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The Useful Field of View of Reading Disabled Children

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THE USEFUL FIELD OF VIEW OF READING DISABLED CHILDREN

A Thesis
Presented to
the Faculty of the Department of Psychology
Western Kentucky University
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In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
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THE USEFUL FIELD OF VIEW OF READING DISABLED CHILDREN

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Recent research suggests that some reading disabled children process visual information differently due to a transient system or magnocellular pathway deficit. In light of this hypothesis, the present study represents an investigation of the visual processing abilities of both good and poor readers using a new technique which taps several aspects of transient visual input by presenting brief masked targets with varying attentional demand. Sixteen subjects' reading capabilities were assessed by the Woodcock Reading Mastery Test-Revised. The subjects were classified as reading disabled if they had a two or more year lag in reading skill (n=7) or as non-reading disabled if they showed reading capabilities at or above their expected age level (n=9). Subjects performed on the Visual Attention Analyzer in order to assess their UFOVTM, the area of the visual field in which information can be acquired in a brief glance without head or eye movements. The UFOVTM protocol involves subtest measures of processing speed, divided attention, and selective attention. The first subtest requires subjects to identify a target at varying durations. The second subtest requires identification of a central target simultaneously with localization of a peripheral target at eccentricities of 10, 20, or 30 degrees. The third subtest requires the same responses but adds visual distractors with the peripheral target. The reading disabled subjects required longer durations to achieve equivalent performance in both the divided and selective attention tasks. This group demonstrated a more drastic reduction in UFOVTM than did normal readers when distractors were added in task 3. Furthermore, reading disabled individuals processed information in the right vs left half of the visual field differently than did non-reading disabled children. The reading disabled subjects made more localization errors overall and missed a significantly higher
proportion of targets presented in the right half of the visual field. Reading disabled individuals processed visual information more slowly, were more easily distracted, and made more localization errors than did normal readers resulting in a reduction of the UFOV™. This pattern of results fits within the framework of the transient system deficit hypothesis for reading disabled children. Therefore, such differences in processing between normal and disabled readers may be the result of a transient system deficit in visual processing in reading disabled children.
Chapter I
Introduction

Federal law states that an individual may have a learning disability "if a severe discrepancy exists between achievement and intellectual ability in one or more of the following areas: oral expression, listening comprehension, written expression, basic reading skills, reading comprehension, mathematical calculation and mathematical reasoning" (National Joint Committee on Learning Disabilities, 1987, p.107). Learning disabilities are not limited to childhood, but continue into adult life. Learning disabilities may be developmental in nature and may have a basis in inherently altered processes of acquiring and using information possibly due to central nervous system dysfunction (National Joint Committee on Learning Disabilities, 1987).

The National Joint Committee on Learning Disabilities official statement on learning disabilities is

"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, or environmental influences, it is not the direct result of those conditions or influences (Hammill, Leigh, McNutt, & Larsen, 1981, p. 336).

The learning disabled population includes individuals with a heterogeneous group of disorders. Of particular interest in the present study was the group of reading disabilities due to visual-spatial and perceptual disorders. Mattis, French
and Rapin (1975) identified this subtype as having normal intelligence with a verbal IQ 10 or more points above performance IQ. These individuals demonstrate poor visual conceptualization as measured by Ravens Colored Progressive Matrices and have Benton Test of Visual Retention scores at or below borderline.

Other correlates of reading disabilities include delayed onset of speech and early speech disorders, as well as incidence of neurological and attentional deficits (Solan, 1986). Overall, considering the many different correlates and difficulties implicated in the learning disabled population, it is important to avoid classifying learning disabled into one group. Furthermore, methods of intervention should be approached with individual differences in perspective and should be evaluated in two ways. First, the individual's specific deficits should be identified. Confirmation that the deficits are related to disability must be obtained, and it should be demonstrated that treatment of the deficit will result in improved academic performance.

There is a great deal of disagreement among researchers concerning the role vision plays in one type of learning disability, reading disability, with estimates ranging from no relationship to a strong causal relationship. The prevalence of reading disabilities has been estimated to be between 4 and 15% of school aged children (Lovegrove, Garzia, & Nicholson, 1990), comprising 75% of the learning disabled population (Lehmkuhle, 1993). One particular population, which has been defined as "specifically reading disabled", has consistently demonstrated many differences in visual processing skills. "Specifically reading disableds" difficulties are due to problems with visual processing (which are described in detail in the following literature review). This population tends to be predominantly male with reading delays greater than or equal to 2.5 years below expected performance for their age group. However, differences have also been found in individuals who only exhibit a delay of one year. These individuals perform at average or above
average levels in all other areas and have an average or above average non-verbal IQ. The "specifically reading disabled" do not demonstrate evidence of any organic or behavioral problems.

Research on visual deficits in the reading disabled has been correlational and comparative in nature, mostly contrasting the incidence of visual anomalies in reading disabled to incidence in normal individuals. Visual processing differences have been found in such areas as contrast sensitivity (Lovegrove, Bowling & Babcock, 1980; Martin & Lovegrove, 1984), visual persistence (Babcock & Lovegrove, 1981; Lovegrove et al., 1980; Siaghuis & Lovegrove, 1985), flicker contrast sensitivity (Martin & Lovegrove, 1984, 1988; Siaghuis & Lovegrove, 1984), and flicker masking effects (Siaghuis & Lovegrove, 1984; Martin & Lovegrove, 1987). Another interesting finding has been that reading comprehension is better for disabled readers in single word presentation versus passages and that blurring of images enhances their search times (Williams & LeCluyse, 1990).

Rourke and Strang (1983) hypothesized that children with visual - perceptual learning difficulties do not have adequate organization in visual processing. Thus, these individuals require more effort for lower order sub-skills and divert more attention to such skills in order to compensate. This diversion of attention leads to the individual allocating less effort and attention toward higher order skills such as comprehension and conceptualization in reading. The consequences of such deficits have been implicated in perceptual grouping deficits and an inability to selectively attend (Brannan & Williams, 1988). Reading disabled individuals require longer time intervals to make accurate temporal judgments (Brannan & Williams, 1988), allocate attention across visual space without eye movements (Brannan & Williams, 1987), and to locate letters embedded in distractors (Williams, Brannan, & Lartigue, 1987). Overall, reading disabled individuals tend
to process information more slowly.

