contrast sensitivity to low spatial frequencies independent of neglect. The aspect of simultaneous and sequential task administration, in the study design, may account for the differences in results from two other studies, as the authors have noted. It clearly may have confounded the study. Studies of this matter do not converge, since the results of Kobayashi et al. (1985) for contrast sensitivity, and Grabowska et al. (1989) for contrast discrimination at high, low and medium spatial frequencies in RBD, have differentiated neglect populations from others (cited by Spinelli et al., 1990).

The findings and analysis of Riddoch et al. (1995) may help explain this process. Relevant distinctions being made by the visual system include recognition of something as an object (within-one-object versus between-several-objects), and the hypothesis of two spatial systems: the categorical (left/right; above/below; actions) and coordinate (distance) (Kosslyn et al., 1989). Different hemispheres may process the image depending on if it is processed as a single object or multiple array; and similarily if it is imaged from a global or local perspective (see Eriksen & Yeh, 1985; Humphreys &

Bruce, 1989, cited by Riddoch et al., 1995). In that event, neglect may be explained by a hemispheric activation explanation by which, for directed attention, asymmetric hemispheric activation is dependent on task demands, and that a decreased arousal (indicated for neglect and for ADHD) will have task specific consequences. Thus, verbal and right manual action requires and recruits left hemisphere activation, and, visuospatial and right manual actions use right hemisphere activation, with the attention then directed to the contralesional hemispace (Kashiwagi et al., 1990, cited by Riddoch et al., 1995). Riddoch et al. also cited a similar case which can be explained by this mechanism: Costello and Warrington's (1987) subject showed right-sided neglect in visuospatial tasks and left-sided neglect for single word reading. They suggested that a threshold theory would explain task specific neglect patterns: an inability in a subject to "... sustain activation to the right when there was strong right-hemisphere activation and left-sided orienting, and unable to sustain activation to the left when there was strong left-hemisphere activation and right-sided orienting" (Riddoch et al., 1995, p. 572).

Keenan et al. (1989) found that left visual field (LVF) errors were highest in the absence of low spatial frequencies, while right visual field (RVF) errors were highest when a higher range of spatial frequencies was removed, in a facial recognition task, thus confirming that the hemispheres show a differential efficiency in processing such information. Positive emotional tone, when added to a task, results in a relative decrease in left hemisphere efficiency for ADHD patients (see Becker et al., 1993 for additional review). Mattingly, Bradshaw, Phillips and Bradshaw (1993) found reversed perceptual asymmetry for faces in left unilateral neglect. Global and focal spatial processing may be associated with disordered perception mechanisms in ADHD subjects, and, if it can be linked to different hemispheric specialization for positive and negative emotions, important psychophysiological implications may be proposed. The evidence in this area is mixed. Ahern and Schwartz (1985) have reviewed the conflicting evidence, and have found, using EEG spectral analysis that "... In frontal zones, a differential lateralization for positive and negative emotion was observed, with relative left-hemispheric activation (as measured by decreases in alpha abundance) for positive emotions and relative right-hemispheric activation for negative emotions." This study is consistent with results in normal subjects (Ladavas et al., 1984). Other physiological differences from controls have been noted: for instance, galvanic skin response in right hemisphere patients (Heilman, Schwartz & Watson, 1978), and in ADHD (Satterfield & Dawson, 1971); diurnal saliva cortisol irregularities in ADHD subjects (Kaneko et al., 1993). When tested in auditory stimuli (dichotic word tests) in ADHD subjects, significant differences were found between control and patient groups: "... The abnormal response to positive emotional tone supports the reward system dysfunction hypothesis of ADHD and may also have implications for learning problems, behavioural difficulties and disturbed interpersonal relationships in this population" (Becker et al, 1993). Ginsburg et al. (cited by Shaughency & Hynd, 1989) studied groups of dogs which responded differently to amphetamines, finding that their behaviour on a positive-negative reward paradigm correlated with their differentiation on these chemical indicators. If this is relevant to humans, it may illuminate the issues of methylphenidate responsivity and of reward reversals in ADHD populations.

The issue of the responses of ADHD students to modality specific information is relevant to this study (see Bedi et al., 1994). Is it easier to attend in one modality than another? Evidence from CAPD and auditory neglect, and regarding the neural mechanisms for sensory blending is relevant and supportive, but cannot be reviewed in detail here. An auditory processing deficit may be implicated: Carter and Shostak (cited by Zentall, 1993) found more memory errors, and less seated time, for auditory instructions alone than combined instructions and a visual model.

Cue validity and visuo-spatial orienting.

Posner et al., (1984, 1987) developed a theory of attention in which three operations are part of visuo-spatial orienting. These steps are to disengage, move attention to the new location, and engage in the new location (see Swanson et al.,1991; for contrary evidence, see Arguin & Bub, 1995) It is suggested that different brain areas are responsible for these tasks. Response times (RT) in cueing experiments shed light on these functions in ADHD. Swanson et al. (1991) reviewed response time evidence in normal subjects, drawing some general conclusions: that "... RT is faster to targets after valid cues than invalid cues; decreases as a function of cue-target interval, and does not differ for responses to targets in the LVF and the RVF " (see saccades section for contrary evidence). Cue-related performance of ADHD children was observed in the Swanson et al. (1991) study: that directed attention of the ADHD group was not maintained when a left hemisphere cue required the students to orient to right, although they were able to maintain directed attention after a cue to the right hemisphere required leftward orienting "... the observed complex pattern of RT may be related to which hemisphere receives the cue rather than which hemisphere receives the target" (Swanson et al., 1991). In this study, smaller and nonsignificant laterality effects were found for the normal subjects and reflected an opposite visual field RFV advantage (Swanson et al., 1991).

Posner's studies have suggested that in unilateral parietal lobe damage, the "move" and "engage" operations operate well, the "disengage" operation is disrupted (Swanson et al., 1991). ADHD children were tested on a cued reaction-time test, with results that indicate that, in the 100 ms. condition, (the covert shifting, earlier and posterior, parietal stage) ADHD children perform normally in covert orienting to a peripheral cue, and the response time for the invalid cue, RVF is also normal; only the invalid LVF cue condition produced abnormal, faster than expected RT's (Swanson et al., 1991, p. S125). This happened in the 800 ms. duration, a later, anterior, frontal brain based stage. An important implication for ADHD children is that the focused attention of these children dissipates rapidly (in 800 ms), suggesting that the problem of Attention Deficit Disorder is not one of task attention over an interval of minutes but occurs in a rapid time (Swanson et al., 1991). Carter et al. (1995) confirmed the findings of Swanson's study and, unlike Swanson et al., affirmed a right hemisphere hypothesis to account for the findings. Pearson et al. (1995) also confirm this phenomenon and indicate that it operates at considerably less than the 800 ms. window also. Klorman (1991) used another measure in similar time horizons. The P3 or P300 (ERP component) is a late positive wave with latency of 300 to 800 msec and maximal amplitude over the parietal area. Its amplitude is increased by stimuli characteristics including task relevance and novelty (see citations in Klorman, 1991, p. 130). In Klorman's study, methylphenidate "reversed the deterioration of performance under placebo and increased the amplitude of P3b, while preventing the increase in P3b latency that developed during the course of the placebo session" (cites Strauss, et al., 1984). In another study, Satterfield, Schell et al. (1994) found amplitude and latency differences in preferential processing of attended stimuli: " When ADHD subjects attended, little or no negative responses were found in either modality, and enhanced positive P3b responses were found only in response to visual target stimuli. Auditory N1, N2 and P3b and visual N2 amplitudes to attended target stimuli were significantly reduced in ADHD subjects as compared with normal subjects. No between group differences were found for responses to nonattended stimuli".

Attention capacity.

Schneider and Schiffrin (1977) and Schiffrin and Schneider (1977) presented an influential theory defining controlled and automatic information processing as distinct processes, the first related to short term memory and capacity limitations, the second to long term memory, learning, and dependence on mapping of stimuli onto responses. Van der Meere & Sergeant (1987, 1988) have found that the ability to develop automatic processing was not impaired in hyperactive children, and that divided-attention tasks (which test cognitive load) were also intact, though slower speed, more frequent errors and variable reaction times did characterize their hyperactive groups. In reviewing relevant neurotransmitter studies, Clark et al. (1989) say that catecholamines may act to regulate the capacity available for processing information (intensive attention), without affecting what is processed (selective attention) (Clark et al., 1986 a, b, 1987, cited in Clark et al., 1989). Neglect researchers have attempted to identify if each is deficient in neglect patients.

Early controlled processing is a limited capacity system, and image complexity has a tendency to increase neglect (as well as ADHD problems). Two theories could explain this: (1) that of attentional capture (Posner) or (2) that of controlled processing (Schneider & Schiffrin, 1977). According to Riddoch et al. (cited by Robertson, 1989, p. 158) "controlled perceptual processing requiring serial attentional capacities is selectively impaired in visual neglect. Clearly there is skewing to one side in this disorder, but the above evidence suggests the possibility that not only is there a lateralization of attention but also a limitation in the ability to deploy attention systematically irrespective of side" (Robertson, 1989, p. 158). Ladavas et al. (1993), regarding neglect, has surveyed sources showing that performance can be ameliorated by cueing attention to the neglected side, and that in left-side neglect "... attention is disproportionately deployed to the right side, and, the degree of contralateral neglect increases with the attentional requirements on the intact side" (Ladavas et al., 1993). This renders task and stimuli conditions especially relevant, and suggests that, in studying the ADHD-Neglect relationship, the formal properties of the task and setting may have been a potentially confounding factor in results of previous ADHD studies of classroom performance. Attentional capacity and the role of competition for its allocation are raised by Sava et al. (1988), who showed that a second task does influence response times, and, that response times were faster to the RVF (right visual field) than LVF stimuli (however, see also results of Ladavas et al., 1990). ADHD children show performance deficits when non-relevant stimuli overlaps important information (Zentall, 1993). Dividing attention and moving it between tasks is also a problem area (Reeve, 1994).

Some implications about this in relation to motor movement stages were suggested by Robertson and North (1992). They found that left hand movements in left hemispace were able to reduce severe left neglect, but this may implicate a capacity situation since the problem must be in the sequence or amount of information needed to "keep the system on", as the competition of the right hand moving flattened out these results in the same subjects (Robertson & North, 1992). It is possible that these results relate to those found in ADHD students, where complexity, task overlaps, and directed attention all create differences from normal students. Perhaps these results can be explained by the findings of Karnath & Hartje (1987), whose neglect (but not hemianopia) patient was presented with stimuli in visual half-fields whether unilaterally or bilaterally. Simultaneous bilateral stimulation was associated with significant error rate increase for accuracy with LVF stimuli, which cueing did not affect. Authors felt that this condition presented itself when information in the right hemispace attracts attention or must be consciously processed (Karnath & Hartje, 1987).

Overt and covert attention: definition, neurology.

Helmholtz first distinguished a shift in attentional focus from a visible change in head/eye/body position; the first is called covert attention. Covert orienting occurs when attention is involuntarily drawn to a stimulus, without any overt orienting response; overt attention involves actually looking at or turning toward a stimulus (Coren & Ward, 1989). Gainotti et al. (1991, cited in Gainotti, 1993) has suggested that the right hemisphere's organization may be more strongly dependent on automatic orienting reactions, and, if lesioned may produce an ipsilateral orienting bias.

A covert shift of attention occurs for cue-target intervals as short as 50 ms. and without eye movements. It precedes an overt shift, and the extrafoveal focus of attention may guide a change in fixation (Swanson, 1991 cites Posner, 1988). Neglect subjects "fail to orient automatically to stimuli from the visual field contralateral to their lesion" (Riddoch & Humphreys, 1983, p. 593). Is cueing thought to affect the overt or covert orienting of attention? The two types are distinguished by cueing experiments: if overt, cueing on any end of line, regardless of hemispace will encourage fixations; if covert, neglect will increase with a right side cue because patients have problems in shifting to the left side of internal space once attention is fixed (as cited by Posner et al., 1982).

Automatic and voluntary orienting may also be distinguished. Humphreys (1993, p. 149) has related these two processes to peripheral and focal signals and to cue validity, implicating a data driven processing level as a possible factor in neglect, and suggesting that the information value of the cue may be relevant. The relevance of these findings to ADHD should not be underestimated and should be further investigated.

Ladavas, Carletti and Gori (1994) tested covert orienting in visuo-spatial neglect patients to see if issues of central or peripheral presentation of material, and if informative or non-informative cues can help to distinguish whether neglect is internally or externally controlled. Issues of verticality and horizontality were also considered, with a view to identifying "whether altitudinal neglect is an attentional deficit". Authors concluded that a dual-mechanism hypothesis best explains the data, suggesting that automatic and voluntary orienting are subserved by separate mechanisms possibly located in different parts of the brain" (Ladavas et al., 1994).

Ladavas, Carletti et al. (1994) conclude that a lesion in the right parietal lobe causes a deficit of externally controlled covert orienting in the contralesional visual field. Consistent with a gradient hypothesis, this is more pronounced in the lower than the upper visual field, but the contralateral visual field is accessible to the patients in the internally-controlled orienting condition. This suggests that a lesion in the parietal lobe affects automatic orienting while leaving voluntary orienting largely unaffected (Ladavas, Carletti et al., 1994). Internally-controlled covert orienting is mediated by the frontal lobes (Alivisatos & Milner, 1989 cited by Ladavas, Carletti et al, 1994). "The findings supporting the dual-mechanisms hypothesis of covert orienting are in agreement with the anatomical dissociation proposed for reflex-like and volitional orienting eye movements" (Dorecchi et al., 1991; Guitton & Buchtel, 1985); the frontal lobes may mediate volitional eye movements, and the parietal lobes may mediate reflex-like movements (Ladavas, Carletti et al., 1994; see also Heilman et al., 1985b as cited by Vallar, 1993). Mesulam (1994, p. 174) noted, however, that the parietal sensory role and the frontal motor role creates only a relative division (along different lines than that proposed by Ladavas et al., 1994). Mesulam cited the findings of Daffner, et al. (1990), to suggest that the "exploratory-motor components of unilateral neglect are more severely affected after frontal lesions whereas the sensory-representational components are more severely affected after parietal lesions." Corbetta et al. (1993), in PET scans, found that the parietal region activated for cognitive and sensory cue stimuli, not for any overt response, and the frontal area activates when selected lateralized stimuli are overtly detected. Neglect was correlated with cortical hypoperfusion (Perani et al., 1987; see also 1988), and Vallar et al. (1988) has found that behavioral recovery from neglect paralleled reduction of cortical hypoperfusion, results replicated by Bogousslavsky (1988a; cited by Vallar, 1993). This may directly relate to ADHD, since Lou et al. (1984) has found frontal hypoperfusion in ADHD.

Clark et al. (1989) noted that Posner's (1979, 1980) covert orienting task was used to test the role of dopamine and noradrenaline on orienting and switching of attention. "Covert orienting involves the directional engagement of attention independent of eye movement, whereas re-orienting requires disengagement, covert movement and reengagement". Precueing of a signal location in the absence of eye movements has a facilitatory effect, presumeably related to effects on sensory processing, and not to a decision criterion (see citations of Clark et al., 1989, p. 132).

The role of dopamine.

Clark et al. (1989) measured the role of brain catecholamines in covert orienting in normal subjects. A reaction time task was used which measures directional engagement, disengagement and movement of attention. They found that when droperidol and clonidine were used to suppress dopamine and noradrenaline transmission, reductions were obtained in the cost of invalid cueing, without changing the benefit of valid cueing," suggesting that both noradrenaline and dopamine are involved in facilitating the disengagement of attention" (Clark et al., 1989). This may be an important finding, when related to those of Swanson et al. (1991), who found ADHD subjects deficient in invalid cue conditions. Lou et al. (1989) demonstrated a right striatum hypoperfusion, indicating decreased metabolic activity in an ADD (ADHD) population and in comorbid groups it was found in both regions. In the occipital region at ($p < .05$) for ADHD comorbid group, in left striatum at ($p < .01$) and right striatum at ($p < .002$). In the ADHD group, it was found significant for right striatum at ($p < .002$) and occipital at ($p < .005$). See also Lou (1984) regarding ADHD and periventricular hypoperfusion. Bougousslavsky et al. (1988) using photon emission tomography, found that, in neglect in right hemisphere damage, marked hypoperfusion was not limited to "... the right posterior capsular region, but also involved the overlying parietal cortex, and to a lesser extent the frontal cortex".

In rats, Fride and Weinstock (1988) found that prenatal stress induces permanent alterations in dopaminergic (DA) activity and in cerebral asymmetry (see also Ito et al., 1993; Van der Kolk & Greenberg, 1987). Miyashita et al., 1995 demonstrated that unilateral dopamine deficiency in basal ganglia of monkeys profoundly impaired visual search, including contralateral neglect and ipsilateral frozen peripheral gaze. The role of peripheral stimuli in neglect has also been demonstrated by Seki et al. (1996). Fleet et al.(1987) found that letter, line and geometric figure cancellation tasks significantly improved in neglect when patients were treated with apomorphine, a dopamine receptor agonist. These are the same types of tasks involved in the present experiment.

Schaughency and Hynd (1989) have reviewed several aspects of the neurochemistry of ADD which can profitably be considered here. Among these are the catecholamine hypothesis related to stimulant medications, and the possible differences between responders and nonresponders. Responders may have a presynaptic defect in the DA system, whereas non-responders may have one at the post-synaptic level. Neurotransmitters involved in ascending (perception) pathways are norepinephrine (NE) and serotonin (5Ht) based; DA and acetylcholine (ACH) form the neurotransmitter substrates of activation; both are needed for integrated attention (Schaughency & Hynd). Methylphenidate normalizes the evoked potentials of ADHD children in a vigilance task (Michael et al.1981, cited in Shaughency & Hynd), possibly because D amphetamine may inhibit NE while potentiating DA (Shekim et al., 1983, cited by Shaughency & Hynd).

Eye movements and attention.