Visual attention plays a vital role in the reading process. Reading requires one to direct attention centrally and extract information at the point of fixation. Then, attention needs to be shifted to the right. This attention shift is independent of and occurs prior to eye movement. Deficits in allocation of attention are demonstrated by increased fixation durations and smaller saccades (Henderson Pollatsek, & Rayner, 1990). Reading disabled individuals have demonstrated such attentional deficits particularly in an inability to allocate visual attention across visual space (Brannan & Williams, 1987).

The implication for research in the area of reading disabilities is that visual deficits are indeed a factor and thus, should be evaluated. The perceptual consequences of the deficits exhibited need to be identified. Focal points in research should include identifying methods to improve processing skills and exploring whether improving skills would improve academic performance.

The present study is an investigation of the Useful Field of View, the area of visual field in which information can be acquired in a brief glance without head or eye movements, of reading disabled individuals as assessed by the Visual Attention Analyzer. This instrument is a reliable measure of one’s useful field of view. The present investigation will help further define the visual perceptual deficits experienced by reading disabled individuals. Provided that some reading disabled children have reduced UFOV, remediation of the deficit should also be explored. Sekuler & Ball (1986) and Ball, Beard, Roenker, Miller, & Griggs (1988) reported that practice on the Visual Attention Analyzer can improve visual attention performance, and that such gains have been retained for more than six months. Therefore, the Visual Attention Analyzer may have potential as an effective intervention technique for reading disabled individuals. Future studies should be conducted to examine the Visual Attention Analyzer as an intervention.
technique for reading disabled individuals who exhibit perceptual deficits.
Chapter II

Review of the Literature

Parallel Pathways of the Visual System

Experimental analysis of the visual system has led to the theory of parallel visual processing. It is hypothesized that processing of visual information transpires through parallel neuronal channels which run from the retina to the visual cortex. One pathway connects p retinal ganglion cells to the inferior temporal cortex by way of layers 3 - 6 of the dorsal lateral geniculate nucleus, layer 4Cβ of cortical area VI, and the pale and thin stripes of cortical area VII. The other pathway connects m ganglion cells to layers 1 - 2 of the dorsal lateral geniculate nucleus, both layers 4C α and 4B of cortical area VI, the thick and thin stripes of cortical area VII, and on to the posterior parietal cortex (Lehmkuhle, 1993). These channels are thought to remain mostly separate and independent through the visual system until reaching the visual cortex. Therefore it is presumed each system is responsible for different functions (Merigan & Maunsell, 1993). Today, the pathways are most commonly referred to as parvocellular and magnocellular systems, respectively. The magnocellular system is thought to be responsible for detecting movement, perceiving depth, and identifying form. This pathway is also termed the transient system. The parvocellular system plays a vital role in central vision and color perception and is often referred to as the sustained system (Carlson, 1991).

Experimental evidence supports the hypothesis of parallel visual pathways. Through studying the primate visual system, Trevarthen (1968) proposed that visual processing consisted of focal and ambient mechanisms. Focal is now
referred to as foveal or central vision, whereas ambient represents peripheral vision. Trevarthen's model of focal and ambient vision can be equated to parvocellular and magnocellular aspects of visual processing. The parvocellular and magnocellular pathways differ in response to temporal and spatial stimuli. Thus, the parvocellular pathway has also been termed the low temporal and high spatial stimuli sensitive, or LTHS, pathway -- whereas, the magnocellular pathway has been termed the high temporal and low spatial stimuli sensitive, or HTLS, pathway (Bassi & Lehmkuhle, 1990). These pathways were found to project to the parvocellular layers and to the magnocellular layers of the dorsal lateral geniculate nucleus (dLGN), respectively, and are thus referred to as the P and M pathways. The results of these studies of ganglion cells and their projections led to the idea of separate and independent parallel pathways in the visual system (Bassi & Lehmkuhle, 1990).

<table>
<thead>
<tr>
<th>Transient System</th>
<th>Sustained System</th>
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<tr>
<td>• magnocellular</td>
<td>• parvocellular</td>
</tr>
<tr>
<td>• movement, depth, form</td>
<td>• central vision, detail, color</td>
</tr>
<tr>
<td>• global processing</td>
<td>• local processing</td>
</tr>
<tr>
<td>• high temporal, low spatial (HTLS)</td>
<td>• low temporal, high spatial (LTHS)</td>
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Eighty percent of primate ganglion cells are categorized as P cells whereas only ten percent are M cells. The magnocellular system pools input from a large number of photoreceptors distributed across the retina including both rod and cone type receptors. The parvocellular system pools input from a smaller number of
receptors, most of which are located in the central retina (Lehmkuhle, 1993). The properties of M and P cells are quite diverse. For instance, the axons of M cells are thicker and allow neural impulses to travel more quickly than through P cells. The receptive fields of P cells are much smaller than those of M cells, resulting in P cells responding better to small objects or fine detail. On the other hand, M cells are superior in detecting differences in light. These cells have a lower threshold to light stimuli due to spatial summation. Finally, P cells show selective response to color whereas M cells seem to be "colorblind" (Sekuler & Blake, 1990).

Merigan and Eskin (1986) and Lehmkuhle et al. (1982) found that specific damage to the parvocellular system resulted in complete loss of color vision and considerable depreciation of acute vision. The decrease in visual acuity reasserts the importance of the P pathway in detecting high spatial frequencies (Merigan & Maunsell, 1993). As opposed to P pathway lesions, M pathway lesions result in a loss of ability to perceive higher temporal frequencies and lower spatial frequencies. Such a loss causes a reduction of visibility to rapidly moving or flickering targets (Merigan & Maunsell, 1993). The current explanation of visual processing asserts that the transient system is responsible for detecting movement and responding to stimulus onset and offset (Breitmeyer & Ganz, 1976).

Another interesting finding is that humans' reaction time responses are positively correlated to spatial frequency of the stimuli presented. In general, reaction times to lower spatial frequencies are significantly quicker than to those of high spatial frequencies. Thus, we are faster at responding to spatial frequencies to which the visual system is less sensitive (Bassi & Lehmkuhle, 1990). This phenomenon can be explained by the existence of parallel pathways. It has been demonstrated that the M-pathway is more sensitive to lower spatial frequencies, and neural impulses travel more quickly throughout the M-pathway than the P-pathway. Thus, we react to lower spatial frequencies more quickly because of the
stimulation to the faster M-pathway. (Bassi & Lehmkuhle, 1990).

Psychophysical evidence for sustained and transient parallel pathways has also been obtained through such visual mechanisms as saccadic suppression and patterns of masking (Breitmeyer & Ganz, 1976). According to the parallel processing paradigm, masking of a target occurs when the transient system response to the mask overlaps with the sustained system response to the target. The more overlap in time that exists, the stronger the masking effect (Williams, Molinet, & LeCluyse, 1989).

In conclusion, the magnocellular and parvocellular layers are arranged in an orderly manner and have distinct physiological characteristics, resulting in the systematic visual processing of information being referred to as parallel. The magnocellular system processes information rapidly, while the parvocellular system operates more slowly (Lehmkuhle, 1993). The transient, or magnocellular, system operates preattentively (Williams & LeCluyse, 1990). Therefore, the transient system most likely serves to guide the sustained system in the sequencing of information processing. It has been suggested that the transient system is responsible for directing the sustained system to salient stimuli in the visual field, where analysis of color and form may be required (Williams & Lecluyse, 1990). Thus, normal visual processing requires specific timing. First, the transient system quickly processes general information about the stimulus viewed. For example, magnocellular processing provides such information as the nature of the stimulus and where it is located. This type of processing is referred to as global. Next, the sustained system supplies more specific information so that the details of the stimulus may be perceived. Therefore, the parvocellular system provides what is termed local information. If the proper sequence of information processing is altered, visual deficits will experienced (Lehmkuhle, 1993). Such deficits have been exhibited by reading disabled children.
Reading Disabilities and Visual Deficits

The relationship between visual anomalies and learning disabilities has been explored and debated for quite sometime. The parallel processing paradigm of visual function has served as a useful heuristic in studying reading disabilities in that it has acted as a good predictor of visual processing characteristics and difficulties in this population (Williams & Lecluyse, 1990). Many psychophysical studies have connected specific reading disabilities to possible deficits in the magnocellular transient processing of visual information. Reading disabled children have been found to have deficits which implicate improper processing throughout the M-pathway (Lovegrove, Garzia & Nicholson, 1990). The magnocellular pathway may operate more slowly in reading disabled children, interrupting the normal time sequence of visual processing between the M and P pathways (Lehmkuhle, 1993). Lovegrove, Grazia & Nicholson (1990) have hypothesized that this transient system deficit may be responsible for some reading difficulties. The presumption is that difficulty in processing visual information throughout the magnocellular pathway, early in the sequence of operation, would interfere with higher cognitive processes such as reading (Lovegrove et al., 1990).

During the process of reading, visual information is obtained through fixations which, on average, last about 250 msecs. Following fixation, the eyes move to another location, fixate again, and continue to process information. Lovegrove et al. (1990) contend that during the reading process visual persistence, the phenomenon of a stimulus continuing to be seen after its' presentation, would seem to interrupt the reader by causing him/her to continue seeing the previous fixation while simultaneously attempting to process another. Thus, the phenomenon of visual persistence, which can last up to 300 msecs, would have a masking effect.

Lovegrove et al. (1990) explain that normally parallel processing in the visual system, particularly the transient system, prevents visual persistence from acting
as a mask and interfering with reading. Breitmeyer & Ganz (1976) found that in normal visual processing an eye movement triggers a brief response from the transient system which then inhibits the sustained system and reduces visual persistence. Therefore, the transient system enables us to discern information from fixations by preventing persistence.

Siaghuis & Lovegrove (1985) discovered that specific reading disabled subjects had shorter durations of visual persistence at high spatial frequencies (8 to 12 cycles per degree) and longer durations at low spatial frequencies (1 to 4 cycles per degree) when comparing visual persistence to that of normal readers. Normal readers exhibit visual persistence durations which vary as a function of spatial frequency of the stimuli presented. The relationship is monotonic with lower spatial frequency stimuli resulting in shorter visual persistence. For reading disabled children, visual persistence durations do vary as a function of spatial frequency, but the relationship is quite different. At high spatial frequencies, specific reading disabled's transient system adequately inhibits visual persistence. However, at low spatial frequencies it does not. Lovegrove et al. (1990) provide a possible explanation for these processing differences as a transient system deficit. Provided our current understanding of transient system visual processing, such a deficit would elevate visual persistence at low spatial frequencies by taking longer to inhibit the sustained system. Thus, the image is maintained longer.

Brannan and Williams (1988) have also provided psychophysical evidence of a magnocellular processing deficit in reading disabled children. They divided subjects who were good and poor readers into three age groups (8, 10, and 12 years). Reading disabled were classified as having a reading lag of at least one year as measured by the Spache Diagnostic Reading Scales and having normal or above intelligence as measured by the Stanford Binet. Subjects viewed word and non-word stimuli which were presented in succession via computer, 1 degree from
a central fixation point. The stimuli were presented to the right of fixation first for half of the trials and to the left of fixation first for the remaining trials. Subjects were required to make a temporal order judgment by pointing to the side where the first stimuli appeared.

Brannan and Williams (1988) found that reading disabled subjects required more time to make a judgment about the order of two briefly presented stimuli, suggesting that poor readers may have somewhat slower processing abilities. This effect was demonstrated within all age groups, and occurred for both word and non-word stimuli. There was no main effect of stimulus type (word versus non-word), and no interactions were found.

Reading level was significantly correlated with the ability to accurately make temporal order decisions for both non-word and word stimuli. Forty-four percent of the variance in reading level could be accounted for using non-word stimuli, and 30% of the variance was accounted for using word stimuli. Brannan and Williams (1988) concluded that poor readers require more time to make decisions about the presentation order of stimuli. They further hypothesized that the temporal processing deficit which exists in reading disabled cannot simply be a result of developmental delay.

Another difference that has been found between reading disabled and normal children involves visual attention. Brannan and Williams (1987) studied the allocation of visual attention in good and poor readers. Poor readers were again defined as demonstrating a one year lag in reading as assessed by the Spache Diagnostic Scales. Subjects viewed letters presented on a computer screen 2 degrees from a central fixation point. A cue was presented prior to (< 250 msecs) or with the target letter. Both the cue and target stimuli were viewed for 30 msecs. The cue predicted the target letter position correctly fifty percent (randomly) or eighty percent of the time. The subjects completed 10
trials and demonstrated between 75 to 80% accuracy.

No main effect of group was found. However, there was a main effect of stimulus onset asynchrony (SOA) and probability condition. Thus, the amount of time between cue and target affected accuracy in detection of target, as did probability condition (50% vs 80%). Subjects were more accurate when the cues had longer SOA’s. Detection in the 80% accuracy condition was better. There was also a significant interaction of group and probability effect. Although good readers demonstrated large differences in accuracy in the differing probability conditions, poor readers did not. Poor readers performed significantly worse than good readers in the eighty percent probability condition, while the groups performed essentially the same in the 50% probability condition. Brannan & Williams thus concluded that poor readers did not utilize cues to direct visual attention effectively. The effect of SOA also differed between the groups. For SOA’s of 0-50 msecs., poor readers were less accurate than good readers. However, at longer SOA’s poor readers were as accurate as good readers in target detection. Thus, poor readers needed more time to shift visual attention. Further, good readers showed higher accuracy for targets presented in the right visual field. Poor readers, on the other hand, did not differ in right or left field accuracy.