Colby (1991) has stated that "gaze direction and locus of attention normally coincide. People with restricted attentional processing, as in neglect, exhibit restricted eye movements (see sources cited), and children and adults with attentional and reading disorders exhibit disturbed and erratic eye movements (cited references #16-21)". Certain cognitive tasks demand only loose connection of eye position and attention (Colby, 1991, see sources cited). Dunn et al. (1989) investigated the relationship of eye movement to brain organization and cognitive style in sentence and pictorial inference and recognition tasks, finding some support for a relationship of right eye movement and left handed subjects on acquisition tasks. Caution is in order in this area of research because of problems in choice of correct experimental paradigm (task specifications) in relation to neural complexity, and the hemispheric activation literature remains inconclusive in many respects. According to Gainotti (1993, see additional sources) attention can be allocated to different parts of the spatial field without overt eye movements (see Posner, 1980; Umilta, 1988, for reviews); however, the generation of eye movements and the spatial allocation of attention may not be separate processes. The size of the visual field attended to is also relevant to making quality visual discriminations, as in line bisection tasks (see Ikeda et al., 1977, cited by Marshall et al., 1993).

Saccades.

It is normal that we have faster response times to the right visual field than to the left (Sava, Liotti et al., 1988, p. 204, see also Tegner & Levander, 1991; Mesulam, 1994). The inferior parietal lobe plays a role in the control of saccades and of pursuing eye movements (for right hemisphere attention in this, see Ladavas, Carletti & Gori, 1994). Doricchi et al. (1991) studied saccadic eye movements in REM sleep, of neglect patients, and found that "... saccadic movements directed toward the left half of space are virtually absent" in these patients, thus developing the assumption that "...unilateral sensory neglect is due to disruption of mechanisms determining the automatic orienting of attention towards stimuli arising in the half space contralateral to the damaged hemisphere" (cited by Gainotti, 1994). The principle of a dynamic balance of an attentional field is supported by the findings, in several studies, of a type of "magnetic attraction" by stimuli of the right side (De Renzi et al., 1989; Gainotti et al., 1991; Mark, Kooistra et al., 1988, cited by Gainotti et al., 1994), implicating a disinhibition of the right-sided vector. Hornak (1995; see also Karnath & Huber, 1992) used both tachistoscopic and free viewing to record the eye movements of neglect patients and controls, finding that the neglect patients failed to report the missing left side of a figure when it completely lay in the left hemifield, but not when it lay partly in the right. This is the retinotopic hypothesis, although there is also evidence for the non-retinotopic hypothesis, which assumes that the fixation position is the relevant one (e.g. Gainotti, 1994). Bracewell et al. (1990) measured saccades to remembered target positions as a function of the left or right visual hemi-field, finding that in normal populations of right handers, the majority of subjects were able to more accurately direct gaze to LVF than RVF locations, leading the authors to propose that the right hemisphere is superior to the left in oculomotor control. Abnormal saccade processes were implicated in neglect following right hemisphere stroke in another study also (Fanthomme & Lincoln, 1995).

Cueing.

Neglect is sensitive to cues (Gainotti, 1994). This suggests that it is an attentional, not a perceptual or sensory problem (Ladavas, Paladini & Cubelli, 1993). Cueing to the left tends to lessen neglect; cueing to the right tends to worsen neglect (Riddoch & Humphreys, 1983). They found that subjects oriented to stimuli in the non-neglected field readily, and, even when there was a competing stimulus in the non-neglected field, neglect decreased markedly when subjects were cued and forced to report the neglected field stimuli. This contrasts with reports by Heilman and Valenstein (1979) of somewhat differently designed experiments, and possibly can be accounted for by a separation between automatic and conscious orienting processes (Riddoch & Humphreys, 1983). Forced reporting and manual cancellation tasks involve an additional neural step and can present potential confounds in neglect research. It seems clear that a voluntary or cued, conscious intervention lessens neglect. However, there are likely sensory modality effects related to cues: Bedi et al. (1994) found distractibility to be modality specific for children, and in a case study of neglect, Riddoch et al. (1995) found that modality of the cues reduced neglect in divergent ways: visual cues reduced neglect within, but not between single objects, the opposite effects found for motor cues.

Priming.

The two contrary theories of attentional selection processes are defined by Ladavas, Paladini et al. (1993), as early-selection (cites Broadbent, 1982; Triesman & Gelade, 1980), wherein selection occurs prior to stimulus identification and semantic processing (colour, location, low level processing); and late-selection, which theorizes that all stimuli are processed to identification before selection occurs (identity, meaning, higher level) (cites Deutsch & Deutsch, 1963; Tipper & Driver, 1988).

Evidence suggests that there is some implicit processing in the neglected field (see Bisiach, Meregalli & Berti, 1990; Marshall & Halligan, Berti & Rizzolatti, 1992; Ladavas, Paladini et al., 1993; Driver, Baylis & Rafal, 1992). Buxbaum and Coslett (1994, p.283) discuss priming and stimulus cueing. They suggest that attention issues are not related to space per se, but to a spatial marker in one's egocentric map, or to an object description linked to the marker (hence a later effect). Grabowecki et al. (1993) showed that preattentive processing of contralateral stimuli took place for each subject they tested. Marshall and Halligan (1993) have suggested that the implicit processing found may relate to a problem of degraded but partial information representation that seems unconscious but is not; which may thus be extinction. This might relate to signal thresholds or just-noticeable-difference problems (Weber fraction), as suggested by Marshall, Halligan and Robertson (1993, p. 315).

Arousal.

The general level of activation and directing of attention are also relevant to sensory attention. Fleet and Heilman (1986) have indicated that reduced arousal increased neglect and greater arousal reduced neglect. Robertson and North (1994) theorize that two hypotheses could account for the finding that bilateral hand activation cancelled neglect gains found in unilateral activity: either right brain damage to arousal systems; or activation of left representational fields by left movements changes thresholds due to the CNS relationship of action and attention. Robertson and North (1992) suggested that arousal was not the main factor in a study of hand activation; whereas Riddoch et al. (1995) did not implicate fatigue per se as a factor in their study, but do suggest that differences between the hemispheres in arousal levels may be a factor in neglect.

Heilman, Musella and Watson (1973), in an E.E.G. study of neglect patients found that 13 of 15 neglect subjects demonstrated focal E.E.G. abnormalities as well as diffuse asymmetrical slowing over the entire hemisphere, and suggest that this supports the theory that unilateral neglect is a defect in alerting caused by "... disconnection of the sensory association areas from the limbic and reticular activating systems". Heilman et al. (1978) investigated hypoarousal in right hemisphere parietotemporal patients with neglect, relating lower galvanic skin response (GSR) in subjects to disturbances in bilateral arousal and to disinhibition. The lower GSR (Satterfield & Dawson, 1971) in hyperactive children, was found to be responsive to stimulant drugs. However, Vallar, Sandroni et al. (1991b) reported normal visual evoked potentials on the left in patients with left neglect (cited by Marshall et al., 1993).

In ADHD subjects, Rothlind et al., (1991) attribute results of covert attention tests (such as that of Swanson et al., 1991) to possibly involve the "right lateralized vigilance network", and note that vigilance is known to have widespread inhibitory effects including "a negative shift in the EEG, a reduction in motor activity, and a slowing of heartrate all indicating a parasympathetic reaction "(Rothlind et al., 1991). Risser and Bowers (1993), in monitoring E.E.G. activity in ADHD, found that relatively high levels of slow wave activity, low patterns of arousal and low abilities to demonstrate inhibition were characteristic. There is considerable evidence supporting disordered alpha/beta forebrain ratios in ADHD children (e.g. Lubar et al., 1995; Klorman, 1991).

Stimuli Characteristics Influence Neglect

The brain attends differently to cues of different salience, including arousal, emotional valence, size of object, how they "read" and how easily they are matched to stored representations. Neglect has been shown to vary with many stimuli conditions. Speed of processing as well as accuracy are variables investigated. Researchers have studied meaningfulness, location, distractors that are similar to the target, or in spatial proximity, grouped, relation to the reference frame of the position of the viewer's body, or the environmentally uprightness of the objects: (i.e. are the viewer's body and/or the external environment features stable and upright? Do cue effects depend on context?) (reviewed by Grabowecky et al., 1993, p. 289). What is the effect of cues in contralateral, ipsilateral and both hemifields? Why is the periphery of such importance in both neglect and ADD/ADHD ? It is of interest to understand how normal subjects perform in these conditions, what the effects are of task complexity and cues within or external to task stimuli. These conditions may take on added importance in only some populations, as one study has found: "Stimulus material (shapes vs. letters) and array, (random vs. structured) interacted in a complex manner to influence target detection only in patients with right sided lesions" (Weintraub & Mesulam, 1988). In Fanthomme and Lincoln's (1995) study of eye movements in right hemisphere damage, the scores on the BIT test were correlated with the time spent viewing: lower scores were linked to longer right-viewing. Saccades, severity of neglect and degree of bias were all relevant.

Gainotti (1993) postulates that the distinction between right and left space is a dynamic integration of factors including body trunk position, head in relation to trunk, and eyeballs related to head and trunk. These ergonomic constraints and the formal attributes of a task must be integrated with cognitive elements in our understanding of how awareness works. For instance, Kinsbourne's attentional gradient hypothesis assumes that the midline distinction between left and right is formed by the focus of attention location, and not relative to the body midline (Kinsbourne, 1993). In this case, as attention moves, so does the left/right distinction. Eglin et al. (1994) concluded that neglect is more severe in larger display areas, where attention has to be moved, for neglect patients. Nikolaenko & Menshutkin (1993) suggest that right hemisphere inhibition results in deformation of perceptual space, creating a sense of compression of its right, and extension of its left parts. Tests of line bisections in left-handed and right-handed subjects, such as that of Luh (1995) seem to support this idea, and implicate perceptual and possibly also motor factors, since results differ for computer versus manual presentations, as well as with line length and body position, factors elsewhere described.

Neglect subjects were found by Ladavas et al. (1990) to be faster processing stimuli in right relative position rather than left, when compared to controls, because they probably have brought focal attention to the right relative position, unlike the more evenly distributed attention of the controls. Tegner and Levander (1991) tested a variety of line lengths and figure-ground contrast conditions in neglect patients. Their findings have interesting implications for the ideas of this paper. Weight is lent to the theories of how object(s) are recognized: they suggest that figure-ground contrast and pointed or sharp edged stimuli are relevant to neglect. Long lines may lead neglect patients to approach the zone from the right and make rightward errors; shorter ones (when the zone is in central vision) may lead them to approach the zone from the left (a normal scanning strategy), and make leftward errors (Tegner & Levander, 1991). This evidence should be related to that of Riddoch et al. (1995), who found that copying from different directions led to opposite neglect patterns for their neglect subject, which is consistent with this idea. Decreased general arousal, and the side of cueing thus affecting the hemisphere aroused, are the explanations given (Riddoch et al.). This should be considered with reference to ADHD subjects in several ways: because of eye movement anomalies; related to reading and dyslexia; to the grouping of letters or of words (as objects) and to differential hemisphere activation depending on the qualities of the letters as shapes. Riddoch et al. indicate that performance may vary as a function of the interaction of attentional cueing with the "form of spatial representation mediating task performance". Neither overall fatigue nor an effect of start position on performance were indicated as possible factors.

Object-based neglect.

The issue of frames of reference capable of eliciting neglect is an important one for classroom consequences to ADD/ADHD students. Object-based neglect is the impairment of processing of single objects, irregardless of their egocentric location (Driver & Halligan, 1991). Driver and Halligan studied one left-neglect, right-hemisphere damaged patient, finding that she neglected one side of each object in a scene, irrespective of its hemifield, leading them to theorize that neglect may operate in object-centred coordinates. Using nonsense shapes they found that neglect related to the principal axis of the shape, and not to the location of the shape in relation to the egocentric midline (see Buxbaum &

Coslett, 1994 also, for similar findings).

Three types of *spatial reference frames* were identified by Farah et al. (1990), and studies have been done to see which conditions are linked to neglect (for review, see Farah et al., 1990). These are the viewer-centred, the environment-centred, and the object-centered frames of reference. They tested this construct through rotation of the object and the viewer, finding that the "neglected hemifield was defined with respect to both viewer-centred and environment-centred frames of reference, but not with respect to an object-centred frame of reference" (Farah et al., 1990). Viewer centred frames can be retina, head, or trunk centred also (Farah et al., 1990), suggesting that the reference point of the coordinate system for identifying and storing the inner representation is somehow relevant to neglect. Robertson and North (1992, p. 561) studied the relationships of hand, hemispace and motor activation in cueing in neglect, finding that under some conditions the side of space is dominant over the side of the body in mediating responses in space. Rizzolatti and Berti (1993) have identified some issues related to coding of space, noting that studies have shown that certain neurons have retinotopically organized receptive fields which are gated by eye-position (cites Andersen et al., 1990). It has also been observed that, in dichotic listening tasks, the eyes orient to and remain fixated in the direction of the relevant ear (Gopher, 1973, cited by Gainotti, 1993).

When the head of a normal subject is tilted, a rotation of the eyeballs, about 6-8 degrees in the opposite direction, occurs (Farah, 1990, cites Howard & Templeton, 1966). According to Farah et al. (1990, p. 345) the locus of points of an object, not its objective (upright) orientation are relevant to neglect. This accords with several other studies which implicate spatial reference points (rather than viewer or object centred) as a key for neglect. Hillis and Caramazza (1991) found that in words, left errors were a function of the distance from the centre of the word. Format and type of stimulus were relevant. Karnath and Huber (1992), however, indicated that neglect patients manifested abnormal eye movement patterns: return sweeps ending in the middle of the next line while reading, and a series of short saccades which followed, finding that the spatial border for this was a body-centred not retinal coordinate system. Relative position in space, not the size or shape parameters were found to be important to neglect in the Massironi et al., (1990) study, as were the task parameters. Seron et al. (1989) found in both free viewing and tachistoscopic studies that meaningful information on the ipsilateral side of the stimuli influenced neglect (pertinent for ADHD). It might be possible that the task load, task overlaps, and/or deployment of attentional resources toward meaningful material, which are issues in ADHD subjects, relate to a similar mechanism. Seron proposed that "... perhaps the later stage losses relate to a self terminating process of positional encoding as opposed to identity (meaning) as proposed by Ellis (in Seron et al., p. 496).

Tegner and Levander (1991) postulate two independent mechanisms related to visual recognition of stimulus properties and suggest they operate differently with certain types of stimuli: ..." the left-pushing mechanism is operative with small objects in central vision and the right-pushing mechanism with larger objects in peripheral vision" (p. 886). They found that..." neglect patients perceive shorter lines as longer than they were and longer lines as shorter than they were" (Tegner & Levander). According to Gainotti et al. (1986), peripheral vision neglect is found in those with left brain damage and central vision neglect in those with right brain damage (Tegner & Levander, 1991). Frontal eye fields have been found important in generating voluntary saccades and in the preservation of foveal visual analysis (see Pantano et al., 1992).

Both viewer and environment centred frames of reference could account for a neglect patient omitting the left side of words when reading them, or when spelling them from memory (Farah et al., 1990). These issues are of especial importance in student performance and, were neglect found to be related to ADHD, would be of interest for this population. Neglect dyslexia, however, has been found dissociated from visuospatial neglect (De Lacy Costello & Warrington, 1987).

Attention Deficit Disorder (ADD/ADHD)

This section will address cue and stimuli characteristics of ADHD children, eye movement evidence, and discuss ways in which neglect and ADD/ADHD may be related. DSM-IV (APA, 1994) describes the differential-diagnosic criteria for ADD/ADHD. Diagnostic criteria changes from edition to edition reflect the fact that the disorder is not unitary and that significant disagreement exists over an underlying commonality for ADD and ADHD. Neurobiological and neurocognitive factors in ADHD have been reviewed in several recent articles (Voeller, 1991; Hynd et al., 1991 a, b; Zametkin & Rapoport, 1987; Riccio et al., 1993). These concur that, although significant recent progress has been made, it is still very difficult to "...map behavioural descriptors onto relevant neurologic components" for ADD (Riccio et al., 1993). The inclusion of some findings from this area in this paper must therefore be taken as suggestive only.

The case for a possible relationship of neglect and ADD/ADHD rests on two specific studies which have found a relationship of ADD or ADHD and neglect, and on evidence of eye tracking difficulties in ADHD patients, (Swanson et al., 1991; Carter et al., 1995; Ross et al., 1994) ADHD can be indirectly linked to neglect in the following ways: eye movement behaviours mimic those of neglect patients; sensory-merger studies indicate an interrelationship during the processing of different modalities, which can be neglect or extinction related where auditory and visual are concerned (e.g. Soroker et al., 1995 a, b); issues of global and focal processing are common to both populations; the influence of peripheral cues acts similarily; and there is similar behaviour to complexity and location and invalidity of cues, task load, and overt attention. Hypothesized mechanisms in ADHD include disrupted right hemisphere processing, a complex relationship through the neuroanatomy of attention and the dopamine and norepinephrine neurotransmitter systems, including their similar responsivity to methylphenidate; dopamine hypofunction, and slow wave function in forebrain (Zametkin et al., 1993; Lou et al., 1984). Dopamine and norepinephrine (catecholamines) are generally accepted to be implicated in ADHD (Voeller, 1991). Frontal lobe dysfunction (hypoarousal) is perhaps relevant, and the posterior parietal cortex may also be involved. Grodzinsky and Diamond (1992) reviewed the literature of frontal lobe function in ADHD, and studied a clearly diagnosed group of subjects to investigate performance on a battery of tests sensitive to frontal damage. Weaknesses were found for ADHD boys on several of the tests used relating to vigilance, inhibition/impulsivity, and planning and organizing of output.

Evidence for a Neglect-ADD/ADHD Connection

Voeller and Heilman (1988) conducted a small study to investigate whether ADD children resemble adults with inattention and neglect secondary to right hemisphere dysfunction. Controls and ADD children performed a letter cancellation task often used to define a left hemispatial neglect in adults with right-hemisphere dysfunction. Five of seven children made left-sided errors far more often than right; one, substantially more right-sided errors and one student very few errors, and all subjects showed left sided neurological signs. Authors indicated that these children were very similar to the neglect diagnosed adults, but suggested that ADD is unlikely to be solely related to a defect in attention induced by right-hemisphere dysfunction. Omission/commission error research, and the hemispheric lateralization studies of ADD/ADHD populations would be useful additional avenues to study. Malone et al. (1994) extended the Voeller and Heilman (1988) study to a larger sample of ADHD children using the same letter cancellation task while children were on placebo or on methylphenidate. ADHD children omitted more left sided targets than right sided ones on placebo; implicating a partial left visual field neglect, perhaps right hemisphere dysfunction, which was treated by methylphenidate. The ADHD/LD subgroup seemed to mostly account for this finding (Malone et al., 1994).

Heilman, Voeller and Nadeau (1991), have investigated the evidence regarding a proposed pathophysiological substrate for ADHD that implicates right hemisphere dysfunction: noting that ADHD is associated with defective attention and response inhibition and motor restlessness, right hemisphere damage traits. These traits are symptomatic of children with ADHD, who evidence left sided neglect and decreased activation of their right neostriatum. " We propose that children with ADHD have dysfunction in a right-sided, frontal-striatal system. Motor restlessness may reflect frontal lobe dysfunction due to the impairment of the meso-cortical dopamine system" (Heilman, Voeller & Nadeau, 1991). Heilman et al. (1991) also attribute the motor restlessness and, perhaps the inattention and defective response inhibition of children with ADHD to frontal lobe dysfunction due to hypofunction of the mesocortical dopamine system. In studies of rats, lesions of the ventral tegmental area of the midbrain (the origin of the mesocortical and mesolimbic dopamine systems) are found to create marked motor restlessness, decreased attention and increased reactivity to stimuli (LeMoal et al., 1976); the restlessness and inattention respond well to dopamine agonists (Tassin et al., 1978, both cited in Heilman et al., 1991). Guitton et al.'s (1985) explanation that a small increase in the rate of signal processing associated with frontal lobe lesions can lead to a variety of inappropriate activities, because of failures to abort inappropriate behaviour, is also worth considering. Among the behaviours he mentioned are excessive reactivity to stimuli, motor hyperactivity and abnormal distractibility (cited Fuster, 1981). These accounts are not exclusive of one another.

Just as ADHD subjects have been studied on tests related to right hemisphere dysfunction, in a study from the opposite direction, 93 % of students identified with right hemisphere dysfunction were found to meet DSM-III criteria for attention deficit disorder (Voeller, 1986); extreme distractibility and inattention were found. However, theorists concur that ADD is not simply attributable to right hemisphere dysfunction, and some studies measuring right hemisphere functions do not support the idea. A study by Branch, Cohen and Hynd (1992, cited by Voeller, 1993) compared right and left hemisphere dysfunction subjects on ADD sensitive measures and found no group related differences, except in impulsivity and commission errors. ADHD children have been found to have decreased regional cerebral blood flow and hence decreased metabolic activity in the striatum; more diminished on right than left in one of the two studies done by Lou et al. (1984; 1989). Auditory evoked potentials were studied in ADHD subjects by Satterfield et al. (1994) who found that there were significant differences from the controls, in a two choice, discrimination task.

Attention, Representation and Capacity in ADHD

Posner (1994) does not think that the attentional (beta) versus representational (d prime) accounts of neglect are especially useful constructs, (see also Ladavas et al., 1990), and some evidence from ADHD research tends to support this for the ADHD population (van der Meere & Sargent, 1988; Hamlett, Pelligrini & Connors, 1987). However, Schachar and Logan

(1990) tested capacity in relation to temporal overlaps of primary and secondary stimuli, finding that the secondary task provided greater deterioration of first task performance in the ADHD group, and created longer response times for the secondary task. The authors concluded that greater refractory effects or difficulty shifting capacity from primary to secondary task processes is implicated. However, neglect research indicates that stimulus cue presentation (e.g. invalid cues in ADHD) can profoundly impact results, and may have confounded findings of many such studies done to date. Increasing task difficulty often increases neglect (Riddoch et al., 1995). Kaplan et al. (1991) studied distractors and task complexity issues in a right hemisphere neglect population, finding that the number of targets cancelled in left hemispace was linearily related to the number of distractors and not to complexity per se; increasing right sided distractors increased neglect on both sides. Authors suggest that a more limited attentional capacity in the left hemisphere, or, one more focally directed, may explain the failure to respond to stimuli on the neglected side dependent on what is presented on the non-neglected side (Kaplan et al. 1991, cited Heilman; Mesulam; Kinsbourne).

Differences in the Research Basis

ADHD and neglect are treated differently by the literature of the two disciplines. Even though reaction time, stimulus cueing, and perceptual-motor skills are tested, the variables being controlled and tested, as well as the focus of interest do differ. Language differences too, have made a poor fit between the literature from the two areas. An example might be differing definitions for what is found: e.g. Zentall's (1985) "narrow focus" condition. In neglect "narrow focus" would mean a reduced attentional demand and a more focused window of attention; here, it means valid cueing and has few implications for the attentional window.

The results of numerous ADHD studies, while they demonstrate many attentional differences between normal and ADHD subjects, are not well controlled for neglect-related variables. Hyperactivity experiments seem less systematic in exploration of the relevant stimulus cueing factors than the methodological approach used in neglect research. Also, the tasks offered, and instruments used differ between the two areas of research. Many ADHD experiments should control for variables essential in neglect, such as the location of the cue, the salience or embeddedness of targets, the temporal sequence of stimuli processing. From an educational psychology point of view, studies of students and classroom performance should examine gradient effects in error lateralization in written assignments, student test-retest performance, pictorial or language based stimulus cues, and should control for cue and target placement, and for visual and auditory input modality in test instructions.

Omission and commission errors in hyperactive children.

An important aspect of the neglect-ADHD connection which has not been taken into account sufficiently, in previous stimulus-task studies of ADHD populations is the laterality of the omission errors. In Zentall's (1985) study, commission errors were fewer than omission errors. Long latencies and frequency of omission errors were found to cluster on a principal components analysis of the targets. These variables are held to measure different psychological constructs from commission errors. Omission errors and latency are associated with signal detection and signal processing speed, whereas commission errors are associated with impulsivity (Zentall, 1985).

Sustained attention.

Continuous performance tasks (CPT) have been used for ADHD children to assess the ability to sustain attention. Schachar et al. (1988) have reviewed studies of this type, which often involve a warning cue and response to target letters embedded in a series of nontarget letters. Omission and commission errors are recorded on these tasks, which involve discriminating repeated letter sequences, with possible pattern and colour variations (Zentall, 1986). Latencies are also measured (e.g. Zentall, 1989). ADHD children have been characterized in several of these studies as making more false positives, fewer correct responses and slower mean response times for correct positives (e.g. Sykes, Douglas, Weiss & Minde, 1971; Sykes et al, 1973; Michael, Klorman, Salzman, Borgstedt & Dainer, 1981; Neuchterlein, 1983; Rapoport et al., 1980, cited by Zentall, 1986). Random assignment to group, and counterbalanced sequences of tasks are used in these studies (e.g. Zentall, 1986).

Studies of this type do not necessarily mean that inability to sustain attention is at the root of the problems noticed, since alternative explanations can include aspects such as coordination, vision, understanding and cooperation (Schachar et al., 1988). Time-on-task is one studied variable (Sykes et al., 1973; Michael et al., 1981). Schachar et al., (1988) studied both time-on-task and time related to a warning signal, but, in contradiction to Michael et al. (1981) did not find lower overall rates of accuracy for ADHD children. A summary of some findings of stimulation/vigilance variables is available in Zentall (1986).

The *optimal level of stimulation* theory is one ADHD construct reviewed by Zentall (1985), which suggests that ADHD subjects are less tolerant than others of low stimulation. ADHD's seem similar to neglect patients in that data driven tasks and within-task complexity increase errors for both populations. Searching a complex field is harder for ADHD subjects (see Alabasio, 1972; Douglas & Peters, 1979, cited by Zentall, 1985). Continuous performance tasks are a paradigm common in ADHD studies. For example, the CPT task used by Sykes, Douglas and Morgenstern (1973), and the experiment of Zentall (1985) both used a random signal stimulus with randomly assigned colour. It may be that it is aspects like the formal arrangement of the array, the need to fixate the window of attention anew, the complexity of the task and overlapping stimuli conditions, stimulus frequency and modality, all of which may be able to be quite specifically controlled, that are critical to the "optimal level" hypothesis. The Wisconsin Card Sorting Task (WCST) was used in Carter et al. (1995) and also cited by Shaughency and Hynd (1989), as a measure of sustained attention. Carter et al. found that the degree of cost asymmetry (a loss of costs on invalidly cued left visual field targets covertly addressed) correlated negatively with the number of categories children were able to sort on the WCST. This suggests that a measureable academic consequence can ensue from this visual processing problem found in the ADHD population.

Impulsivity.

The Matching Familiar Figures Test (MMFT 20, Kagan et al., 1964) is commonly used to assess impulsivity (Douglas and Peters, 1979, cited by Zentall & Dwyer, 1989). Error scores on vigilance tasks used to assess attention are indices of sustained attention. Match-to-sample tasks and CPT tasks that require a response to an infrequent target letter stimulus in sequential random presentations of letters are frequently used to assess sustained attention (Zentall & Dwyer, 1989). Rapid responses (commission errors and short latencies) and failure to respond - indicated by omission errors, are characteristic of hyperactives (Zentall & Dwyer, 1989). A portion of failures-to-respond of ADHD stucdents might be attributable to neglect, and are classroom relevant. This study may help to identify whether that is possible.

The go-no go paradigm is often used in ADHD experiments; it probably measures ability to inhibit responses, which is not central to the thesis being explored here, although it is also affected by methylphenidate in ADHD children (see Trommer et al., 1991).

Within task stimulation in ADHD.

Neglect studies can possibly shed light on the issues of within task-stimulation for ADD/ADHD children. Cruickshank, et al., (1961) suggested increasing within-task stimulation for hyperactive children, such as the size and colour of materials (cited by Zentall, Zentall & Barack, 1978). However, when task figures are embedded within a background of competing lines, performance decreases for ADHD's as contrasted to controls (Adams, Hayden, & Canter, 1974) as well as for non readers, as contrasted to readers (Sabatino & Ysseldyke, 1972, cited by Zentall et al., 1978). Zentall has criticized these studies for not controlling the order of stimulus presentation (Zentall et al.). Sabatino and Ysseldyke (1972) found that the Bender Visual-Motor Gestalt test (as scored using Koppitz, 1964 system) was not sensitive enough to discriminate between readers and non-readers in a learning disabled population when the competing background lines were involved. These studies imply that, in neglect, the grating (stimulus spatial frequency) may be a factor. Perhaps this is true for ADHD also. Watt (1991) has illustrated this regarding neglect. "Evidence suggests that hyperactive children have a wider attentional field than nonhyperactive children, that is, hyperactive children are characterized by attention to peripheral or salient extratask stimuli (Bremer & Stern, 1976; Katz, 1971; Patton, Routh & Offenbach, 1981; Radosh & Gittelman, 1981; Shores & Haubrich, 1969; Steinkamp, 1980" (all cited by Zentall & Gohs, 1984). ADHD children were studied in a cued reaction time experiment to investigate whether methylphenidate induced overfocusing in these children, authors concluding that it did not, although overall generalized efficiency of information processing was found (Tannock, Schachar & Logan, 1993).

Intratask stimulation makes performance of ADHD's worse (Rosenthal & Allen, cited in Zentall, 1986). Stimulation added later in complex trials may assist the ADHD subject - for instance, competing distal stimulation (Conners, 1975, cited in Zentall, 1986). Issues of the leading eye, or ear also, as related to task requirements may be relevant for environmental scanning traits of ADD/ADHD subjects and should be investigated regarding possible right-hemisphere dysfunction.

Other task factors.

The role of colour in cueing for ADHD children has been intensively studied by Zentall (1986; 1989; Zentall et al., 1978; Zentall & Kruzek, 1988). She has found significant differences between ADHD's and controls on a number of indices, including task response rates, level of activity and the role of colour in learning and selective-attention-demanding tasks in early and repeated trial conditions. The thrust of such studies is that the attentional dysfunctions of ADHD students are extremely specific.

Image characteristics of the test materials are important. Letters and pictures, and other image characteristics are may affect results. The formal and random distribution of the images on the page may matter. Issues of figural shape for stimulus targets may be relevant (closure, rounded forms, X, letters, curved and parallel lines) since they may relate to hemispheric specialization (see, for instance, Polich, Lentz and Crossman, 1986). Ladavas, Paladini & Cubelli, (1993), say that the employment of digits or letters as cues may reduce left sided neglect on such tasks as line bisection, line cancellation, or free report (cites Riddoch & Humphreys, 1983; Butter, Kirsch & Reeves, 1990). Part of this idea was tested by Arguin & Bub (1993, p. 153), for neglect, as to foveal and peripheral targets. Response type, as in verbal and motor responses, are aspects to be aware of in designing the task paradigm.

<u>Subsets of ADD/ADHD</u>

If two subsets of ADHD children are recognized: MPH responders/not; and Comorbid LD/not, it might be worth investigating a possible link of neglect (if viewed as a reading, LD type of problem) and MPH response for a possible catacholamine connection. Although this is speculative, the question of subsets of the ADHD population relate to the ADHD-neglect connection. The learning disabled population may form one subset of ADHD, and differential methylphenidate (MPH) responders may form another subset. L. Rapport et al. (1994) have noted that, for many children, behavioral, attentional and academic functioning respond to MPH (methylphenidate) in a parallel way. In another group of children, academic functioning appears unrelated to "attentional and behavioral response to MPH". The specificity of effects of MPH was noted in this study and the findings are similar to those of Malone et al. (1988, 1994). L. Rapport et al. (1994) say that "Overall, children failing to respond at lower dose levels have a high probability of improving or becoming normalized as a function of increasing dose" (See also Malone et al., 1994). Might there be overlap of academic non-responders to MPH and ADHD/comorbid learning disabilities groups? If so, might there be a relation to eye or ear advantage (the sensory organ dominance as related to the dominant brain). This would create differing impacts for the child as an able learner, if there is right hemisphere malfunction. Perhaps the global/focal spatial frequency gratings issue is also important. Each eye is specialized for certain perception skills (global/focal). There may be also left neglect, and some type of tracking deficits (e.g. Swanson et al., 1991; Carter et al., 1995; Ross et al., 1994). Is there a lead eye effect, and, are these children lateralized differently? Which eye relates to their dominant brain for language, for instance? The findings in ADHD's for dichotic listening experiments have relevance to this hypothesis, and possibly, so do body orientation and head turning experiments (in neglect, see Karnath et al., 1991; 1994).

Cueing in ADD/ADHD

The comparability for studies of neglect and ADD/ADHD is often weak, because they use different tasks and control differently for stimuli conditions. Also, ADHD studies use reaction time experiments for cognitive rather than formal purposes, unlike neglect studies. Zentall and Gohs (1984) found that ADHD subjects performed worse than the control group in tasks that only offered detailed cues, and responded more impulsively in those conditions, these findings did not relate to overall group differences in motivation, ability to request information, information processing speed or to nonspecific impulsivity. This finding seems important with reference to neglect because neglect studies show that specific stimulus cueing can help overcome neglect related deficits. Also, global and focal perceptual processing has been linked to eye movement patterns suggestive of certain visual-neglect deficits. The global-focal issue may contribute markedly to academic and social difficulties in ADHD students. Jonides (1983) showed that "when the subjects used the focused mode in response to a precue, and the precue was invalid, attention reverted to the diffuse mode for processing the other display elements (cited by Eriksen & Yeh, 1985). This is useful in understanding the ADHD deficit: serial and parallel search switching may be affected. Neglect-related, stimuli-processing, physiological characteristics may be a factor in the unusual attentional responses of ADHD children. Any findings related to neglect may propose avenues for further investigation of the neural processing in ADHD, but probably cannot account for all aspects of the disorder (e.g. the impulsivity; motor activity). However, see Guitton et al. (1985) for a possible explanation which can encompass these symptoms. If the blending problem described by Guitton et al. occurs across other sensory modalities and at motor action levels this mechanism may explain many of the problems of hyperactivity.

Zentall, Zentall & Barack (1978) have specified some cueing conditions. ADHD's in their study "tended to perform faster than normals on visual-motor tasks, but performed slower than normals on tasks involving visual concentration." They say that their results indicate that the locus of added stimulation may be important in determining effects on performance, and impulsivity or response speed may be unrelated to performance problems of hyperactive children

(Zentall et al., 1978). Addition of stimulation to a task may produce increased attention to a task, but may embed the task within the added stimulation, whether or not the cues are competing (Zentall et al., 1978). Campbell et al., (1971) found that hyperactive children have more difficulty than normal separating embedded figures from ground (cited in Zentall et al., 1978). Thus it appears that adding stimulation to a task (not increasing stimulation in general) "... contributes to the learning problems of hyperactive children" (Zentall et al., 1978). Adding visual cues helped ADHD children normalize their skills in an auditory task, but did not help control group children (Carter & Shostak, cited in Zentall, 1993). Cued-recall helped ADHD students, who in free-recall performed worse than controls (Hamlett, Pelligrini & Connors, 1987; Weingartner et al., 1980, cited in Zentall, 1993). ADHD students have been found to selectively attend to novelty (colour, size and movement changes) (Copeland & Wisniewski, 1981; Radosh & Gittelman, 1981, cited in Zentall, 1993). Tant and Douglas (1982) found that ADHD students fail to focus on neutral, subtle, small/detailed or embeddded stimuli (in Zentall, 1993). This trend is consistent with the local/global focus difficulties documented for neglect, and with the cue-target overlap conditions in invalid cue and in eye movement studies in ADHD. This avenue should be explored more systematically as a possible defining symptom of ADHD.

Although earliest evidence was contradictory to this theory, more recent evidence suggests that increased distal and peripheral stimulation may have a facilitative, not disruptive effect on ADHD children (Browning, 1967; Carter & Diaz, 1971; Scott, 1970; Zentall & Zentall, 1976, all cited in Zentall, Zentall & Booth, 1978). Zentall's study sought to find out if within-task stimulation affected activity and performance in ADHD's in classroom spelling, finding that these children made more initial errors (adjusting more slowly to high levels of within task stimulation), and that high levels of activity were predictors of poorer later performance for both groups of subjects (Zentall, Zentall & Booth, 1978). This study concluded that within-task stimulation increases activity and decreases performance, whereas distal and peripheral stimulation tend to do the opposite for an ADHD child.