Williams, Brannan, and Lartigue (1987) compared visual search in good and poor readers. The task consisted of searching for a target letter in a list of distractor letters. Search times of poor readers were longer than those of good readers. However, when high spatial frequencies (greater than 15 cycles per degree) were removed from the display through blurring, poor readers performance improved drastically. Good readers search times also improved, but only slightly. In light of the theory that the specifically reading disabled demonstrate transient system deficits, Williams et al. (1987) asserted that eliminating those frequencies slows the sustained system because it is more active
in processing high spatial frequency information. Eliminating such frequencies would then reinstate the normal time sequence of global information processing by reducing the activity of the sustained system. The normal time sequence of sustained and transient systems information to the visual cortex would then occur.

Brannan and Williams (1988) also studied selective attention in reading disabled and normal children through perceptual grouping tasks. Subjects sorted cards containing brackets into piles on the basis of the right element. For the control group, only relevant information, the right bracket, was varied. In the experimental conditions, subjects sorted cards in which both the left and right stimuli varied. The grouping conditions sorted \([\ )\] and \(\)\) cards into one pile, and \([\ [\) and \(\]\)\] into another. Variation of the left element is thus irrelevant. The non-grouping conditions sorted cards in the same manner. However, the cards contained one vertical and one horizontal bracket (\([\ -], [\ -], [\ -], [\ -]\)).

Card sorting times differed among subject groups and varied with age. There was also a main effect of stimulus type (group versus non-group). Card sorting times were the same for the control and experimental groups within the non-grouping conditions. However, grouping stimuli did affect card sorting times differently for the control and experimental groups. Poor readers showed stronger grouping effects, requiring more time to sort cards in the grouping category than good readers. Perceptual grouping effects were significantly correlated with reading level \((r = -.65)\). Good readers showed smaller perceptual grouping effects, demonstrating better ability in selectively attending than poor readers. The strong perceptual grouping effects found in poor readers suggest that these individuals had difficulty ignoring irrelevant stimuli. Grouping stimuli were processed as a whole as opposed to the relevant portions. Thus, Brannan and Williams (1988) concluded that the reading disabled subjects demonstrated visual processing
deficits in selective attention.

Overall, these studies can be summarized by the statement that reading disabled tend to process information globally, obtaining general information, rather than specifically, paying attention to detail. Williams and LeCluyse (1990) explained that this processing difference is the result of a slow transient system which provides global information. For the reading disabled, transient system processes require more time. Thus, disabled readers have less capacity in processing detail through the sustained system and tend to focus more on global information. The slowing of the transient system interferes with the temporal order of processing, resulting in the previously described visual deficits.

The Useful Field of View

Another way in which visual processing has been studied involves examination of subjects' useful field of view. The useful field of view (UFOV<sup>TM</sup>), originally described by Sanders (1970), is the visual field area over which information can be acquired in a brief glance without head or eye movements. The UFOV<sup>TM</sup> is a measure of the spatial area within which an individual can be alerted to visual stimuli under a variety of situations (Verriest, Barca, Dubois-Poulsen, Houtmans, Inditsky, Johnson, Overington, Ronchi, & Villani, 1983) and is conceptually distinct from the visual sensory field which describes luminance sensitivity throughout the field (Ball, Owsley, and Beard, 1990). UFOV<sup>TM</sup> related tasks measure preattentive level processing of visual attention. The preattentive level is the "earliest stage of attention and is used to quickly capture and direct one's attention to highly salient visual events" (Owsley et al., 1991, p. 3).

The UFOV<sup>TM</sup> is measured binocularly and involves detection and identification of targets. A central target identification task coupled with a peripheral target localization task provide a measure of the size of the UFOV<sup>TM</sup>. Three subtests are performed on the Visual Attention Analyzer in order to
measure the subject's UFOV™. The first subtest is a task of pattern recognition in which the targets (8 x 9 degrees) are presented at a central location at durations ranging from 40 to 250 milliseconds. The targets are followed by the one second presentation of a full field mask. Tasks which measure UFOV™ also include divided attention between visual stimuli and selective attention to visual targets within distractors. Both of the tasks require peripheral detection, the point at which visual sensory mechanisms are specialized for detection (Mulligan & Shaw, 1980). The Visual Attention Analyzer provides a speed of processing score in milliseconds, thereby representing the minimum presentation time required for discrimination of two similar objects. Scores are also derived in terms of percent of reduction for the speed of processing, divided attention, and selective attention tasks. A reduction in one's UFOV™ may be the result of: reduced speed in processing of visual information, a divided attention deficit, an inability to ignore irrelevant information, or a combination of any of the three.

UFOV™ related tasks are preattentive and examine the allocation of visual attention across the visual field. Furthermore, it has been explained that reading disabled individuals demonstrate transient system deficits, which are implicated as working at a preattentive level and result in slower information processing abilities. It is therefore hypothesized that disabled readers will have slower processing speeds than will good readers as measured by the Visual Attention Analyzer. If the transient system does in fact direct the sustained system to salient stimuli in the visual field, an improperly functioning transient system would interfere with performance on the Visual Attention Analyzer which requires responses to rapidly presented stimuli within the visual field. Furthermore, the transient system deficit increases visual persistence which would result in longer processing times and stronger masking effects. Backward masking is involved in all tasks of the UFOV™ protocol. Therefore, such difficulties would hinder UFOV™ Visual
Attention Analyzer performance.

The expectation was that reading disabled children would perform worse than non-reading disabled children on the first task of target identification due to the brief presentation of the stimulus (<250 milliseconds) and to the target being followed by the full field mask. The transient system responds quickly to stimulus onset and offset. Thus, an individual with a sluggish transient system may require more time to identify the target. Also, if the transient system operates more slowly, inhibition of the sustained system would occur later. Thus, the responses to the target and mask would overlap at longer durations than normal and result in more difficulty in identifying the target.