There have been numerous studies of stimulation in the auditory modality. Similar effects are found. Zentall and Shaw (1980) found that task overlapping linguistic noise affected ADHD and control children differently. In a task requiring auditory processing of information, ADHD children were most active and performed math and alphabet tasks more poorly in the high noise condition, the opposite results were found in the control group. This study, and one by Douglas and Peters (1980, cited in Zentall & Gohs, 1984) differentiates omission and commission errors, finding more commission errors for ADHD. A letter cancellation task (similar to neglect tests) was part of the Zentall & Shaw (1980) experiment; it seems that omission/commission issues should be reviewed in light of recent neglect findings. In one of Zentall & colleagues experiments, high noise and new/initially difficult task conditions presented greater challenges for ADHD children relative to others, and led to a significant increase in commission error rates. In well practiced and overlearned tasks, overlapping linguistic noise may be helpful to ADHD children (Zentall & Shaw, 1980). Hommel (1990) found that nonverbal, music and white noise could improve subject performance in right-handed, left-visual neglect.

Eye Movement Evidence

A circumstantial case for an ADD/ADHD-Neglect relationship lies in the eye movement evidence. In their study of visual-spatial attention in ADHD, Swanson, Posner, and colleagues (1991) tested covert and overt attention tasks using the Posner (disengage-move-engage) paradigm. Their findings indicated intact ADHD operations at the 100 ms. response time (RT) but a significant lateral difference in RT between leftward eye directions in the 800 ms. task. As demonstrated elsewhere, the longer response time is consistent with a covert or cognitive stage of processing, probably anterior based, unlike the earlier "orienting" automatic response. In ADHD subjects, only the shift of eye movements to the left is impaired, being significantly faster in controls, in invalid trial conditions. This is a decreased cost of an invalid cue, suggesting that ADHD children do not maintain attention well to a cue projected to the left hemisphere requiring a move to the right. See also Pearson et al. (1995).

Clark et al. (1989, p.136) have investigated dopamine and noradrenaline antagonist drugs in relation to valid/invalid cue response times, suggesting that central catecholamine activity "... played a role in determining the ease with which attention can be disengaged" and that the direction of effect obtained in this study demonstrated faster disengagement and switching of attention following reduction in central catecholamine activity. The results described by Carter et al. (1995) and Swanson et al, (1991) seem to coincide: the ADHD difference found in Carter et al. was a controlled attentional orienting loss of costs (too quick) to an invalidly cued left visual field target (central cues). Swanson et al. (1991, p. S124) found that a "... significant visual field effect emerged in the invalid cue condition for the ADHD subjects but not for the normal subjects." In Ross et al. (1994) the task involved visuospatial working memory, and the ADHD children were found to have deficits in inhibiting response in the delay period but no significant differences in accuracy, or latency (preparation of motor response). ADHD boys made a premature saccade during the delay period, and significant differences were found in performance of ADHD boys in the oculomotor delayed response task in medicated and unmedicated conditions. Task design issues make the comparability of studies difficult, because some of the cue stimuli occurred in each side of the fixation stimulus in this case (Ross et al, 1994) (thus some are valid, and others, invalid cues when related to the other experimental paradigms cited, and direction is also relevant). Also, the ability to delay was being tested rather than response time, memory of a cue location is involved, and overlap/cue complexity issues would also be relevant factors.

Rothlind, Posner and Shaughency (1991), in their study of ADHD, eye movements and covert attention, identified a right hemisphere problem in ADHD, finding it difficult for this population to sustain attention to a cued location, more rapid eye movements in left direction, and a different error rate in 3 of 4 conditions tested (p. 378). Control children, unlike ADHD subjects, were faster in moving their eyes in directions controlled by the right cerebral hemisphere, in non-cued conditions. Many RT target studies in ADHD should be revisited with a view to the neglect findings and because of the Carter et al. (1995) and Swanson et al. (1991) studies which find anomalous responses only for invalid targets related to faster left direction eye movements in left hemifield. Studies which have not parcelled out the eye movement in relation to a previous cue may have confounded a critical element on many trials.

Ross et al. (1994) tested three tasks: inhibit response, prepare motor response, and, accuracy of memory guided saccade- visuospatial working memory. In the delayed oculomotor response task, cues could appear to left or right of fixation stimulus- so, some trials are "in left hemifield toward left periphery" thus relating to the Swanson (1991) question. " Of interest is the finding that the methylphenidate responsive ADHD children showed no effect of methylphenidate on their rate of premature saccades (their ability to inhibit saccades during the delay period)" (Ross et al, 1994). There were more premature saccades in ADHD children, nearly half with latencies of greater than 530 msec., held to indicate probable inability to inhibit response to information coded in working memory. More difficulty for ADHD's to inhibit a saccade to a cue stimulus was also seen (Ross et al, 1994).

In tasks involving control of eye movements in pro and anti saccade directions, the ADHD population differed from controls because they did not demonstrate expected asymmetry of faster movement of eyes in directions controlled by right cerebral hemisphere when no warning of impending target was given (Rothlind, Posner & Schaughency, 1991) . This might be interpreted to mean that unlike the findings of Swanson et al. (1991), where cue validity was relevant, ADHD children also differ in non-target conditions. Guitton, Buchtel and Douglas (1991) found that frontal lobe lesions disinhibit oculomotor activity. Perhaps the frontal lobe hypoperfusion of ADHD children (e.g. Lou et al., 1984) also disinhibits oculomotor activity.

Considerable evidence using a variety of paradigms implicates numerous oculomotor differences in the ADHD population. Guitton et al. (1985) has presented a compelling hypothesis which might account for a variety of ADHD symptoms. Authors explain that "frontal lobe lesions in man cause difficulties in suppressing reflexive glances and in generating goal-directed saccades". Authors state that "a small increase in neural processing times can lead to totally inappropriate oculomotor behaviour... An increase in the rate of signal processing caused by a frontal lobe lesion, may lead to a cancellation signal which appears 100 ms. later than it should and this may make the difference between 0% and 100% in the frequency of reflexive glances". Authors suggest that several nonspecific-frontal lobe syndromes (excessive reactivity to stimuli, motor hyperactivity and abnormal distractibility (Fuster, 1981) can be caused by one factor: "... a small increase in the time taken by the frontal lobes to abort the inappropriate behaviour" (Guitton et al, 1985). An ability to suppress an reflexive glance may not relate to the same areas as the ability to generate antisaccades (Guitton et al., 1985). In any case, the hypothesis of such a mechanism, which was found to relate to task difficulty, to contralaterality, and to the cue-symbol time interval, may be a parsimonious explanation for the numerous and diverse effects seen in hyperactivity. It is consistent with certain neglect-related characteristics, frontal lobe dysfunction in ADHD and with some of the other eye movement, asymmetry and blending of input issues identified for ADHD children, as well as with theories of a failure in inhibitory processes in ADHD, and of the relevance of directed attention to these symptoms. Eye movement findings in ADHD need further study, to see what common features may indicate a consensus across several studies, to identify any studies which present contradictory evidence, and to analyse the various paradigms used, to understand what they imply about the etiology of ADHD.

Hornak's studies (1995) of neglect patients indicate that "... during free vision tasks, the fixations of neglect patients tend to be crowded towards the right, which would place the left side of a stimulus in the right field", and, that they demonstrate a strong bias to look to the right when searching for a nonexistent target in the dark (Hornak, 1992 cited in Hornak, 1995). Eye movement patterns of neglect patients demonstrate neglect of the left side of stimuli in the absence of directions. Various types of cueing (including verbal prompts at cognitive levels of processing) have been shown to increase ability to respond to stimuli in the left visual field (in neglect patients, see sources cited by Hornak, 1995).

Although there are few eye movement studies in ADHD, it seems possible that the faulty tracking patterns seen in neglect may also be implicated in ADHD, as they are in reading disabilities and in neurological disorders. While only about 9% of ADHD students have true reading disabilities, results vary - up to 39% in clinical referral populations (see Zentall 1993, p. 145). Poor and good readers have been found to differ in ability to direct attention when cued, behaving differently for invalid cues than normal readers, and have poorer accuracy when the cue precedes the target letter by less than 100 ms. Right visual field enhancement was found in adults and good readers, but not poor readers (Brannan & Williams, 1987). Poor readers also show stronger perceptual grouping effects and may be more inclined to global, transient processing (Brannan & Williams, 1987). Marshall, Halligan & Robertson (1993) have suggested that neglect may only appear when a wide focus of attention needs to be narrowed to see detail. Also, a study by May, Williams & Dunlap (1986) indicated that poor readers take more time to make decisions about the temporal order of two stimuli (cited in Brannan & Williams, 1987). An interesting convergence of ideas of focal and global attention habits, cue response behaviour emerges. If a strong connection exists between neglect and ADD or ADHD, it may only be applicable to a learning disabled subgroup, but it may also point toward a different theoretical understanding of the physiological, perceptual and attentional basis of ADD/ADHD.

Right Hemisphere

Literature Review

The right hemisphere has been shown to be dominant in visual perception and visual exploration or search (e.g. Mesulam, 1981; Weintraub & Mesulam, 1988). Right handed subjects were found to be more accurate in directing gaze in LVF than in the RVF (Bracewell et al, 1990), suggesting to authors, right hemisphere superiority for visuomotor control. ADHD children have been shown to have poor performance on visual perception and scanning tasks (Douglas, 1983). Perceptual efficiency has improved with stimulant medication (Reid & Borkowski, 1984, all above cited in Malone et al., 1994).

The right hemisphere predominates in controlling attention (Deutsch et al., 1987; Heilman & van den Abell, 1980; Jutai, 1984; see also Yokoyama et al., 1987). ADHD children perform poorly in tasks involving the maintenance of attention (Dykman et al., 1979; Sykes et al., 1972, above cited in Malone et al., 1994). 93% of children selected by neuroimaging or neurological examination for right hemisphere dysfunction were found to meet DSM-IIIR criteria for Attention Deficit Disorder (Voeller, 1986). Tasks sensitive to right hemisphere dysfunction, such as motor persistence (Voeller & Heilman, 1988) and letter cancellation (Voeller & Heilman, 1988b) are impaired in ADHD children. An expected right visual field (left hemisphere) advantage for a lexical decision making task was not found in a tachistoscopic study of ADHD children when taking placebo, but was found on medication (Malone et al., 1988). Stimulants have improved performance in left hemisphere tasks also (Malone et al., 1988). Hemineglect may occur because of damage to right hemisphere attention-arousal systems (Heilman & van den Abell, 1980).

MRI studies have shown reduced corpus callosum connections between the hemispheres in ADHD children (Hynd et al., 1991; Semrud- Clikeman et al., 1994). Connections between the two hemispheres are relevant because the two directions are unequal (see Nowicka et al., 1996; Hellige et al., 1989). If ADHD children are "wired differently" (having the less commonly found ear dominance or language brain for instance) a quantitative difference in neuron projections between the two directions would be of importance. Ladavas, Nicoletti, Umilta and Rizzolatti (1984) found that reaction times to lateralized visual stimuli were selectively lengthened for those mediated by the right hemisphere during production of negative affect. Thus the right hemisphere deficit hypothesis may relate to affect, to social/emotional processing.

Is the right hemisphere dominant for visuospatial organization? Bracewell, Husain and Stein (1990) have suggested right hemisphere specialization for visuo-motor control, especially for remembered target positions, where "the majority of right-handed subjects were found to be more accurate at directing their gaze to locations in the LVF than in the RVF...". Meador et al. (1989) found that in right handed subjects with left cerebral language dominance, the occurrence and severity of eye deviations were greater for right as opposed to left hemisphere injections, whereas mixed cerebral dominance for language/handedness yielded no left/right differences in the incidence of eye deviation. These results, they say, are consistent with right cerebral dominance for attentional/intentional mechanisms directed at external space (Meador et al., 1989). This eye movement element identified by Meador et al. should be examined relative to window of directed attention theories in neglect (see Halligan; Riddoch et al., 1995) and with reference to the evoked potential differences found between ADHD and control subjects. For instance, both amplitude and latency differences are found for attending to visual target stimuli (Satterfield, Schell & Nicholas, 1994). According to Riddoch et al. (1995), the hemispheric activation hypothesis would indicate that a patient having decreased processing resources may express neglect on different sides according to the hemisphere required for the task - perhaps showing right neglect in tasks like reading and picture naming that use left hemisphere resources; left neglect for spatial tasks like copying and line cancellation that require strong right hemisphere activation. This theory would be applicable for

ADHD, where hypofunction is found, and account for those differences in side of neglect, seen in the Malone et al. (1994) study, if one's dominant eye or language brain is a relevant factor. It also implies that a test battery like the BIT might be scored with reference to types of test rather than as an aggregate, and that neglect in even one type of test is relevant.

Trauner & Ballantyne (1988) tested for neglect in patients with early onset (before age one) in right and left hemisphere damage, noting poorer performance on the left side and more omissions on both sides compared with the controls on a visual task (target circling), and also significantly greater left side search times. Studies need to address the question of search performance of ADHD children. Trauner and Ballantyne suggest that "early damage to the right hemisphere produces similar patterns of spatial neglect as those found in late-acquired RH lesions", namely, inattention to the left hemispace and milder ipsilesional impairments. This is of importance to the hypotheses presented here, since a neglect-ADHD relationship is dependent on hypoarousal and/or neurochemical explanations rather than lesions in the ADHD population. Brumback & Staton (1982) formalized a table of differences in hemispheric specialization emphasizing a right hemisphere involvement in learning disability, attentional disorder and depressive disorder. Sunder, DeMarco, Fruitiger & Levey (1988) tested children aged 5-10 years old with no overt neurological damage, to investigate the prevalence and characteristics of a developmental right hemisphere deficit syndrome, using a battery of tests including WISC-R and visual-motor tests. The characteristics of twenty children identified under the scoring criteria included dyseidetic reading patterns (80%), apraxia (75%), subtle left sided deficits (100%), attention deficits in 75% and significant social and emotional difficulties (75%) (see also an associated study, De Marco et al., 1988). These findings are of interest for the ADHD population.

Matazow & Hynd (1992b) thought that ADD/H and ADD/WO children, and LD (dyslexic) children could be differentiated on tests which discriminate right hemisphere functions. Tests they used, measuring visuo-spatial abilities, (especially those measuring posterior or parietal lobe functioning) included: Beery Tests of Visuo-motor Integration, Benton Line Orientation, Test of Facial Recognition, Block Design subtest of the WISC-R, Math Subtest of the WRAT-R. Minimal linguistic requirements are features of these tests. Most measures showed insignificant results, though a comparison of right and left-sided errors on the Judgement of Line Orientation test yielded significant results. ADD/H children exhibited most right-sided errors, ADD/WO the most left sided errors ($p < .05$). Another study (Matazow & Hynd, 1992a) of anterior-posterior gradient in ADD children included an amended version of this test, but found what were termed marginally significant results ($p. < .09$). The error direction was again similar, suggesting to authors that it might be accounted for by Shaughency and Hynd's (1989) theory that left frontal deficits distinguish ADHD children from ADD/WO subjects who show a right frontal deficit. The Matazow and Hynd (1992a) study included only dyslexics as the LD group, the Matazow and Hynd (1992b) included many codiagnosed dyslexics in the ADD group, which may have posed a difficulty in interpreting results and comparing these studies.

Hemispheric specialization, transfer.

Is there specificity of the hemispheres for processing certain information, and, would it be relevant to the Behavioural Inattention Test (BIT) (Wilson et al., 1987) subtests? (see Nowicka et al., 1996; Kolb & Whishaw, 1990 pp. 590, 690, 387). Polich, Lentz and Crossman (1986) tested letter shapes (T, I and O) and detail of the array, finding, in tachistoscopic studies, that the type of letter being detected was correlated with hemispheric error rates- superior right hemisphere performance for O presentations, and left hemisphere for T. Letter tasks of a different type used in Nowicka et al. (1996) were considered specialized for left hemisphere processing; and, longer left-hemisphere to right-hemisphere transmission times were found than right to left, in agreement with the Nowicka et al. hypothesis that faster transfer of information occurs from the non-specialized hemisphere to the specialized hemisphere. An alternative hypothesis (see Marzi et al., 1991) is directional, suggesting that transfer from the right hemisphere to the left hemisphere is faster than that in the opposite direction. This idea is attributed by Marzi et al. to an asymmetry in callosal connections (more neurons project); and by Braun (1992) to direction of the visual field advantage: "a LVF advantage is usually associated with faster transfer from the right hemisphere to the left one and an RVF advantage with faster transfer in the opposite direction" (Nowicka et al., 1996). This concept is important because corpus callosum differences are found in ADHD patients (Hynd, Semrud- Clikeman et al., 1991; Semrud- Clikeman et al., 1994). These findings might be, also, a possible consequence of right hemisphere dysfunction, an eye movement problem, or a dominance relationship. Research in neglect addresses direction and specialization issues, so neglect may be helpful for solving this problem for ADHD populations. A study by Nikolaenko and Menshutkin (1993) studied coordinate displacement and visual space compression during right hemisphere inhibition, implicating a perception process. This relates to the similar findings in neglect regarding line bisection perfomance (Tegner & Levander, 1991; Luh, 1995) and space perception (Massironi et al., 1990).

<u>Lesion Areas and Academic Task Performance in Right Hemisphere Deficit</u>

A study by D'Esposito, McGlinchey, Alexander & Verdaellie

(1993) tested visual neglect in 16 right hemisphere damage/left visual neglect patients. On semantic priming/lexical decision (SP) tasks, and on delayed, forced choice discrimination (DSC) tasks finding that subject deficits and intact abilities correlated with the area of lesion. Group 1 had posterior lesions and poor DSC in Left visual field and intact priming; Group 2 had extensive deep anterior lesions and normal priming and DSC in both fields; Group 3 had extensive deep anterior lesions and normal priming, but poor DSC in both fields. Authors indicate that attentional processes (group 1) and intentional ones (group 2), or a global attentional disturbance executive to this process may help to account for the data. Lesions have not been linked to deficits in ADHD populations and, although anatomical differences are useful information, the attentional deficits of ADHD subjects may relate to neurochemical factors.

Social Characteristics of ADHD Children - Neglect and/or Right-Hemisphere Related ?

Ozols & Rourke (1985) investigated social sensitivity in learning disabled children, finding, in a number of studies, two groups of learning disabled children, one with deficits relating to poor left-hemisphere skills, speech and language; the other relating to right-hemisphere, visual-spatial organization and synthesis, bilateral psychomotor, and tactile-perceptual difficulties, perhaps relating to "nonverbal learning disabilities" (term of Myklebust, 1975).