It was also expected that reading disabled children would have slower processing speeds on task 2. If the reading disabled subjects have difficulty identifying the center target, the added load of locating an outside target would result in more difficulty and a reduction in the divided attention score. Reading disabled have shown deficits in the allocation of visual attention and difficulty in ignoring irrelevant stimuli. Thus, it was also expected that disabled readers would have higher reduction scores in selective attention than would normal readers on the Visual Attention Analyzer UFOV™ task 3. Good readers have shown preference in processing information presented in the right field while poor readers do not. Therefore, it was hypothesized that normal subjects would show this trend of processing, detecting targets in the right field more accurately than disabled readers.
Chapter III

Method

Participants

Normal and reading disabled subjects were recruited through advertisements in the local newspaper. Information regarding the study was also sent to area schools. Some subjects were referred to the investigator by the local schools. Twenty-five subjects were tested. The average age of the subjects was 128 months ($M = 128.76, SD = 19.85$). The group was comprised of 17 males and 8 females. None of the subjects demonstrated evidence of neurological damage such as past incidence of head injury.

Seven subjects were defined as reading disabled; four of which had been previously diagnosed as reading disabled by a psychologist. Three were referred to the investigator by the school system as suspected reading disabled but had not yet been formally diagnosed. The reading disabled group was comprised of seven males and one female. The average age of this group was 136 months ($M = 136.43, SD = 14.89$).

Nine of the subjects were classified as normal readers. This group was comprised of 5 males and 4 females. Their average age was 132.56 months with a standard deviation of 21.24 months.

Seven subjects, three females and four males, did not score at or above expected for their age level on the WRMT-R, had not been diagnosed as reading disabled, and were not significantly more than one year behind expected. Two male subjects had been previously diagnosed with Attention Deficit Disorder.
Therefore, these nine individuals were excluded from further analysis.

**Materials and Apparatus**

One hundred and twenty-eight 4 inch x 6 inch index cards with brackets drawn in black ink were used by subjects to perform the perceptual grouping task as described by Brannan and Williams (1988). The brackets were 8 mm in height and 4 mm in width.

The Visual Attention Analyzer (Ball, Roenker, & Bruni, 1990) was utilized to measure the subjects' UFOV™. This instrument has a 20 inch diagonal video monitor with a touch screen by which computer controlled displays are presented to the subject.

The Ammons Quick IQ Test (QT) (Ammons & Ammons, 1962) was administered. Scores on the QT assess verbal skill in comprehension as a measure of global mental ability. Plees, Snider, Eaton, and Kearsley (1965), (cited in Nicholson, 1977) found the QT to be a valid and reliable measure of intelligence for children. WISC-R full scale was highly correlated with the QT ($r = .84$). Otto and McNenemy (1965, cited in Nicholson, 1977) administered the QT to children aged 6 to 16 years who demonstrated reading problems. The QT scores tended to be higher for this population than their respective WISC-R scores. However, the differences were not significant.

The Woodcock Reading Mastery Test - Revised (WRMT-R) was utilized to assess subjects reading capabilities. The short scale full reading cluster of the WRMT-R, which has reliability ranging from .91 to .99 for first to eighth graders, was administered.

**Procedure**

Subjects were invited to participate in the study. The experimenter verbally described each test to the subjects, and informed them that they could take breaks or end participation at any point of the testing protocol. Parental consent was
obtained.

For inclusion in the study, subjects had to demonstrate visual acuity of 20/40 or better and contrast sensitivity of 1.95 or better. The subjects' visual acuity was screened using the Modified Bailey-Lovie Chart, which measures distance acuity for letters from 4.2 meters. Subjects' contrast sensitivity was assessed with the Pelli-Robson contrast sensitivity chart. This chart measures how much contrast is required for an individual to visualize letters at a distance of one meter.

The Ammons Quick IQ Test (QT) was used to provide a measure of verbal intelligence. The subjects responded either verbally or by pointing to indicate the picture which best represented the meaning of a target word. The test was discontinued when the subject had made six consecutive errors or when the list was exhausted. Scores for the test are expressed by mental age in years.

Subjects' reading capabilities were assessed with the Woodcock Reading Mastery Test. Based upon the results of the WRMT-R, the subjects were to be classified as reading disabled if they had a twenty-four or more months lag in reading skill despite a mental age IQ not less than 12 months from their actual age on the QT. Three individuals scored worse than 12 months from their actual age on the Ammons Quick IQ test. However, these three individuals had been previously diagnosed as reading disabled with more extensive intelligence testing by psychologists. Files from their previous intelligence testing were reviewed by the experimenter in order to assure the individuals were not below average intelligence. Subjects were classified as normal if they showed reading capabilities at or above their expected level.

Subjects completed the perceptual grouping task as described by Brannan and Williams (1988). Time in seconds was recorded while the subjects sorted the cards. Order of card type was counterbalanced across subjects.

Subjects also performed on the Visual Attention Analyzer in order to assess
their UFOV™ This microprocessor-based instrument presents three subtests which are reliable measurements of UFOV™ size expressed in terms of the percentage reduction (0-90%) of a maximum 35 degree radius field (Ball et al., 1990). The task provides subtest measures of processing speed, divided attention, and selective attention -- as discussed in Owsley et al. (1991).

The visual processing speed subtest requires subjects to identify a target at varying durations while viewing the screen at a distance of 28.5 cm. The target is an 8 x 9 degree outline of a box with the silhouette of a truck or car presented at fixation. This task is performed in order to determine the fastest speed at which the subject can correctly identify the target. The second subtest, which measures divided attention, involves identification of a central target along with a simultaneously presented peripheral target (3 x 6 degrees) at eccentricities of 10, 20, or 30 degrees. This task requires the subjects to localize the peripheral target. The third subtest requires the same two responses (also at varying stimulus durations) but adds visual distractors to the peripheral target in order to measure selective attention. In each of the tasks, the targets are followed by the one second presentation of a full field mask.

Three scores from the UFOV™ were obtained representing the extent of difficulty the subject had with respect to speed of processing, divided attention, and selective attention. The divided attention and selective attention scores were obtained by comparing the time required for the tasks with the subjects speed of processing score (task 1). These scores range from 0 (no problem) to 30 (great difficulty). In order to summarize UFOV™ performance, the three scores were summed to yield a score between 0 and 90, which represents the percentage of reduction of a maximum 35 degree radius field. A detailed error printout was obtained for each subject. These printouts provided data on what type of errors the subject made and at what locations targets were missed.
Chapter IV

Results

Descriptive statistics for visual acuity, contrast sensitivity, WRMT-R scores expressed in relation to age in months, and the QT scores were obtained. Refer to Table 2 below.

Table 2

Descriptive Statistics for Visual Function (VA, CS), Reading (WR), and Verbal Intelligence (QT) Measures.

<table>
<thead>
<tr>
<th></th>
<th>RD</th>
<th></th>
<th></th>
<th>NRD</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>VA</td>
<td>- .12</td>
<td>.10</td>
<td>- .12</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>1.89</td>
<td>.08</td>
<td>1.88</td>
<td>.11</td>
<td></td>
</tr>
<tr>
<td>WR</td>
<td>-44.71</td>
<td>13.03</td>
<td>21.56</td>
<td>8.22</td>
<td></td>
</tr>
<tr>
<td>QT</td>
<td>27.29</td>
<td>1.60</td>
<td>33.89</td>
<td>5.18</td>
<td></td>
</tr>
</tbody>
</table>

The average visual acuity score was better than 20/20. All of the subjects demonstrated good visual acuity and normal contrast sensitivity.

Two-tailed independent t-tests were performed in order to determine if there were significant differences between the two groups. There were no significant differences between the reading disabled and non-reading disabled groups in visual acuity ($t_{14} < .00$, $p = .999$), or contrast sensitivity ($t_{14} = -.05$, $p = .962$). The reading disabled group performed significantly worse on the WRMT-R ($t_{14} = 12.46$, $p < .0005$) than did the
normal group. The reading disabled group also performed significantly worse than the non-reading disabled on the QT \( (t_{14} = 3.23, p = .006) \).

Pearson correlations between the dependent variables (QT scores corrected for age, WRMT-R standard scores, UFOV™ total reduction scores, and the number of right and left field UFOV™ errors) and age were computed to test for possible age effects, and to examine the degree of overlap among the variables. The results are presented in Table 3 below.

Table 3

**Pearson Correlations of Age in months and the Dependent Variables.**

<table>
<thead>
<tr>
<th>Age</th>
<th>QT</th>
<th>WRMT-R</th>
<th>UFOV</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.00</td>
<td>- .09</td>
<td>- .17</td>
<td>- .23</td>
<td>- .04</td>
</tr>
<tr>
<td>QT</td>
<td>1.00</td>
<td>1.00</td>
<td>.78***</td>
<td>- .37</td>
<td>- .65**</td>
</tr>
<tr>
<td>WRMT-R</td>
<td>1.00</td>
<td>- .54*</td>
<td>1.00</td>
<td>- .75***</td>
<td>- .45</td>
</tr>
<tr>
<td>UFOV</td>
<td>1.00</td>
<td>.54*</td>
<td>1.00</td>
<td>.43</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p ≤ .05 ** p ≤ .01 ***p ≤ .001

Age was not a significant correlate of any of the dependent variables. The number of right field UFOV™ errors was significantly correlated with QT corrected age score, the WRMT-R score, and total UFOV™ score. WRMT-R scores were also a significant correlate of QT corrected age scores.

To test the hypothesis that reading disabled children would perform more poorly than non-reading disabled children on the perceptual grouping task, a two-tailed independent t-test was performed. No significant differences were found between the two groups \( (t_{14} = \)
A comparison of the scores for the two groups indicated a great deal of individual variability. Grouping effect scores on the task ranged from -3.1 to 6.9 seconds with a mean of 4.03 and a standard deviation of 3.05 for the normal individuals. The reading disabled group scores ranged from -17.9 to 6.6 seconds with an average of .29 and a standard deviation of 9.33 seconds.

The UFOV™ total reduction score for the normal individuals ranged from 0 to 12.5% reduction with an average of 3.06% reduction. The disabled readers' scores ranged from 7.5 to 12.5% reduction with an average of 8.21% reduction. Descriptive statistics for the three UFOV tasks are depicted in Table 4 below. Processing speed scores are presented in milliseconds. Divided attention and selective attention scores are expressed in percent reduction.

Table 4

<table>
<thead>
<tr>
<th>The Useful Field of View Scores</th>
<th>RD</th>
<th>NRD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M SD</td>
<td>M SD</td>
</tr>
<tr>
<td>Processing Speed</td>
<td>14.67</td>
<td>2.00</td>
</tr>
<tr>
<td>Divided Attention</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Selective Attention</td>
<td>8.21</td>
<td>1.89</td>
</tr>
</tbody>
</table>

To test the hypothesis that reading disabled participants would perform worse than non-reading disabled participants in overall UFOV™ performance, statistical analysis with a two-tailed independent t-test was performed. The result revealed that the reading disabled group performed significantly worse than the non-reading disabled group in their overall UFOV™ scores ($t_{14} = -2.67$, $p = .018$). In order to better understand the nature of this difference, the overall UFOV™ scores were reevaluated. For both task 2
and task 3, subjects' scores were broken down into separate scores for all six durations (40 to 240 msecs). Subjects received 1 point for each correct target localization at 10 degrees eccentricity, 2 points for those at 20 degrees eccentricity, and 3 points for targets correctly localized at 30 degrees eccentricity. Five targets were presented at each eccentricity. Therefore, for each duration a total of 30 points was possible. These scores were analyzed with a repeated measures ANOVA mixed design (2 groups x 2 tasks x 6 durations). There was a significant main effect of task ($F_{1, 14} = 277.34, p < .0005$), duration ($F_{5, 70} = 149.60, p < .0005$), and group ($F_{1, 14} = 10.42, p = .006$). These results are depicted in Figure 1.

In task 2, the divided attention task, the two groups performed perfectly at durations of 240 to 120 milliseconds. However, while the non-reading disabled participants performed perfectly at durations of 80 and 40 milliseconds (Task 2, NRD), the reading disabled individuals' scores tended to decline (Task 2, RD). Post hoc multiple comparisons by Tukey tests with Kramers modification for unequal n's revealed that the differences between the groups on task 2 at durations of 80 and 40 milliseconds were not significant ($p$'s > .05).

On task three, the selective attention task, the two groups performed perfectly at durations of 240 and 200 msecs. Post hoc multiple comparisons for task 3 means were also performed utilizing Tukey tests with Kramers modification for unequal n's. At durations faster than 200 msecs, the reading disabled subjects (Task 3, RD) performed significantly worse than the non-reading disabled (Task 3, NRD) ($p$'s < .05).

The interactions of group by task ($F_{1, 14} = 5.43, p = .035$), group by duration ($F_{1, 14} = 4.17, p = .002$), task by duration ($F_{5, 70} = 111.73, p < .0005$), and group by task by duration ($F_{5, 70} = 2.89, p = .020$) were all significant. The subjects' performance differed in general between tasks 2 and 3 of the UFOV test. Task 3 was more difficult for the subjects than was task 2. The significance of the group by duration interaction can be explained in that the two groups performed essentially the same at slower durations and
quite differently at faster durations. Another significant interaction was that of task by
duration. Performance varied on both tasks across the different durations. The reading
disabled individuals performed as well as the non-reading disabled individuals at durations
of 240 and 200 milliseconds on both tasks. However, the reading disabled group
performed worse than the non-reading disabled at durations of 160 milliseconds and less
on task 3. Therefore, the group by task by duration interaction was also significant.