Social-behavioral, attitudinal and motivational problems are found. Ozols and Rourke (1985) suggest that these children may be at greater risk for social problems because of a lack of critical perceptual and cognitive skills: difficulty attending to and interpreting visual-perceptual information, poor skill in interpreting and attending to nonverbal social cues (facial expressions, hand movements, body postures), have difficulty processing novel stimuli and informational complexity (Ozols & Rourke, 1985, p.287). Mattingly, Bradshaw, Phillips and Bradshaw (1993) have investigated reversed perceptual asymmetry for faces in left visual neglect. Children with ADD have problems understanding non-verbal feedback (e.g. facial expressions, emotions) (Jones, 1994). ADHD children were shown to incorrectly attribute the actions of other children as hostile (Milich & Dodge, 1984). If a right hemisphere deficit in processing can be implicated in ADHD, some of the social and behavioural problems of ADHD children may relate to the physiologically driven misperception of cued information, both at a cognitive and an emotional level. This is consistent with a prenatal stress related model of dopamine-norepinephrine difficulties, early hemispheric asymmetries and the role of the right hemisphere in stress related emotional processing, as discussed elsewhere in this paper (see Fride & Weinstock; McFarlane, 1993; Ito et al., 1993; Teicher et al., 1993).

<u>Summary</u>

The possible relationship of ADHD and neglect remains to be verified in additional studies. It may relate to hypofunction of catecholamine systems, especially dopamine and norepinephrine, and possibly to damaged right-hemisphere attentional mechanisms. Eye movement patterns may be a by-product of right hemisphere deficits, and, a preference for certain stimulus cue conditions, or global and focal processing habits may also be implicated. Some combination of hemispheric control deficit and physiology (perhaps eye, ear or brain dominance) with neurochemical malfunction may account for the subpopulations or heterogeneity in populations of ADD or of ADHD. It seems possible that there is a disruption of cognitive processing of the information, since preattentive or priming processes seem intact, and evidence of E.E.G. and E.R.P. abnormalities in ADHD are at latencies that correspond to later stages of attention processing. Parallel deficits may be found in other sensory modalities, and work in Central Auditory Processing Disorder deserves further investigation to see if neglect in the auditory modality may characterize ADD or ADHD populations. The postulated link between neglect and ADD or ADHD also merits more study, since it has consequences for the learning patterns of Attention Deficit Disorder populations.

Assessment of Visual Neglect

The incidence of neglect in stroke patients has ranged, depending on the study, from 12% (Smith et al., 1983) to 85%

(Hier et al., 1983, cited in Halligan et al., 1991a). Schenkenberg et al. (1980) has found that as many as 90% of right brain damaged (RBD) subjects demonstrate unilateral neglect (UN), depending on how it is measured. Reasons for this discrepancy include factors like etiology, duration after onset of stroke, lesion size, test criteria, and test measures employed (Halligan, Cockburn & Wilson, 1991). Diagnosis is usually made on the basis of simple (bedside tests) including cancellation (barrage tests), line bisection, copying, spontaneous drawing, reading and writing, and by soliciting description of details from long term memory (Halligan & Marshall, 1994a; see also Bisiach, Brouchon, Poncet & Rusconi, 1993). The total number of failed tests is used as a clinical index of neglect, yet this can be a potential problem because each test may potentially measure different aspects of the syndrome (Kinsella et al., 1995) and in the case of the BIT test (Wilson et al., 1987), cut-off scores may contribute differently to the weighting of each subtest to the total (Cermak & Hausser, 1989) potentially missing some subjects.

Traditionally, assessment has been through simple perceptual-motor tasks, such as line crossing, and cancellation tasks. Problems encountered with these methods include a degree of subjectivity, especially in drawing tasks, and poor standardization, as well as uncertain relationships to behaviour in everyday life. Advantages of such tasks are their relative simplicity to adminster, and excellent reliability. Controls include the size and type of the paper and orientation to the midsaggital plane of the respondent. Vallar (1994) has pointed out important nuances in test administration, for example, protocols for target cancellation & line bisection permit head and eye movements and use of the unaffected arm, thus helping to control for primary sensory or motor deficits.

Fox (1983) has reviewed earlier studies of neglect, which have used copying, figure drawing, object naming, line bisection, reading, writing and pegboard design tasks. Schenkenberg et al.(1980) found good reliability and validity for these instruments, but recommended that a broad range of instruments be used. His investigation of the reliability and validity of several instruments yielded the following results: on a test-retest, using alternate forms, for bisection test (20 lines), he found reliability coefficients of .84 to .93 for four subject groups; geometric designs from memory, tested for omissions and embellishments, yielded scoring reliability across groups of .99, and accuracy of group classification of 81%. In subject drawings of daisy, wagon wheel, clock and humans, 100% reliability of classification was found, for control and RBD groups, 86% for LBD group (Fox, 1983).

Heilman, Valenstein and Watson (1994, p. 134) suggest that there are four common tests for spatial neglect: line bisection and cancellation, drawing and imagery. These authors have reviewed each test and the types of error that may be expected. Visual double simultaneous stimulation is also advocated as a test for neglect by some writers (Halligan, Marshall & Wade, 1989 cite Mesulam 1985; Heilman, Watson & Valenstein, 1985).

Neglect and Related Disorders

Unilateral visual neglect may need to be disentangled from a range of other possibly co-occurring disorders. Numerous simple tests have been found reliable and valid. In the study reported here, the pertinent question was to identify whether a well defined population (ADHD) demonstrated neglect for part of a page in controlled testing conditions (operationalized, for instance, through six conventional tests of the BIT test). In the experiment design, task performance and its consequences for academic performance were more relevant than the type of neglect or comorbid syndrome represented. Theorists continue to debate the traits of neglect, which is not unitary. Kolb & Whishaw (1990) identify numerous visual disorders, and, following Benton (1979) group visuospatial disturbances into 4 groups, of which unilateral visual neglect is one; localization of points in space, judgement of direction and distance, and topographic orientation ability are the others. Each of these groups have been implicated in neglect, and neglect may not be discriminable by Benton's proposed grouping. In addition, previous studies forming the model for this study (Voeller & Heilman, 1988; Malone et al., 1994) and many of the neglect research studies, have little addressed the task of differentiating neglect from other potential, similar dysfunctions. Findings are inconclusive as to the influence of visual-spatial issues in neglect. Wilson et al. (1987) cited studies of Oxbury (1974); Weinberg et al. (1977) which found a relationship to neglect (see also Ogden, 1985), but the study of Halligan, Marshall and Wade (1991) did not support this association. Clinical tests (confrontation or perimetry) for visual field defects are described by Wilson et al. (1987).

Albert (1973), the developer of an early and often cited neglect test, used the following tests as part of a standard neuropsychological battery: unilateral spatial agnosia, spatial alexia, spatial dyscalculia, spatial dysgraphia, constructional apraxia, spatial disorientation, spatial localization, body image, visual agnosia, prosopagnosia, dressing apraxia (Albert, 1973, p. 662; Vallar, 1994). Visual acuity was tested, and visual fields evaluated by Goldman perimetry and finger confrontation (Albert, 1973). Kinsella et al.(1995) tested for simultaneous double stimulation (*extinction*) using a confrontation method in visual, auditory and tactile modalities (Strub & Black, 1988 cited in Kinsella et al., 1995). Extinction is vulnerable to those having an accompanying primary sensory deficit (Kinsella et al.) Walker, Findlay et al. (1991) used perimetry tests to rule out hemianopia, and say that standard tests of hemianopia may also constitute tests of neglect. Questions remain with reference to co-occurring disorders: what is being measured? Is some aspect of attention faulty in neglect (Robertson, 1989) ? Do these tests measure attention or neglect (Albert, 1973)?

<u>Albert's Test</u>

A common test of neglect is Albert's test (Albert, 1973) which involves cancellation of 41 lines on a page, each line about 2cm long and randomly dispersed. This test is similar to the first subtest of the Behavioural Inattention Test. Albert modified it from one used by Denny-Brown (1963, cited by Albert, 1973). Albert's test was found by Fullerton, McSherry and Stout (1986) to be a significant predictor of mortality and of functional activity six months after stroke. Albert's (1973) test population (66 right handed, unilateral cerebral lesion patients and 30 controls) was examined as to lesion location and frequency of neglect, finding that 37% of RBD and 30% of LBD omitted at least one line; and the highest frequency of neglect was for anterior and posterior mixed lesions regardless of hemisphere. This is a factor of interest, since, in ADHD both regions have been implicated. The finding is of mixed importance for hemisphere theories since the hemisphere aspect was less critical, though posterior right hemisphere lesions were the source of the next level of frequency of neglect. All regions were associated with significant neglect. Frequency of neglect was similar after lesions of right and left hemisphere, but severity of neglect was strikingly different, worse after right hemisphere damage (mean error 4.77 as to .72) (Albert, 1973). Only two of all RBD subjects neglected only the left, and only one LBD subject neglected solely on the right. Albert (1973) noted, consistent with the findings of Halligan, Robertson, Pizzamiglio et al. (1991) that ..."after damage to the right side of the brain, the severity of neglect is greatest on the left, moderate in the centre and least marked on the right. After damage to the left side of the brain, the severity of the neglect is greatest on the left, moderate in the centre, and least marked on the right!". Albert noted that aphasia, in left hemisphere lesion cases, may render it difficult on some tests of neglect to obtain a true measure (Albert, 1973).

Albert assessed the relation of visual neglect to various control tests on his subjects: finding visual neglect highly correlated to constructional apraxia, and, that the visual neglect that occurs after RBD is highly correlated with defective performance on tests of visuospatial organization and dressing apraxia (Albert, 1973, p. 662). Posteriorily located lesions in either hemisphere produced more severe neglect than anteriorily located lesions in the same hemisphere, visual neglect more often was in centre and on both sides than only on the side contralateral to the lesion, visual neglect is dissociable from visual field defects, and oculomotor dysfunction- 20 % of RBD and 45% with LBD had no visual field defects nor oculomotor dysfunction (Albert, 1973). His study supports the conclusion that visual neglect is not unitary and a manifestation of several possible areas of neurologic dysfunction.

Albert's test, as well as motor and somatosensory tests, were used by Tegner and Levander (1991) in conjunction with a letter cancellation task (Weintraub & Mesulam, 1987), a line bisection task and a reading task. Neglect dyslexia was tested also using 10 sentences of 4 words each. Weintraub and Mesulam (1987) found the shape cancellation task to be more sensitive than the line crossing task (of Albert, 1973) finding many more omissions, which may be a function of the amount of detail on the array.

Smith (1994) has proposed the use of parametric equations to analyse the line bisection and star cancellation tasks, noting that the attention of the client will vary as to filled and unfilled space so that, as they orient for the task the space will appear more or less filled, that these types of space are perceived differently, and that a logistic regression can estimate the probability of cancelling a star when it is at a certain location.

Rivermead Behavioural Inattention Test

This test (RBIT) is an earlier version of the Behavioural Inattention Test (BIT), and was validated against six previously published tests of neglect. These included Letter Cancellation (Diller & Weinberg, 1977), Line Crossing (Albert, 1973), Figure Copying and Figure Drawing (Oxbury et al., 1974), and omission scores from the Wide Range Achievement Test arithmetic and reading tests (WRAT) (Wilson et al., 1987). Two parallel forms with balanced order of presentation were used. The test differs from the BIT somewhat: it does not include Picture Scanning, Article Reading and Card Sorting. The test has both conventional and behavioural sections.

The simple pass/fail scoring criteria in the conventional (RBIT) subtest section has been criticized by Cermak and Hausser (1989) because the points given for each subtest range so widely (from 3 to 54), meaning that the total scoring can be affected by poor performance on a larger subtest, and also that diagnosis, reliability, and validity calculations are all based on the total score. The behavioural subtests are more equally scored. In addition, the test is faulted for failure to pay attention to possible age-performance relationships in establishing scoring levels (Cermak & Hausser, 1989). Six conventional tests of inattention were subjected to an intercorrelation matrix to see how they correlated with the behavioural subtests. Positive and significant correlations (r. = .58-.87) were found between the RBIT and five of the six tests (Wilson, Cockburn & Halligan, 1987). On the 6 conventional subtests, significant differences were found between the attention and non-attention groups in independent *t* tests, but one reviewer noted potential Type I errors in the use of this test (Cermak & Hausser, 1989); an amended level of significance should have been selected.

Inattention, based on the RBIT, was found in 37% of left (cerebral vascular accident) CVA and 55% of right CVA subjects; in the left CVA group such a high figure may relate to a strong language component in the test administration (Wilson et al., 1987b in Cermak & Hausser, 1989).

<u>Behavioural Inattention Test</u>

The Behavioural Inattention Test (Wilson, Cockburn & Halligan, 1987) was designed to measure unilateral visual neglect. It consists of two parts: a *conventionally* established series of 6 subtests, and nine *behavioural* subtests more connected to daily life. The test was standardized in Britain in a study of 50 age-matched controls and 30 patients (Halligan, Cockburn & Wilson, 1991). The inter-rater (.99), test-retest (.99) and parallel form (.91) reliability seems excellent. Subjects were excluded for bilateral motor weakness, apraxia, mental impairment, cognitive deterioration, language comprehension deficits, and non-CVA etiology. Groups were evaluated for left and right hemisphere damage, mean age, I.Q., gender, and visual field defects.

The conventional subtests were selected from previously published work and are considered to be "valid measures of unilateral visual neglect" (Wilson, Cockburn & Halligan, 1987). These strongly correlate (.92) to the behavioural subtest, thus helping to establish concurrent, criterion related validity. The six conventional tests are: line crossing, letter cancellation, star cancellation, figure copying, line bisection, and representational drawing.

The BIT test may be improved by North American norming, and more studies using control groups are needed. Test-retest performance is important, in neglect, for assessing the reliability of the measure. Kinsella et al. (1995), used the BIT; the patients were retested after 5-7 days (based on absolute scores on the tasks). Authors found significant Pearson's product moment correlations for each task and "highly substantial correlations", except for line bisection and extinction tasks. In the case of the drawing scores the correlation may be misleading due to the scoring method. High test-retest reliability was seen to refute the idea that stroke subjects are essentially unstable in their response to neglect tasks. Line bisection and extinction were the most varied between test sessions (Table 5 of their study describes this). Various neglect subtests differ in their power to detect neglect, and, since neglect may not be unitary, the deficits across a sample will also vary.

Factor structures.

Sensory, scanning external space and representation or spatial imagery skills should all be measured in neglect tests (Kinsella et al., 1995). Line bisection and figure copying are conventional clinical tests of neglect, which focus on impaired scanning of stimuli in external space (Kinsella et al., 1995). Imaginal tasks should also be included in order to measure the representational aspect of neglect found in some studies (e.g. Rizzolatti & Camarda, 1987, cited in Kinsella, 1995).

Total scores for the tasks were used for a principal components analysis and identified two factors that accounted for 77% of the total variance; one related to *scanning of stimuli in external space*, one related to tasks using *internal representation skills*. Only the tactile maze task did not load significantly on the first factor; extinction loaded relatively insignificantly on each factor (Kinsella et al, 1995). Halligan, Marshall and Wade (1989) reported the results of a principal components factor analysis on what appears to be data from the initial BIT study (Halligan, Cockburn, Wilson, 1991). A rotated factor matrix showed that one factor accounted for 72.6 % of the total variance; no other factor accounting for a significant proportion of variance, and that the factor had substantial loadings from all six neglect tests, suggesting to them that the tests are homogenous, measuring one robust construct, but further, that they loaded quite differently (representational drawing loaded 0.75; figure copying loaded 0.92) (Halligan, Marshall & Wade). This differs from Kinsella's paradigm, where certain subtests were first grouped according to two constructs of the skill being measured.

What might account for the two studies yielding different numbers and types of factors? Whereas Kinsella (1995) tested only right-hemisphere damaged subjects, Halligan, Marshall and Wade (1989) tested those with both types of insult. Different tests were used: a series of extinction tests in Kinsella et al. are not included in BIT (Halligan et al., 1989). Kinsella et al. subdivided the test into groups, (e.g. three tests for "external scanning of stimuli", and these were not all the same as the BIT tests of Halligan, Marshall & Wade, 1989). Also, for "internal representation" Kinsella used drawing tasks that are similar, not identical, and a maze task not in the BIT test. Tasks included in Kinsella's study included shape cancellation (Weintraub & Mesulam, 1987), line bisection (Schenkenberg et al., 1980) and circle cancellation (Bisiach, Luzzatti & Perani, 1979). Scoring differences are also found: a total score for the BIT (Wilson et al., 1987) as well as a gradient scoring indicating more left lateralized omissions (Kinsella et al, 1995, p. 245). Distorted imagery tasks were found to correlate most highly with behavioural ratings of neglect (Kinsella et al.). A therapist rating of the behavioural activity of the patients correlated most highly with the tactile maze and drawing tasks (Kinsella et al.).

Description & scoring of BIT conventional subtests.

This section is intended to source relevant reports of the use of each test. Administration protocols for the subtests can be found in Kinsella et al. (1995); BIT Manual (Thames Valley Test Company., 1987)

Tests for *scanning of stimuli in external space include shape cancellation (Weintraub & Mesulam, 1987),* line bisection (Schenkenberg et al, 1980), circle cancellation (Bisiach, Luzzatti & Perani, 1979). Tests for *internal representation of space, or imagery* include representational drawings, tactile maze (De Renzi, Faglioli & Scotti, 1970, cited in Kinsella et al., 1995). Kinsella et al. (1993, cited in Kinsella et al., 1995) have argued that scanning of environmental stimuli and spatial representation can theoretically dissociate.

Halligan, Cockburn and Wilson (1991) maintain that a diagnosis of neglect involves two components: a failure to attend to target stimuli, leading to omitting targets or incomplete drawings, and an assessment of the relative spatial location of targets omitted with reference to the side of the lesion or the saggital midplane of the patient. For the omission error component, each subtest is scored with reference to a cut-off point one point below the lowest control subject score, on each individual subtest. For the lateralized component, omissions on the contralesional side are counted, and sometimes subtracted from those on the other side (Albert, 1973; Caplan, 1985; Halsband, et al, 1985; Ogden, 1985, all cited in Halligan, Cockburn & Wilson, 1991).