In order to test the hypothesis that normal subjects would detect targets in the right
field more accurately, the localization errors from the UFOV™ scores were also
examined with independent two tailed t-tests. Since multiple t-tests were performed, a
conservative α level of .01 was adopted for significance. The number of peripheral target
localization errors at all eccentricities made in the right visual field (spokes 2,3,4), left
visual field (spokes 6,7,8), and center (spokes 1,5) visual field across the 35 degree radius
were calculated for each subject (refer to Figure 2). The reading disabled individuals
missed significantly more targets which were presented in the right portion of the field
than did the non-reading disabled individuals ($t_{14} = -5.32, p < .0005$). The two groups did
not differ significantly between in the numbers of errors made in the left portion of the
field ($t_{14} = -2.18, p = .047$). The two groups also did not differ significantly in the
amount of targets missed which were presented on either spoke 1 or 5 ($t_{14} = -1.31, p =
.210$). Means and standard deviations are presented in Table 5. The reading disabled
children made an average of 39% of their localization errors in the right portion of the
field, whereas the non-reading disabled subjects made only 28% of their localization errors
in the right portion of the field.
Table 5

Useful Field of View Field Errors.

<table>
<thead>
<tr>
<th></th>
<th>RD</th>
<th>NRD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Errors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>13.71 3.01</td>
<td>6.55 3.01</td>
</tr>
<tr>
<td>Left</td>
<td>11.29 3.73</td>
<td>7.78 2.73</td>
</tr>
<tr>
<td>Center</td>
<td>10.29 1.60</td>
<td>8.89 2.42</td>
</tr>
</tbody>
</table>

Finally, a Stepwise Multiple Regression analysis was performed to determine whether or not group membership (reading disabled vs. non-reading disabled) could be predicted. Group membership was utilized as the criterion variable. UFOV™ Visual Attention Analyzer scores from task 2 at durations of 80 and 40 msecs and from task 3 at durations from 160 to 40 msecs, the number of right, left, and center localization errors, and the QT scores corrected for age were all used as predictor variables. Table 6 depicts the regression analysis results. Including the variables of right UFOV™ field errors, QT corrected age scores and UFOV™ task two scores at the duration of 80 milliseconds, an $R^2 = .81$ was obtained.
Table 6

Summary of Stepwise Regression Analysis for Variables Predicting Group Membership.

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>( \beta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>.093</td>
<td>.018</td>
<td>.818</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>.060</td>
<td>.019</td>
<td>.529</td>
</tr>
<tr>
<td>QT_CA</td>
<td>-.007</td>
<td>.003</td>
<td>-.444</td>
</tr>
<tr>
<td>Step 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>.064</td>
<td>.017</td>
<td>.563</td>
</tr>
<tr>
<td>QT_CA</td>
<td>-.007</td>
<td>.002</td>
<td>-.414</td>
</tr>
<tr>
<td>T2-80</td>
<td>-.068</td>
<td>.028</td>
<td>-.269</td>
</tr>
</tbody>
</table>

Note. Adjusted \( R^2 = .65 \) for Step 1 (p = .0001); \( \Delta R^2 = .09 \) for Step 2 (p < .0005); \( \Delta R^2 = .07 \) for Step 3 (p < .0005).
Chapter V
Discussion

In this study, the researcher attempted to replicate the perceptual grouping effects found in reading disabled children as reported by Brannan and Williams (1988). The main purpose of the present investigation was to examine the UFOV\textsuperscript{TM} of disabled readers in comparison to normal readers. At the onset of the present study, the expectation was that reading disabled children would perform worse than non-reading disabled children on the first UFOV\textsuperscript{TM} task of target identification. It was also expected that reading disabled children would have higher reduction scores in divided attention (task 2) and selective attention (task 3) than normal readers on the Visual Attention Analyzer UFOV\textsuperscript{TM}. Finally, it was hypothesized that reading disabled subjects would make a higher proportion of right field errors than would non-reading disabled subjects.

No significant differences were found between the two groups in performance on the perceptual grouping task, thereby failing to replicate the results of Brannan and Williams (1988). Performance on this task varied greatly among individuals. Perhaps a larger N is required to obtain such results. Considering the small range of ages within the reading disabled group, and the large range in the normal group, developmental effects could be a source of the variability. Not only did Brannan and Williams (1988) have a larger N (N=30) but they also separated out developmental effects by dividing their subject pool into three age matched groups. The present investigation did not involve enough subjects to replicate this methodology.

Brannan and Williams (1988) had concluded that the strong perceptual grouping effects they found in poor readers suggest that these individuals had difficulty ignoring irrelevant stimuli and demonstrated visual processing deficits in selective attention. Even
though the perceptual grouping effects were not replicated, these same conclusions could also be drawn from the overall results of the UFOV\(^\text{TM}\) test, particularly with regard to scores on task 3. The UFOV\(^\text{TM}\) as assessed by the Visual Attention Analyzer may be a more sensitive test of selective attention than the perceptual grouping task.

The inter-relationships of the dependent variables, which were examined by Pearson correlations, proved to be interesting. The number of right field UFOV\(^\text{TM}\) errors was negatively correlated with scores on the WRMT-R and scores on the QT. Therefore, the more errors subjects made in the right portion of the visual field, the more poorly they performed on both the reading test and the verbal intelligence test. The overall UFOV\(^\text{TM}\) percent reduction scores were also negatively correlated with WRMT-R scores. Thus, the good readers were more likely to have smaller UFOV\(^\text{TM}\) reduction scores. The QT and WRMT-R were also significantly positively correlated.

The hypothesis that the reading disabled group would perform more poorly than the non-reading disabled group on the first task of target identification was not supported. The two groups did not differ significantly in their processing speeds for target identification (task 1). Most likely, this is due to the simplicity of the task. This task did not appear to be difficult for most of the subjects in that all subjects but two performed at the quickest speed possible. In order to better evaluate this hypothesis, the groups could be compared at faster durations. Unfortunately, the present UFOV\(^\text{TM}\) protocol does not allow this testing. At durations of 240 to 40 milliseconds, reading disabled and non-reading disabled subjects did not significantly differ in ability to identify a central target on the UFOV\(^\text{TM}\) task 1.