Halligan, Robertson et al., (1991) have prepared a table indicating the ways in which laterality calculations have been made in various studies. Overall, in neglect subjects, the

Halligan, Robertson et al. (1991) results support the idea that the greater the omission score, the more lateralized the distribution of omissions, a finding which they say is consistent with the attentional bias models of Kinsbourne (as cited 1977, 1992; Rizzolatti et al, 1985; De Renzi et al., 1989). A gradient of severity is found, from a maximum in the extreme contralateral hemifield to a minimum in the extreme ipsilateral hemifield (Halligan, Robertson et al., 1991, p. 292).

Their (Halligan, Robertson et al., 1991) results were separately calculated for each test, so it can also be observed that there is a possible continuum of severity for the different forms of attentional impairment. The most severe neglect cases were found to have deficient performance on the greatest number of tests. Clinical experience in using the BIT test has led these authors to suggest a strong relationship between the bias of the lateralized omissions and the number of targets omitted (Halligan, Robertson et al., 1991). The total of correct targets and the laterality score was found to be significantly correlated in three visual search tasks: line crossing, letter cancellation and star cancellation. This accounted for 64-86% of the variance, and 26-27% of the variance was accounted for by figure copying and representational drawing, when regressed.

By placing the error results on a continuum, authors selected four patterns of spatial error: those showing contralateral neglect, left bias inattention, non-lateralized inattention, and right bias inattention. For 54-62 % of patients, the majority of omissions were contralesional, 11-36 % non-lateralized, and 1-12% demonstrated 5% or more omissions on the ipsilesional side. Mild and moderate impairments were identified by figure copying and star cancellation tasks, usually these errors were left or non-lateralized. Severe neglect cases had problems with 5 of the 6 conventional tests, and four of these identified the group: star and letter cancellation and figure copying and line bisection. Time after stroke and degree of severity have not been found to be correlated in several studies (Zarit & Kahn, 1974; Zoccolotti et al., 1989 cited in Halligan, Robertson et al., 1991) Less than 3% showed a right bias for inattention.

How can the cutoff score be established? Kinsella et al. (1995) and Wilson et al. (1987) used a cutoff one level below the lowest control level; and Kinsella also implemented a gradient criteria for omission scores across left to right space.

<u>shape cancellation.</u>

In this task, Kinsella et al. (1995) found that controls omitted fewer marks than patients, especially on the left, thus consistent with Kinsbourne's 1987 gradient theory.

<u>star cancellation.</u>

Star Cancellation differs from a letter cancellation task because it is less structured and linear; Mesulam (1985, in

Halligan, Cockburn & Wilson, 1991) stated that more omissions will be found in more random arrays. In this test the subject cancels the smaller size of stars in a field of larger stars and letters. Star cancellation (BIT test) has been shown to be the most sensitive test for neglect in these studies: Halligan, Marshall and Wade, 1989; Halligan, Cockburn and Wilson, 1991; Halligan, Robertson et al., 1991; Friedman, 1992). It identified 80% of the population, closely followed by figure copying (77%), line bisection (64%) and letter cancellation (56%) (Halligan, Robertson et al., 1991). Friedman (1992) developed a simple ratio index for the calculation of asymmetrical performance, which was used in the Halligan, et al. study.

<u>representational drawing.</u>

The BIT test includes tasks of drawing a clock face, a butterfly, and a human shape (testing recall functions). Representational drawings are analysed as to symmetry and hemispace of errors. Kinsella et al. (1995) states that, in their study, it was rare that subjects made omissions on the left in all their drawings, arguing for an effect of image salience. Salience, stimulus complexity and the attentional window are all theories that might account for this effect. All subject omissions were in left hemispace and occurred most often in the clock, wheel and daisy drawings rather than in human images. The pattern of eye movements that neglect patients use in viewing drawings been studied by Hornak

(1995). Ishai et al. (1993) note that clock copying did not correlate as well with neglect severity as did line-bisection, line-cancellation and daisy copying, and attribute this to the possible impact of left-hemisphere skills relating to the numerals.

line bisection.

This widely used test involves bisecting a line at the midpoint. Patients with neglect bisect lines to the right of their true centre. A deviation score is calculated and compared to control samples (Halligan, Cockburn & Wilson, 1991). The test was used by Halligan & Marshall (1994); and by Riddoch and Humphreys (1983) for a cueing experiment. Tegner and Levander (1991); Bisiach, Geminiani et al. (1990); Coslett et al. (1990); and Halligan and Marshall (1988, 1994b) also used this test. Coslett et al. (1990) used it to uncouple the direction of a visual stimulus from the direction of hand movement.

This test was used by Reuter-Lorenz and Posner (1990), to assess neglect in manual, right to left and left to right conditions. This suggests that, as for dyslexia, scanning direction - e.g. left to right in the English language- may be relevant (see also De Lacy Costello & Warrington, 1987). Significant neglect was found in the manual and left-scan tasks only (pen started on right and moved to the left). This finding seems consistent with the ADHD deficit measured by Swanson (1991), where reaction times are extremely fast for

ADHD subjects who receive a null cue, or an invalid cue in the RVF requiring a move to the left. This finding could implicate a left parietal injury except that latencies are extremely different (Swanson et al., 1991). However, there are some ambiguities in Swanson's study owing to its interpretation through Posner's attentional model. This may reach the heart of the ADD/ADHD and right-hemisphere-deficit problem, since some combination of variables: those at 800 ms. in left hemispace pointed out by Swanson et al. (1991) and Carter et al. (1995), the eye movements/saccades problems shown by Hornak (1995) in neglect and Ross (1994) in ADHD, and the focal-peripheral attention window and invalid cues, and the issue of spatial frequencies, may help explain how ADD or ADHD students attend.

Line bisection was calculated, as total mean percentage deviation, consistent with Schenkenberg et al. (1980), by Kinsella et al.(1995). A two way ANOVA was conducted (group, line position) with line position as repeated measure, finding significant main effects and interaction. An attentional scanning task; it was found less reliable because of poor test-retest correlations (Kinsella et al., 1995).

An important issue in line bisection tasks is that certain patients seem to produce an increasingly large displacement as line length increases, whereas the right displacement of others is relatively independent of line length. A discussion of this issue is available in Bisiach et al., 1983; Bruyer, 1984; Bisiach & Vallar, 1984, cited in Halligan & Marshall, 1988; Tegner & Levander, 1991; Bisiach et al., 1994).

<u>Letter cancellation.</u>

This test was used by Diller and Weinberg (1977); it is included in the BIT. Fleet and Heilman (1986) used letter cancellation to demonstrate that fatigue worsened neglect, attributing findings of less neglect when error feedback was received to the relationship of fatigue/arousal to neglect. It is possible that these results could also be explained by a cueing, attentional model.

<u>Line cancellation.</u>

Mark, Kooistra and Heilman, (1988), found that cancellation by drawing over and by erasing produced different results, suggesting to these authors that performance improved when lines had been erased and that stimuli in the non-neglected hemispace influences performance. Reasons for this finding could include load, window of attention, and task complexity explanations. This finding has important implications for student performance.

<u>Shape copying.</u>

Three geometric shapes with edges are copied by students onto the left side of a page from the image placed on the right side.

<u>Behavioural subtests of BIT.</u>

(Halligan, Cockburn & Wilson, 1991). The behavioural subtests are: picture scanning, telephone dialing, menu reading, article reading, telling and setting time, coin sorting, address and sentence copying, map navigation, card sorting. These are not discussed here, as they are less relevant to the experiment conducted.

BIT Test Results in Right and Left Brain Damaged Patients

Halligan, Cockburn and Wilson (1991) tested 30 brain damaged patients and 50 controls, finding significant differences between each patient group and the controls, and also significant neglect differences between the LBD and RBD groups. Patient performance was significantly different from controls, on each of the six conventional tests, as was the difference of RBD from LBD group, for each test considered individually. The entire BIT test was also used by Robertson and North (1994).

Relative Sensitivity of Tests to Identify Neglect

Kinsella et al. (1995) found that the shape cancellation and line bisection tasks identified neglect for 38-43% of the population; the representational drawings, tactile maze and extinction tasks identified 14-30%, and the circle cancellation task identified only 10% (Kinsella et al., 1995; see also Wilson et al., 1987)

Applicability of BIT tests for ADHD Subjects

Is a test battery most commonly used with elderly stroke subjects applicable to ADHD children? This is not certain. The test battery (BIT) has much in common with well accepted tests of visual perception, and it is held to test attention. Each element of the test has been widely used in neurological populations of many ages. Since aspects of attention are tested by the BIT test, both neglect and ADD/ADHD populations may well suffer from some common attentional/perceptual deficit which can be described by the BIT test. Both disorders may possibly be linked by a commmon right-hemisphere dysfunction, even though derived differently, and the BIT test may be useful for specifying areas of behavioural deficit. Are there developmental changes in the skills measured by the test? ADHD is identified early, whereas neglect is more commonly associated with stroke in older persons, although it has been discussed for children (Ferro & Martins, 1990). The BIT test has not been normed for children, though its components are used widely in populations of many ages. Elements of the test may create some age effects in young children (e.g., ability to read for letter cancellation); in other respects, however, the test is easy to adminster and each task easily explained.

Tests of ADHD

Diagnostic and Statistical Manual (DSM-IV).

A thorough discussion of the DSM-IV (APA, 1994) criteria and of changes from DSM-III-R is found in McBurnett et al., (1993). A differential diagnosis process occurs with reference to several important constructs and a checklist method of establishing the severity and duration of these symptoms. Several methods of assessment and a broad consultative process, usually involving home, school, family doctor and psychologist establish the diagnosis. Criteria include duration of symptoms, presence across settings, noticeable differences from peers, interference with functioning, and symptoms not more consistent with some other disorder. The DSM-IV divides symptoms into 3 subtypes (314.01) *Attention Deficit/Hyperactivity Disorder, Combined type; (*314.00) *Attention Deficit/Hyperactivity Disorder,* Predominantly Inattentive Type; *and (314.01)* Attention Deficit/Hyperactivity Disorder, Predominantly Hyperactive-Impulsive Type (DSM-IV, 1994). Field Trials were used to test the reliability and validity of the symptom criteria against other measures (McBurnett et al, 1993). ADD/ADHD are not homogenous disorders, (e.g., responses differ in those taking stimulants, see Malone et al, 1988, p. 383).

Research and clinical assessment of ADHD commonly involves teacher and parent rating scales, interviews and observation (McKinney et al., 1993). Issues of the educational assessment of Attention Deficit Disorder are found in McKinney et al., (1993). Parent and teacher rating scales include the SNAP (see Swanson & Pelham, 1988), and the ADHD Rating Scale (DuPaul, 1991), which assess for ADD with or without hyperactivity and which are normed. Both have been referenced to categories of the DSM-III-R. A variety of other rating scale measures and multifactor rating scales exist, among the latter are the Conners (see below) and the Child Behaviour Checklist (CBCL- Achenbach & Edelbrock, 1983, cited in Sattler, 1992).

Issues in quality of assessment of ADD include the following: The need to measure all three constructs underlying ADD: impulsivity, hyperactivity and inattention (McKinney et al, 1993); co-occurrence with learning disabilities (in 10-20% of stringently diagnosed cases, but ranging from 9-63%) and other disorders; the subjectivity of the DSM ratings; severity and threshold issues, its variability over situations and symptomology; issues in the assessment of social adjustment characteristics of this population (McKinney et al., 1993).

Conners Parent Rating Scale.

Malone et al., (1988) implemented the Abbreviated Conners Rating Scale (Conners, 1973) with norms as reported by Goyette, Conners and Ulrich (1978). Conners Parent Rating Scale (1985), in the 48 item version, and a 93 item version which yields eight factors rather than the four in the abbreviated test, are updated versions. Sattler (1992) reports that Conners Parent Rating Scale has adequate reliability and validity (Conners 1985), and that factor analysis supports the five factors of the scale. The test can be used to identify behavioural problems in children from 3-17 years of age.

Conners Teacher Rating Scale (Conners, 1985).

The teacher rating scale is applicable to behavioural problems in 4-12 year olds. Several versions are available (Sattler, 1992). Six factors are identified in the 39-item version of the test, and supported by factor analysis; this version has adequate reliability and validity (see Conners, 1985; Epstein & Neiminen, 1983; Schachar, Sandberg & Rutter, 1986, all cited in Sattler, 1992, p. 393). The shortened version of the scale uses the most heavily loaded items from the factor scales, and is often used as a hyperactivity index (Sattler, 1992, p. 393). Norms for the 39 item teacher rating scale are available, which are based on a study of 9,583 Canadian schoolchildren (Trites, Blouin & Laprade, 1982, as cited in Sattler, 1992, p.393).

Diagnostic Criteria in Relevant Studies

Ross et al. (1994) used the following criteria to select his ADHD population: DSM-III-R diagnosis based on school and clinical interview; Conners (1973) Rating Scale, cut-off of over 15; methylphenidate responsiveness in a three week trial; I.Q over 75. Age ranged from 110.9 to 155.8 months.

Swanson et al. (1991) used teacher identification, the Iowa Conners (Loney & Milich, 1982) and the DSM-III-R with a structured parent interview as part of a clinical screening process for his ADHD population. The subject population of Schachar et al. (1988) included hyperactive, conduct disordered, emotionally disordered and learning disabled students. An extensive range of measures included a semistructured parent interview, (interrater reliability investigated), teacher completion of the Rutter-B rating scale; Abbreviated Conners Rating Scale (Conners, 1973, a SNAP questionnaire (W.E. Pelham, 1981, personal communication); 4 subtests from the WISC-R (Wechsler, 1974) and the Wide Range Achievement Test (WRAT; Jastak & Wilkinson, 1984). A DSM-III diagnosis was also made. The scoring criteria and cut-off for each test are provided (Schachar et al., 1988).

CHAPTER 3. RESEARCH METHODS

This study investigated one visual processing characteristic in Attention Deficit Hyperactivity (ADHD) populations. "Unilateral visual neglect" is frequently found in stroke patients, and is especially more prevalent and severe in right hemisphere stroke. If found in ADHD subjects, it would help to explain classroom performance problems. Unilateral visual neglect for images on the left side has been demonstrated in two previous studies of children, one using ADD (undifferentiated as to subtype) subjects, the other using ADHD subjects. Authors of these studies have suggested that a right hemisphere deficit may be linked to these findings. Spatial neglect has been found in very young populations as a result of early right hemisphere damage (Trauner & Ballantyne, 1988). Neglect is responsive to methylphenidate (Malone et al., 1994).

The learning disabled comorbid group in the Malone et al. (1994) study responded differently to the test than did the other subjects. However, only one task, a letter cancellation test, was used in this experiment, as for the Voeller and Heilman (1988) study. Ogden (1985) found that a broader test battery identified more neglect for the right side (although in a largely tumour population). Previous studies have several weaknesses including small samples, use of only one test instrument, and potential confounding factors related to clear diagnosis of subjects, control over dominant hand, and comorbidity. Malone et al. (1994) indicates that methylphenidate effects ameliorated neglect differently for the learning disabled (LD) subgroup than for other subjects. It may be that the learning disabled ADHD or the ADD (no H) population is especially prone to neglect.

The purpose of the present study was to measure the neglect performance of an ADHD population on a battery of conventional tests for neglect. This extended previous work in the following ways: the sample carefully specified characteristics of the students, controlling for several comorbid factors and for handedness. ADHD subjects, specifically not the inattentive type, were selected from district files; and, the test battery was more extensive. It was expected that ADHD students would demonstrate neglect when compared to control children. The laterality of omission errors was of interest.

Statement of the Research Problem

Do ADHD children demonstrate a pattern of lateralized omissions on a conventional battery of neglect tests? The study was intended to help confirm or refute whether neglect is a symptom of ADHD. A lateralized pattern of omission errors has implications for the theory and etiology of hyperactivity. The Malone et al. (1994) study is the most specific in this regard, and differentiated ADHD subjects from those with comorbid learning disabilities. However, that learning disabled (LD) subgroup was quite small, may not have been homogenous, and the disabilities were not specified in the report. Studies of eye movements and performance on tests for right hemisphere damage have shown divergent results. The Matazow and Hynd (1992b), and Shaughency and Hynd (1989) studies indicate that right-sided errors might be expected. Findings of Carter et al. (1995), and perhaps also Swanson et al. (1991) tend to imply that left-sided omissions would be more likely. Malone et al. (1994) suggests that left-sided neglect will be found in ADHD subjects with comorbid LD. Voeller and Heilman (1988) suggests that left-sided errors will be found; this small subject group was described as ADD, the selection criteria being inattentiveness, but ADD was not differentiated from ADHD (applying DSM-III criteria) and the study did not report on possible LD. No study to date has clearly demarked these populations and used a battery of tests. A pattern of lateralized omissions was of most interest. If found, it would add weight to theories of the possible reasons for ADD/ADHD, and imply certain teaching strategies for that population. The association of greater neglect prevalence and severity with right hemisphere damage would argue in favour of the hypothesis of more left-sided omissions.

Null Hypothesis

No significant differences will be found in total scores, total omission error rates or the laterality of the errors, between an ADHD diagnosed group and a classroom drawn control group in the six conventional subtests from the Behavioural Inattention Test for visual neglect.

Design

A sample group drawn from regular classrooms was to be compared to an ADHD group. Total errors of omission, and a total score was compared, and also left and right sided errors was compared between groups. The two-tailed non-directional hypothesis was selected, since Malone et al. (1994) found error lateralization in all but one of 17 (ADHD) students (12 making left errors, 4 making rightward errors). The classroom derived group included students of the same age group (8-12 years old) and gender to previous studies. Handedness information was also obtained.

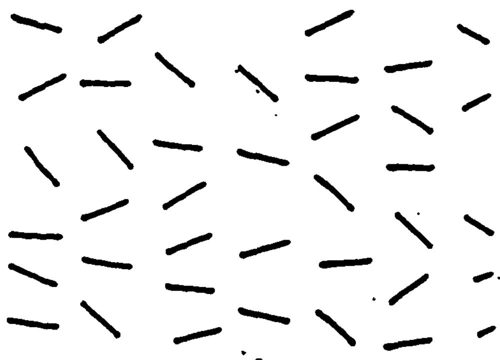
Measures

Test instruments.