It was hypothesized that reading disabled children would also have slower processing speeds in performance on task 2 of the UFOV\(^\text{TM}\) test given the added load of target localization. The reading disabled individuals' scores began to decline on this task at durations faster than 120 milliseconds, while the normal readers performed perfectly. Although the present experiment did not reveal significant differences, significant
differences between the two groups would most likely be exhibited at faster durations.

The reading disabled subjects had higher reduction scores in selective attention than did normal readers on the UFOV\textsuperscript{TM} task 3 as expected. Specifically, reading disabled subjects performed significantly worse than the non-reading disabled subjects at durations faster than 200 milliseconds. Task 3 is a more difficult subtest than the divided attention portion (task 2) of the UFOV protocol. The reading disabled individuals were still slower at processing the visual information, but were also more distracted by the visual information added to the display. This result supports the conclusion that reading disabled individuals are not as effective in selectively attending than are normal readers, as previously asserted by Brannan & Williams (1988).

Overall, the reading disabled individuals required longer durations to achieve performance equivalent to the non-reading disabled. Furthermore, the reading disabled individuals demonstrated a more drastic reduction in UFOV\textsuperscript{TM} than good readers when distractors were added in task 3. Reading disabled individuals processed visual information more slowly, were more easily distracted, and made more localization errors than did good readers (specifically in the right portion of the visual field) resulting in a reduced UFOV\textsuperscript{TM}.

Brannan & William (1988) asserted that poor readers performed poorly in utilizing cues to effectively direct visual attention. Poor readers required more time than did good readers to shift visual attention. The UFOV is a measure of an individual's ability to orient attention to appropriate locations, particularly in tasks 2 and 3. The difficulties described by Brannan & Williams (1988) could also explain the differences between reading disabled and non-reading disabled participants which were observed in the present study. These results support Brannan and Williams (1988), who asserted that poor readers need more time to shift visual attention. Brannan and Williams (1988) also demonstrated that good readers showed higher accuracy for targets presented in the right visual field. In this study, the same results were obtained using the UFOV\textsuperscript{TM} test protocol.
The differences exhibited between reading disabled and non-reading disabled individuals could be the result of a transient system deficit in visual processing. The pattern of results of the present study and the perceptual deficits previously observed fit within the framework of the transient system deficit hypothesis for reading disabled children. A transient system deficit interrupts the normal sequence in processing of visual information. The transient system is responsible for orienting attention to target location. Therefore, a transient system deficit would result in more time being required to successfully orient visual attention. The present study demonstrated that reading disabled individuals require more time to successfully locate visual targets than do normal individuals.

The UFOV™ test protocol utilizes backward masking in all three subtests. As previously stated, masking of a target occurs when the transient system's response to the mask overlaps with the sustained system's response to the target. The greater the overlap in time that exists, the stronger the masking effect. Individuals with an improperly functioning transient system, which normally operates more quickly than the sustained system, would experience stronger masking effects at longer durations than normal. An improperly functioning transient system could also explain the differences found in reading disabled and non-reading disabled performances on the UFOV™.

Ball, Roenker, and Bruni (1990) reported that the impact of variables such as duration, eccentricity of target, and distraction on the UFOV™, as measured by the Visual Attention Analyzer, was much greater for older individuals. Aging is associated with a restricted UFOV™, accounted for by either a divided attention deficit, an inability to ignore irrelevant information or both (Ball, Roenker, & Bruni, 1990). Steinman, Steinman, Trick, and Lehmkuhle (1994) have asserted that the reduced visual attention exhibited by older individuals is primarily caused by a deficit in magnocellular input in the visual system. Lehmkuhle (1994) also compared elderly and reading disabled children and concluded that the deficits observed in both populations were similar. Lehmkuhle
concluded that the deficits exhibited by the reading disabled and the elderly could be accounted for by a deficient transient system which causes a breakdown of global to local processing. Provided that elderly individuals have difficulty on the UFOV™ task, it would logically follow that if, in fact, reading disabled children have the same type of visual processing limitations, they would also exhibit difficulties in this task as evidenced by the present study.

The evidence described indicates that a possible perceptual consequence of reading disability is a reduced useful field of view. If reading skill can be increased by improving the psychocognitive abilities presumed to underlie reading, the Visual Attention Analyzer could be a promising intervention tool. Elderly adults who demonstrated deficits in visual attention as assessed by the Visual Attention Analyzer have been able to improve performance with training (Ball et al., 1988). Further research should be conducted to determine whether reading disabled individuals can also improve their visual attention skills. If so, the potential improvement could transfer to improved reading capabilities. Hopefully, future research endeavors will address these questions.

In addition to the psychophysical evidence cited, physiological evidence has also been obtained to support the hypothesis that reading disabled individuals have temporal deficits due to an abnormal magnocellular visual pathway. Livingstone, Rosen, and Drislane (1991) found that disabled readers demonstrated longer latencies of visually evoked potentials for rapidly changing stimuli, and low contrast stimuli, but had normal responses to slow or high contrast stimuli. Furthermore, they compared the lateral geniculate nuclei in autopsy specimens from five dyslexic brains to five control brains and found abnormalities in the magnocellular layers. Livingstone, Rosen, and Drislane (1991) concluded that reading disabled individuals do in fact have defective magnocellular visual pathways.

Despite the evidence presented that a transient system deficit may be responsible for some reading disabilities, it is important to remember that these deficits only describe a
subset of the reading disabled population. "The problems in reading disabilities are so complex that no theory positing a unitary deficit hypothesis can be acceptable. . . ."

(Fletcher & Satz, 1979, p. 152). Perhaps, however, this information can help us in better understanding some reading disabilities.
Bibliography


Figure Caption

Figure 1. Reading disabled (RD) and non-reading disabled (NRD) UFOV™ group performance for tasks 2 and 3 across durations in milliseconds. The scores are expressed in relation to the number of peripheral targets correctly localized. Targets localized at the eccentricity of 10 degrees were worth 1 point, the eccentricity of 20 degrees were worth 2 points, and the eccentricity of 30 degrees were worth 3 points.
Figure 1.

UFOV Performance

- Task 2, NRD
- Task 2, RD
- Task 3, NRD
- Task 3, RD

Score

Duration
Figure Caption

**Figure 2.** The Visual Attention Analyzer UFOV™ display. For analyzing field errors, spokes 1 and 5 were defined as the middle portions of the field, spokes 2, 3, and 4 were defined as the right portion of the field, and spokes 6, 7, and 8 were defined as the left portion of the field.