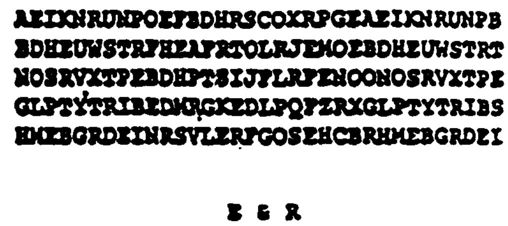
Visual neglect was operationalized by the conventional test group (six subtests) from the "conventional" scales of the Behavioural Inattention Test (BIT) (Wilson et al., 1987) (See Figure One for reductions of actual test pages). These are the Line Crossing, Letter Cancellation, Star Cancellation, Figure and Shape Copying, Line Bisection and Representational Drawings tests. The Star Cancellation test has the most reliability and validity of the 6 tests. Subtest characteristics were described in the previous chapter.

Figure 1. Sample BIT subtest items, reduced.

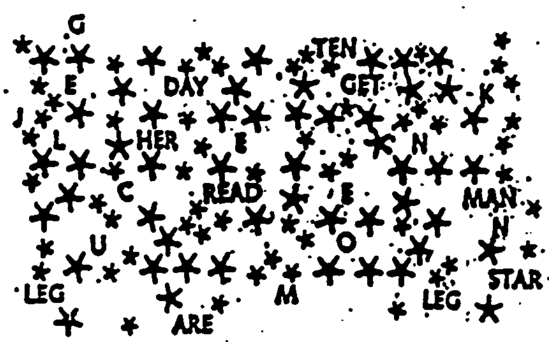
Line Crossing 1



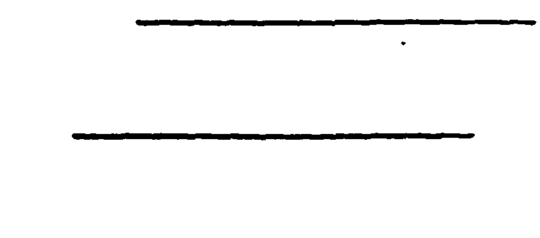
2 Letter cancellation



Star cancellation 3

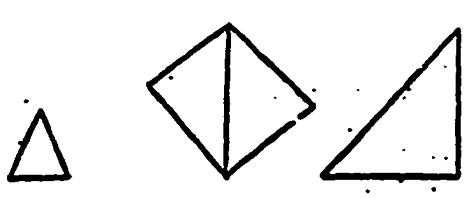


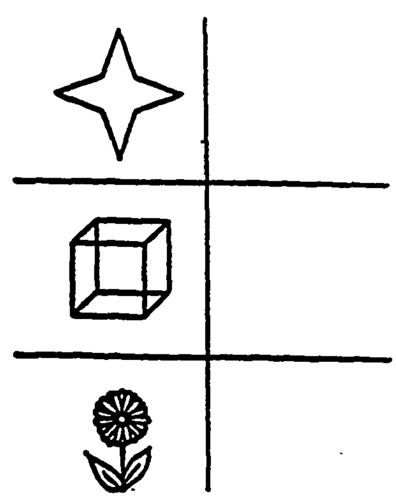
Line Bisection 5



Representational Drawing 6
Butterfly, human, clock face
from memory.

Figure Copying 4





Participants

Subject selection.

Subjects were male students, aged 8-12, obtained through school psychologist referral (ADHD) or teacher sourced (classroom group). Psychologists identified students with ADD (including those not primarily inattentive); however, this was not directly verified with the diagnosing physician. All students, in order to be included, had previously returned a signed parental permission form. I.Q. and achievement test results were then made available to the researcher.

The ADHD group was identified by the school district prior to the study using district criteria (see Appendix A). The criteria for ADHD include Conners Teacher and/or Parent rating scales (n=11) (or Barkley's, 1991 scale, n=11) and/or the DSM-IV criteria. In many cases both the teacher and parent forms were part of the basis for an ADHD diagnosis. Actual scores were not made available to the researcher. Other measures common to all ADHD subjects included a Wechsler I.Q. Scale (WISC-R or WISC-III). The K-TEA or the C-QUIET was used to measure achievement. A formula applicable in the district identified whether further testing is warrranted. If so, Learning Disabilities criteria (see Appendix A), might also indicate additional testing for LD.

Identification of the ADHD group

Criteria for admission to the study included subjects who had no comorbidity for anxiety, depression, or conduct disorder. This was verified with the school psychologist relevant to the case and, when indicated, with a parent. Indications that there had been physician or psychiatrist referral and DSM diagnosis (n=12) were verified with the school psychologist. The subtype characteristics and doctor's records were not systematically verified.

All ADHD subjects were to have a I.Q. with a mininmum score of 80 (based on Wechsler scales) in order to be included in the study (n=12), for reasons of comparability with other studies. When warranted by district criteria students also had an achievement measure (n=12) as part of investigation of possible learning disabilities. This additional step applied to four subjects in the test group (Subjects 24, 30, 32, 42). All subjects in the ADHD group were tested using K-TEA (n=11), except for one, who received a C-QUIET.

The initial design of the study intended to include 40 boys drawn from files in the school district, clearly diagnosed to form two separate groups: ADHD, ADHD with comorbid Learning Disabilities. These students were to be compared to an age and gender matched control group. It was intended that enough WISC tested boys, without any diagnosis could be found for the classroom group, but too few suitable candidates were found. The study design was changed to provide boys drawn from the regular classrooms; classrooms selected were in the age range developed for the study (aged 8-12). No academic test data was available for these students. All were boys from regular classrooms, not those designated to Learning Assistance or Social Development. The age 8-12 range was selected to offer comparability to other studies. Teachers sent explanation and permission forms home with students and parents returned them to classroom teachers. All eligible boys who presented themselves for the study were included; girls were omitted. Certain classrooms were solicited to provide students: these were classrooms for each of the ages ranged in the study, and in schools in the same neighbourhoods as the subject students.

Subject characteristics.

Forty-five boys in total were tested for the study. Four classroom derived subjects taking Ritalin for various purposes were omitted, as were two students for whom English was a second language. This provided 27 regular classroom subjects (Group 1). The age range of the classroom group was 107-146 months, average 129.25 months old. The classroom group included all available age-eligible boys. Eight girls who returned parental permission forms were omitted as outside the parameters of the study.

Prior to testing, two subjects proposed for the ADHD group were excluded, one for a diagnosis of ADD/inattentive only, another for reasons of FAS/NA comorbidity (this left 12 subjects). ADHD students ranged in age from 119 months to 155 months, average 138.25. One student experienced delays in gross motor skill. The effect of this subject's results have been considered, since these scores were the lowest on the test. All ADHD students had been prescribed Ritalin or other stimulant medication. All were off medication for 24 or more hours prior to test adminstration.

Experimental Procedures

Each student executed the conventional subtest group from the Behavioural Inattention Test (BIT test). These pencil and paper subtests take approximately 25 minutes. The test was individually adminstered in a small room separate from the classroom. Other control conditions included a quiet non-distracting environment and a completely clear desk surface except for the test page. Alignment of the student in the chair and centring of the pages, using the indicator arrow aligned with the student's midline (nose), was achieved by reminder. The examiner faced the subject across the table, and ensured that the materials were centred with subject midline.

Tests were adminstered in accordance with the BIT protocol: test order, the language used and scoring procedures were all standardized. Parents of all ADHD boys agreed to (this was verified with the student at test time) leave children off medication for hyperactivity for 24 hours prior to the test, and testing was mainly done in the mornings, so that medication could resume for the school day.

Subjects were boys who have been diagnosed ADHD (or ADHD with comorbid LD) and a classroom comparison group. The number of subjects depended on available students within practical district referral constraints and specific diagnostic criteria. A minimum of ten subjects per group was sought, and 20 expected.

Information was labelled with non-identifying codes and identifying information was separated from the actual study. These materials were confidential. The study was approved through the University of Victoria Human Research Ethics Committee.

Data Analysis Procedures

Recording.

Test administration sheets from the BIT protocol were used and collected from the student as each subtest was finished. This left the working surface totally free of all other materials. Additional information recorded included hand used, student age, grade and birthdate, and methylphenidate status.

Scoring.

Scoring procedures followed the BIT test protocols. Various scoring methods for the subtests are available (see Halligan et al., 1989, 1991; Cermak & Hausser, 1989). A "laterality of omission error" score, for each of left and right was computed whenever this was not provided for in the manual scoring procedures, based on procedures used in other studies of neglect. Separate columns were made for each subtest to record the left and right scores achieved on the test. These totals were used for the analysis. No cut-off score was implemented, nor a score based on subtracting the errors of one side from the other.

Some subtests do not lend to good quantitative interpretation. Two subtests are scored somewhat subjectively: numbers 4 and 6, the drawing subtests. Consistent with other studies, a laterality score was derived for these subtests based on drawing errors; so classified if there were definite differences between one side and the other or, if they were missing elements on one side. Total scores were calculated consistent with the BIT scoring system. However, no cut-off score based on the control group scores was used to determine errors, all errors were counted. In addition, a left and right error attribution was made for subtests 4 & 6. For left and right error totals, only errors which could clearly be categorized as lateral were scored (eg.applicable to the drawing subtests). Therefore, the total errors category is larger than that of the left and right errors added together.

<u>Summary</u>

This study examined neglect in an elementary student ADHD population by adminstering a test battery commonly used for detecting neglect. A pattern of omission errors in test subjects that was significantly different from the classroom group, and lateralized to one side of the page, would add useful information to our understanding of the inattention dimension of ADHD, and have implications for the teaching of these students. Do the ADHD's make more errors on one side of the test than do the control group? Previous studies have indicated that more left-sided errors would be expected. However, a greater number of errors on either side in that group would contribute to our understanding of the theories of ADHD. Non-significant results would indicate that visual neglect is potentially less likely to be a factor in the visual processing problems of ADHD subjects, and that other avenues may be more fruitful to explore.

CHAPTER 4. RESULTS

Data are reported for I.Q., age, handedness, LD status, and comparisons between groups for: overall total scores of all subtests; total errors made on the left; and total errors made on the right side of the test. Also, the effect of comparing a right handed subset of the classroom group (n = 20) to the totally right handed population of ADHD's, but excluding the comorbid gross motor subject (leaving n = 11), was evaluated.

Data Analysis

Analysis was done through SPSS 7.1 and SPSS 6.1 (Advanced) computer programs.

Descriptive Statistics

Descriptive information collected for the sample included age, I.Q., and scores on test measures. Nonparametric statistics reported include total score, total omission errors, total left and right omission errors.

Statistical Analysis

Non-parametric statistical analyses, for reasons of non-normal population distributions, were performed in addition to descriptive statistics. Calculation of statistical significance of the frequency distribution of scores used the Mann-Whitney U test for the between subjects variables Total Score and (omission) Error Scores, and the Mann-Whitney U test for the Left and the Right Error scores, again, between subjects. An alpha level of .05 was set for the study.

Results

Academic screening.

I.Q data was available for the ADHD Group only. The mean Full Scale WISC-III I.Q. was 98.67 (range 86-117). The WISC Performance I.Q. mean was 99.17 (range 84-117) and Verbal I.Q. mean was 98.17 (range 84-118). Achievement measures were available for all ADHD students, based on the Kaufman TEA test (n = 11) or the Canada QUIET (n = 1) test. Mean Kaufman Math score was 90.64, range 75-101, and Reading Score mean was 87.73, range 77-105. An estimated reading score of 84 and Math score of 86 based on (C-QUIET) percentiles is indicated for the remaining subject. WISC I.Q. tested subjects were unavailable for the classroom group, so comparisons for the academic and achievement measures were not made.

Age.

The age of the Classroom group (n = 27) was 129.26 months; range 107-147. The age of the ADHD group (n = 12) was 138.25 months; range 119-155. The difference in variances (Group 1 = 168.05; Group 2 = 134.02) of the two groups for Age was not significant (Levene's F = .78, p = .38). The age difference between groups was marginally significant (df 37, 2 tail p = .05). However, when the scores of the 9 youngest classroom students were compared to the remainder of the classroom group (age-equivalent to the ADHD group), the average scores of the younger group (142.38) were slightly higher than those of the older students (142.15). This suggests that the age difference is not a factor in the test scores, and that the results are not related to a developmental effect.

Total score.

The Total Score represents the total score on the test out of a possible score of 146. It is calculated by adding the total scores achieved on each subtest. The frequency distribution of these scores is shown in Table 1. One half of the students in each group made two or fewer errors on the test, indicating a ceiling effect. The Mann-Whitney U test indicated a $\underline{U}$ value of 135.0, a two-tailed $\underline{p}$ = .41 (see Table 2). This result is not significant. These groups have similar central tendencies, suggesting that the two samples may be from populations similar on this trait. However, there was considerably more variability in the scores of the ADHD group. Even when the ADHD student with comorbid gross motor difficulties is excluded, the range of scores in the ADHD group is more bimodal in appearance.

Total errors.

This score represents all lateralized errors. Mann-Whitney $\underline{U}$ statistic for Total Errors is 138.5, nonsignificant with a 2-tailed probability of .47 (see Table 3). This result is non-significant. The frequency distribution (see Table 4) indicates that the ADHD scores were more variable. Many ADHD students made either 0 errors or 1 error, indicating the ceiling scoring. However, other students in the ADHD group made numerous errors. The ADHD subject with a comorbid gross motor difficulty had the greatest error score on the test, and most of these were on the left side.

Table 1.

Frequency Distribution of Total Score By Group

Count	Group 1 Classroom	Group 2 ADHD	Row Total
129.00		1	1
137.00		1	1
138.00		1	1
139.00	2	2	4
140.0	3	1	4
141.00	3		3
142.00	1		1
143.00	4		4
144.00	5	1	6
145.00	6	3	9
146.00	3	2	5
Column Total	27	12	39

Table 2.

Mann-Whitney U for Total Score By Group

Group	Mean Rank	Sum of Ranks		Cases
1 Class	21.00	567.00		27
2 ADHD	17.75	213.00		12
			Total	39

U	2-Tailed P
135.00	.41

Table 3.

Mann-Whitney U for Total Errors By Group

Group	Mean Rank	Sum of Ranks		Cases
1 Classroom	19.13	516.50		27
2 ADHD	21.96	263.50		12
			Total	39

U	2-tailed p
138.50	.47

Table 4.

Frequency Distribution of Total Errors By Group

Count	Group 1 Classroom	Group 2 ADHD	Row Total
0	3	2	5
1	7	4	11
2	4		4
3	4		4
4	1		4
5	3		3
6	3	1	4
7	2	2	4
8		1	1
9		1	1
16		1	1
Column Total	27	12	39

Total left errors.

For total errors made on the left side of all subtests, the Mann-Whitney $\underline{U}$ is 136.0, a two-tailed probability $\underline{p} = .41$ (see Table 5). This result is non-significant. The frequency distribution (Table 6) indicates the distribution of the left error scores. This statistic tests whether the two groups were drawn from populations where the distribution of ranks indicates similar central tendencies on the factor tested (e.g., a similar mean). No significant differences were found.

Total right errors.

The Mann-Whitney $\underline{U}$ is 161.0, a two-tailed probability, $\underline{p} = .98$ (See Table 7), for the total number of errors made on right sides of the tests. This result is non-significant. The frequency distribution (Table 8) indicates the frequency distribution of the ranks and the scores. No significant differences were found.

Table 5.

Mann-Whitney U for Total Left Errors By Group

Group	Mean Rank	Sum of Ranks		Cases
1 Class	19.04	514.00		27
2 ADHD	22.17	266.00		12
			Total	39

U	2-Tailed p
136.00	.41

Table 6.

Frequency Distribution of Left Errors By Group

Count	Group 1 Classroom	Group 2 ADHD	Row Total
0	12	5	17
1	6	2	8
2	6	1	4
3	2		2
4		1	1
5	1		1
6		2	2
10		1	1
Column Total	27	12	39

Table 7.

Mann-Whitney U for Total Right Errors By Group

Group	Mean Rank	Sum of Ranks		Cases
1 Classroom	20.04	541.00		27
2 ADHD	19.92	239.00		12
			Total	39

U	2-Tailed p
161.00	.97

Table 8.

Frequency Distribution of Right Errors By Group

Count	Group 1 Classroom	Group 2 ADHD	Row Total
0	6	4	10
1	10	3	13
2	1	1	2
3	2		2
4	1		1
5	3	1	4
6		1	1
8		1	1
Column Total	27	12	39

Effects of handedness and comorbidity

All ADHD subjects tested were right handed. Table 9 depicts the total errors per group for the whole sample; and, secondly, those for a right handed classroom group, as contrasted to the ADHD right handed subjects (excluding the ADHD gross motor comorbid subject). This subgroup may be the most comparable of all those tested.

Table 9.

Average Errors By Group For all Subjects; and Only Right-Handed Subjects

All Subjects		Total Errors	Left Errors	Right Errors
Group 1	Classroom	2.89	1.07	1.81
Group 2	ADHD	4.75	2.50	2.25
Right Handed Subjects Only				
Group 1	n = 20	2.70	1.20	1.50
Group 2	n = 11*	3.73	1.82	1.91

* Comorbid Gross Motor Subject removed.

Learning Disabled (LD)subgroup.

The proposed test of a hypothesis of some differences between the LD/ADHD comorbids and ADHD's was not tested because so few were in the study. The average test score (Total Score) for the LD's in Group 2 is not lower than for the ADHD's, and, only 4 of the 12 ADHD's are SLD comorbid subjects, so this subgroup was not separately examined.

Subtest scores.

Because of the overall small number of errors and the non-significant results in those tests done, further testing of individual subtests was not implemented.

Test sensitivity.

Which tests elicited the most errors? The percentage of the students in each group, who made errors in that subtest, shown for each subtest, is presented in Table 10.

Table 10.

Errors Made by Subtest and By Group, as a Percentage

Test	Max. Score	Group 1 Classroom	Group 2 ADHD
		Percentage	
Line Crossing	36	7.5	0.0
Letter Cancellation	40	58.0	66.0
Star Cancellation	54	41.0	50.0
Copying	4	6.8	37.5
Line Bisection	9	6.8	16.6
Drawing	3	25.0	0.0

Student errors on many tests

Sixteen students made one or more errors on only one test, a further 10 subjects made errors on two tests, 5 on three tests, and 1 subject (ADHD comorbid) on four tests (these are not cumulative totals).

CHAPTER 5 DISCUSSION

This study sought, by increasing the number of tests done by the subjects and by carefully describing the subjects, to extend the work of previous studies. The evidence suggests that, based on total test scores, total errors, and left and right errors, the data presented here could have been drawn from similar populations, or from populations with the same central tendencies. Consequently, we are unable to reject the null hypothesis that the means would not differ significantly on any of the four tests of the data. This would suggest that neglect was not prevalent in this sample of boys aged 8-12. The two groups tested responded similarily to the BIT test. In terms of the previous research findings, a logical next step would be to implement a similar test in purely ADD subjects, and in ADD comorbid LD subjects. Based on the theoretical synthesis presented in the literature review, alternate explanations for the visual processing problems in ADHD seem more promising than does neglect. However, it may be presumptious to draw that conclusion on this evidence, because issues of head tilting and work checking may have minimized the results found in this study.

Right and left error totals were not significantly different between the groups, on the Mann-Whitney test. One would conclude that the two groups were drawn from similar populations. The Left Total Errors, and Right Total Errors, though neither is significant between groups in terms of ranks testing, nevertheless do not mirror one another. This effect may or may not, be robust in a larger sample. If it held up, to what can it be attributed? Possibly, differences in starting place and search strategy may exist in readers with different eye advantage. Previous neglect-ADHD studies have found a subgroup in their studies that do show the opposite error pattern. Since ADHD's do make more errors than the normal group does, this effect is worthy of further study.

The results related to handedness and comorbidity are interesting. The sample is not large enough to enable clear conclusions in either direction (see Table 9). However, this data suggests (should the trends hinted at be borne out in larger samples) that right handed people make less errors in all; but more of their errors on the left, and fewer of their errors on the right than does a mixed handedness group. ADHD's make more overall errors than the classroom group does, even when handedness is the same. They make nearly the same number of right-sided errors and almost twice the number of left-sided errors. In the present study, with errors calculated as "one side minus the other", net errors on the left were made by 4 classroom derived subjects, and on the right by 16 classroom derived subjects. In the ADHD group, a left net error preponderance was found in 6 subjects, and a right error preponderance for 4 subjects. The subject numbers are too few to make reliable generalizations, but the results are consistent with the previously cited two studies (Malone;

Voeller & Heilman) as to direction of effect. This data suggests that the trend hypothesized in the study may appear, (more left sided omissions in ADHD group). Unfortunately, the sample sizes, within group variance, clustered scores and small number of errors overall make conclusions unwarranted. The power in this study leaves much to be desired and there are possibilities of Type 1 or Type 2 errors. Statistically these figures are within chance probability.

Reliability and Validity

The BIT test was selected because it has strong reliability and validity characteristics: for test-retest, behavioural correlations, and parallel form reliability. It seemed desireable to implement a reliable and well used battery to search for the same syndrome in another population. The reliability of these findings could be improved by using a more sensitive test with more subjects. However, if the BIT battery did not identify neglect, using a more sensitive test to find it seems misleading. Clearly, as the ceiling scores show, the BIT is well within the capability of young students.

The BIT test incorporates elements used in many neglect tests, with adults and children. Two previous studies with children of this age and similar history have used one of the subtests in a generic form, so we had reason to assume that the tests were suitable. Pilot tests on several high I.Q. students of the same age (not ADHD) yielded scores in the 130's and 140's.

Limitations

Numerous threats to validity were controlled, and represent an improvement over some previous studies. The results obtained here, however, differ from those of the two previous studies, in that no significant differences were found. However, because of the small sample size of the ADHD group, the results should be interpreted with caution. This point is possibly applicable to the Voeller study also.

A variety of circumstances in combination made the subject population fewer than was projected. This, with large within group variances, small between group variances, a small number of errors made, and the ceiling scores indicate either that the BIT test is an unsuitable instrument for testing neglect in a school population, and/or that neglect may not be present in this population. There may, in fact, have been differences between the two test groups but these were unable to be detected reliably. The authors of this test are in the process of developing a BIT test for school children. However, one may conclude that the test is a thorough battery, successfully used in stroke, and that had strong indications of neglect been present, the test would identify them.

Factors beyond the control of the researcher affected this study. Parental return of permission forms provided far fewer ADHD subjects than in the experiment designed (40 eligible ADHD's were identified, yet only 14 returns were received after two mailings). District policies prevented any direct contact with those parents regarding this eligible and well diagnosed pool of subjects. Improvements in recruitment procedures can be made to control this problem. A future study should involve more psychologists in a district, or, more districts.

The age difference between subject and control group was possibly due to variations in teacher interest in explaining the study amongst the classrooms chosen, to more ADHD students possibly being held back for performance reasons, or because more older classrooms should have been solicited. A preferable route for obtaining age matched subjects would be to first solicit all returns for the ADHD group, testing these, and then soliciting appropriate classrooms, although age at time of testing may then differ.

Test Sensitivity

The three tests considered most discriminating for neglect are the letter and star cancellation and line bisection subtests, for which, in all cases, a higher percentage of the ADHD group made errors. The small number of subjects and of errors mean that this is suggestive only. Also, however, the tests are not very comparable, because they do not have equal numbers of items (possible scores were from 3 to 54), and some tests have more subjective scoring (subtests 4 & 6).

Results as They Relate to Previous Studies

A two tailed hypothesis was adopted because of the Malone study results, in which 16 of 17 subjects made lateralized errors on a letter cancellation task, though the side of errors varied. A comparison of side-of-error preponderance to dominant hand might be useful, but in the case of this study, the small number of overall errors would not lead to significant results. Power in this test would have increased if there had been (as expected) a larger gap between scores in groups 1 and 2, if there was less variance within a group, or if all the ADHD's identified had been able to be tested.

The lateralized error effect does not emerge strongly in this study, and the suitability of this test for detecting neglect may be limited if neglect arises in classroom situations. Other test conditions - including greater complexity of the field, more repetitive or sustained attention conditions, or more stimuli in the room in other modalities (simulating classroom situations) might reveal neglect more strongly.

Larger error rates were found in one previous study, and larger differences between groups on the error rate. Voeller and Heilman (1988) found that the 7 ADD subjects made 22.57 mean errors compared to the control group's 8.0 errors on a letter cancellation task (over 18 pages of scattered letters). Malone et al. (1994), in 17 ADHD's, related scores in terms of correctness, finding that mean detections of 32.5 on placebo contrasted with mean detections of 34.5 on medication (in raw terms a relatively small difference). This was a similar task to that of Voeller and Heilman, but used fewer pages of letter cancellation tasks (9 pages, with from 78-156 characters on the page, but 13 target letters (possibly needing more sustained attention than the BIT paradigm). With more errors in the study sample than the compared group, there are found right lateralizations of errors in the controls, and more left lateralizers in the test group in each of these studies. In each study, the ADD population was similarily diagnosed, close in I.Q., and aged 7-12. Voeller and Heilman found that five of seven made left errors, and one of seven made right errors, using a similar "left minus right" model. The results of the present study are non-significant, but tend toward the same direction as previous studies.

Recommendations

Neglect may not be part of the ADHD profile, though possibly of an ADD profile (see Voeller & Heilman, 1988). ADD and ADHD subgroups have not yet been adequately differentiated in studies in this area. A longer methyphenidate washout may also reveal different results. A subsequent experiment should clearly identify large enough samples to create stability of the means. Both ADD and ADHD subgroups should be tested individually. Although the neglect measure chosen could be more challenging, it would seem that if conventional neglect tests do not reveal a visual-neglect problem, it may not be there. One might, on the basis of this study, wish to look instead at other aspects of the visual processing and inattention issues facing ADHD children. Among these, cue invalidity for specific direction of eye movement, and global/peripheral task related shifts seem more promising, especially in the presence of complex and randomly distributed, or multi-modal stimuli.

With regard to total errors, ADHD children in this study made more total errors, even when motor comorbidity was excluded. ADHD children as a group made more of their errors on the left side of the page, unlike classroom group children, who made more errors on the right side. Further study of this may be warranted. It is possible that this idea may relate to eye dominance, and subsequent tests should include an eye dominance measure. When only right handed subjects are included, right handed people make less errors in all; but more of their errors on the left, and fewer of the errors on the right than does a mixed handedness group. ADHD's make more overall errors than the classroom group does, even when handedness is the same. These ideas are implied in the data, but the distributions are not significantly different between groups, using non-parametric tests. Clear conclusions are unwarranted.

Is age a factor in the results? Mean ages do differ, with the ADHD group being slightly older. However, the average scores of the younger subjects are as high as those of older subjects, and this implies, at least within the age range and specific group tested, that developmental factors are likely not implicated in neglect as operationalized here. This is evidence which answers a concern about possible age-related BIT test constraints raised by Cermak & Hausser (1989). Likewise, the Bittotal scores of the LD subgroup are not lower than those of the ADHD group as a whole.

Subjects move their head and body in order to compensate for vision issues, to align themselves with the page. Other students tilt the page up on one corner. This was recorded anecdotally for half of the students tested. These traits form an issue important enough to the theme of this study to need to be controlled in subsequent work. These features were corrected in each student as they were noticed, and "feet flat on floor, page aligned with nose" reinstated. This was only moderately effective. The role of the head tilt, which was seen in my subjects, creates 6-8 degrees of eyeball rotation in the opposite direction (Farah, 1990). This tilt indicates a frame of reference between viewer and page implying relation to the material in body-centred coordinates. It has been proposed that these head tilts are efforts to activate the opposite brain hemisphere, but possibly it may be to compensate for poor eye teaming.

The amount of time on the test was not controlled, but it was noticed how thoroughly the students checked their work. In several cases this resulted in their correcting omission errors. School training in work-checking may have resulted in a potential confound on this test, unique to a school aged population where this skill is practiced.

Implications for the Theories Presented Above

This study does not lend in favour of any theories toward a relationship of neglect and ADHD. No evidence of a difference on neglect measures between the groups was found in the small, clearly diagnosed data sample presented here. A few small differences are present in the results, but the tests certainly are not discriminating of neglect as it is usually understood. However, should the considerable difference between the groups in error patterns on left and right be borne out in a larger and more discriminating test, it might be argued that an eye dominance theory (or another theory) might explain the data more readily than a neglect hypothesis.

Important elements from the theory regarding inattention in ADHD subjects, that may warrant future study, are discussed below. Neglect patients demonstrate neglect of the left side in the absence of instructions, which is consistent with ADHD's who improve when cued. Normals are more likely to sample the right side before the left side of space. The right hemisphere aids distribution of attention in both sides of space. It is possible that a dysfunctional-right-hemisphere population simply does this even more (pathologically symmetrical). The concept of the importance of a focal-to-peripheral vision shift is a useful one in this area of research, and was not tested in this design. The left hemisphere is responsible for the focal step. Neglect may appear, according to Marshall, Halligan and Robertson (1993, p.47) when a wide focus of attention needs to be narrowed to see detail.

Direction of the eye movements may also be relevant. Faster response times are found when the midline is not crossed, and, in the same hemifield. Rizzolatti postulates a link of covert orienting and the programming of explicit ocular movements. Studies by Posner (1994), and by Swanson et al.(1991) suggest that ADHD children perform normal covert orienting to a peripheral cue and fast orienting to a invalid LVF cue. Pearson et al. (1995) seem to confirm these general differences. The theories of central and peripheral orienting and the role of invalid cueing should be further investigated. In this neglect study, the cue conditions and a generally central focus are not similar to the conditions identified by Swanson et al.(1991), and Pearson et al. (1995), as possibly creating a difference between ADHD subjects and others. For ADHD's it is generally eye movements to the left in invalid cue conditions (a movement is expected) that create the problems. This is a decreased cost of an invalid cue; ADHD's do not maintain attention well to a cue projected to the left hemisphere requiring a move to the right. This is a function affected by central catecholamine activity.

The explanations of Corbetta et al., (1993) for this are convincing, and should be examined relative to frontal and posterior parietal regional involvement, which is cue and attention driven. Theories about a role for spatial frequency are also useful, since LVF errors are most when low spatial frequencies are removed (when high spatial frequencies are present) and, for RVF errors, the opposite is true.

According to Ladavas et al. (1993) the degree of contralateral neglect increases with the attentional requirements on the intact side. Halligan and Robertson (1991) found, in clinical experience, that the greater the omission score the greater also the laterality of the omissions. This seems to be true in the present study, also. Searching a complex field is harder for hyperactives, although this may or may not be neglect.

Conclusion

An advance of this study over previous studies include administration of larger battery of neglect tests. However, the BIT test was found to be not especially suitable for the population being tested because of ceiling effects. The small size of the test group minimizes the generalizeability of the results (for interpretation in either direction), and low power indicates a risk of Type 1 or Type 2 errors. The results, because they are non-significant, tend to be inconsistent with previous findings (but consistent with Ogden's 1985 observation that adminstering more tests trends toward more right neglect found) they should nevertheless be regarded as preliminary. Nonsignificant differences between groups in error rates by side of page were present in the data, and a larger sample might reveal whether this is a matter worthy of further study.

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IDENTIFICATION OF STUDENTS WITH SEVERE LEARNING DISABILITIES

DELTA SCHOOL DISTRICT

SEVERE LEARNING DISABILITIES

DEFINITION

"Learning Disabilities is a generic term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning or mathematical abilities. These disorders are intrinsic to the individual and presumed to be due to central nervous system dysfunction. Even though a learning disability may occur concomitantly with other handicapping conditions, (e.g. sensory impairment, mental handicap, social and emotional problem) or environmental influences (e.g. cultural differences, insufficient/inappropriate instruction, psychogenic factors), it is not the direct result of those conditions or influences." (The United States National Joint Committee on Learning Disabilities, 1987.)

IDENTIFICATION AND ASSESSMENT

The majority of students with learning disabilities will be identified within their neighbourhood schools through the process of pre-referral intervention, referral to school based services and subsequent referral to district level services for in-depth psychoeducational assessments.

The screening and identification process consists of 5 phases:

1. The first phase consists of the classroom teacher identifying students with learning problems.

2. The second phase consists of teacher and Learning Assistance Teacher conducting classroom based assessment (e.g. observation).

3. The third phase consists of standardized achievement assessment by the Learning Assistance Teacher. As well, a visual and hearing screening should be conducted.

4. The fourth phase consists of an individual cognitive assessment by the Regional Psychologist.

5. The fifth phase consists of an additional psycho-educational assessment and language assessment to determine if there is evidence of a processing deficit.

Figure 1, which follows, outlines the phases in the screening process to identify students with progressive degrees of learning disabilities. The figure also outlines progressive levels of generic school based support.

MULTI PHASE SCREENING AND IDENTIFICATION PROCESS (Figure 1)

STUDENTS WITH LEARNING PROBLEMS

ASSESSMENT PHASES		CONTINUUM OF SUPPORT
PHASE 1 Classroom teachers' observation.	STUDENTS EXPERIENCING LEARNING PROBLEMS IN REGULAR CLASSROOMS	**LEVEL 1** Consultative school based support (learning assistance teacher).
PHASE 2 Teacher's and learning assistance teacher's classroom screening (observation, C.B.A., classroom strategies).	STUDENTS EXPERIENCING LEARNING PROBLEMS WHO ARE NOT EFFECTIVELY REMEDIATED BY CLASSROOM BASED CONSULTATION AND CURRICULUM MODIFICATIONS	**LEVEL 2** Direct short term school based support (learning assistance teacher).
PHASE 3 Learning assistance teacher's achievement assessment.	STUDENTS BELOW THE 15TH PERCENTILE ON ACHIEVEMENT	**LEVEL 3** Direct ongoing school based support (learning assistance teacher and/or school special education assistant).
	IF STUDENT IS:	
PHASE 4 Cognitive assessment by psychologist.	1. BELOW THE 8TH PERCENTILE ON ACHIEVEMENT ASSESSMENT AND ABOVE THE 20TH PERCENTILE ON A COGNITIVE ASSESSMENT OR 2. BELOW THE 15TH PERCENTILE ON ACHIEVEMENT ASSESSMENT AND 1.5 S.D. DISCREPENCY BETWEEN COGNITIVE AND ACHIEVEMENT SCORES OR 3. BELOW THE 20TH PERCENTILE ON ACHIEVEMENT ASSESSMENT AND COGNITIVE SCORE ABOVE THE 84TH PERCENTILE.	Continue school based support while cognitive assessment is completed.
PHASE 5 Review psycho-educational assessment for determining process deficit.	THEN CONFIRM ELIGIBILITY AS SEVERELY LEARNING DISABLED	Continue school based support while assessment data is being analyzed for evidence of a processing deficit.

Note: If there is greater than 1.5 S.D. between scaled scores on the cognitive assessment, a single scaled score may be used as the indicator of cognitive ability, the single scaled score must be above 95.

CRITERIA FOR CLASSIFYING A STUDENT AS HAVING A SEVERE LEARNING DISABILITY

As part of the process of assessing a student's eligibility to be classified as severely learning disabled, the following conditions need to be satisfied:

1. Medical or health impairments have been medically checked.
2. Visual acuity has been assessed. (If visual acuity meets the criteria for visually impaired, then visual impairment would be the primary handicap.)
3. Auditory acuity has been assessed. (If auditory acuity meets the criterion for hearing impaired, then hearing impairment would be the primary handicap.)
4. Both classroom based instructional and material interventions have been attempted by the classroom teacher and direct remedial assistance has been provided by the Learning Assistance Teacher and/or the school Special Education Assistant. Please note, direct remedial assistance is not required for a student to be classified as severely learning disabled at the secondary school level.

To classify a student as severely learning disabled, the following two conditions must apply.

Condition 1

The student scored below the 8th percentile on the composite scaled score in reading and/or below the 8th percentile on the composite scaled score in math and writing on an individually administered achievement assessment and the student achieved a full scale I.Q. score above the 20th percentile (87 or above) on an individual administered cognitive assessment. If there is a greater than 1.5 S.D. (22 points) between scaled scores on the cognitive assessment, a single scaled score may be used as an indicator of I.Q. The single scaled score must be above 95 and confirmed by a second cognitive measure.

OR

The student scored below the 15th percentile on the composite scaled score in reading and/or below the 15th percentile on the composite scaled score in math and writing on an individually administered achievement assessment and the student achieved a full scale I.Q. score at least 1.5 S.D. above the achievement score.

OR

The student scored below the 20th percentile on the composite scaled score in reading and/or below the 20th percentile on the composite scaled score in math and writing on an individually administered achievement assessment and the student achieved a full scale I.Q. score above the 84th percentile.

AND

Condition 2

The student scored below the 8th percentile on a standardized measure of cognitive processing that theoretically underlies the area of academic difficulty and that there was confirming task performance difficulty on classroom tasks.