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Electrophysiological indicants of reading disability: A longitudinal investigation

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ELECTROPHYSIOLOGICAL INDICANTS OF READING DISABILITY:
A LONGITUDINAL INVESTIGATION

by

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This study examined the black/white discrimination abilities for letter and non-letter patterns in individuals with and without reading disability using event-related potentials (ERPs) and behavioral measures. ERP and behavioral measures, considered to reflect the selective processing of black vs white letter and non-letter patterns, were obtained and examined separately for two samples of first grade children. Selective neural processing was measured as the increase in ERP amplitude in response to stimuli that were task relevant (black) as compared to task irrelevant (white).

ERP and behavioral measures obtained from a group of seventy-four randomly selected first grade children were examined, independent of their reading level, on the black/white discrimination task. Results demonstrated faster and more accurate behavioral performance on the experimental task for the letter as compared to the non-letter patterns. The ERP indicants provided complementary information regarding this letter facilitation effect, indicating the selective neural processing of letter, as compared to non-letter patterns within the initial 100-140 msec (P1) after stimulus presentation. Later ERP measures of selective neural activity (N2 and P3) for letter as compared to non-letter stimuli showed greater differences as a function of task relevance over the left than right hemisphere, suggesting a left cerebral lateralization for these processes. In addition, measures of continuous rapid naming (RAN) were administered and provided a statistical relationship between performance on the black/white discrimination task and linguistic ability.

A group of reading disabled (RD) and non-reading disabled children (NRD), previously selected as being "At-Risk" for developing reading problems, were then compared on the black/white discrimination task based on data obtained in the first and third grades. These subjects were matched in age and on measures of intellectual and attentional ability. Individuals with reading disability demonstrated slower rapid naming performance for letters and numbers and slower and less accurate performance on the black/white discrimination task. Compared to the non-reading disabled groups, the reading disabled group manifested reductions in neural activity at 100-140 msec (P1) which was related to the selective processing of the letter stimuli. Further reductions in neural activity which were greater for letter than non-letter stimuli and larger over the left than right hemisphere were observed at 180-240 (N2) and 460-600 (P3) msec after stimulus presentation. These reductions are assumed to reflect reduced selective neural processing for the reading disabled group, as compared to the non-reading disabled group, during the task. The data suggest further that neural-behavioral deficits in individuals with reading disability are present as early as the first grade and that these deficits persist into the third grade. The deficits appear to involve multiple levels of neural processing in the lateral-geniculate and inferotemporal visual processing system and are frequently manifested in more symmetrical brain activity over the posterior regions. Furthermore, performance differences between the RD and NRD groups failed to support the independence of visual-perceptual and linguistic processing deficits in individuals with reading disability.

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

Developmental reading disability or dyslexia (terms used interchangeably in this proposal) refers to a behaviorally diagnosed syndrome where an individual possesses unsuitable reading achievement in the presence of normal intellectual ability which cannot be attributed to environmental causes nor be considered to be secondary to neurological disease. The definition of reading disability, a disorder affecting approximately 3-6 per cent of the general population (Hynd and Cohen, 1983 and Yule & Rutter, 1976), rests upon the premise that dyslexia is the result of deficits relatively specific to reading performance.

Numerous studies have reported a wide array of behavioral tasks which differentiate normal and disabled readers. While, individuals with reading disability have been proposed to suffer from various basic visual-perceptual (Williams, et al., 1990 and Lovegrove et al., 1990) and linguistic processing deficits (Vellutino, 1979; Bradley & Bryant, 1985; Liberman & Shankweiler, 1985; Stanovich, 1988; Wagner & Torgesen, 1987; and Catts, 1989), few attempts to provide a framework for incorporating visual-perceptual and linguistic deficits in individuals with reading disability have been proposed. Critical reviews of the visual-perceptual deficit hypothesis (Vellutino, 1979 and Stanovich, 1986, 1988) have resulted in the strong support for the existence of a core deficit of reading disability involving basic linguistic processing skills. These linguistic deficits include inferior performance on tasks of semantic (Vellutino & Scanlon, 1982), rapid naming (Wolf, 1984 and Felton, Wood, Brown, Campbell & Harter, 1987) and phonological processing abilities (Stanovich, 1988). Deficits in syntactic/grammatical processing (Mann, Shankweiler, & Smith, 1984), and short-term memory abilities (Torgesen, 1988) have also been suggested. Thus, deficits in visual-perceptual processing have been considered inconsequential to the reading process and confounding for the investigation of the mechanisms underlying specific reading disability.

One issue in the literature which has provided a great deal of controversy is that developmental dyslexia is related to some underlying central nervous system dysfunction. Several accounts of neural anatomical and physiological correlates or "markers" in individuals with reading disability have been reported. These include an abnormal development of the left hemisphere's language areas (Orton, 1928; Bakker, 1979; Geschwind & Galaburda, 1985; Hynd & Hynd, 1985; and Flowers et al., 1991), and the occipitotemporal (Harter, 1991), and occipitoparietal (Conners, 1990) visual processing systems. These neural deficits frequently result in abnormal hemispheric lateralization with a more symmetrical distribution for these brain areas. However, while reading disabled (RD) and non-reading disabled (NRD) individuals have been found to differ on a wide variety of cognitive and neural processing measures, attempts to identify the specific nature of the relationship between these two levels of description are lacking.

In summary, RD presents a serious problem for many children and adults. Our present understanding of the mechanisms underlying this disorder appears to have developed from two bodies of research involving neural and cognitive levels of analysis which have evolved relatively independently. Integration of these levels of analysis might lead to a better understanding of the factors underlying reading disability and the development of more effective procedures for bringing about reading improvement. Studies combining the two levels of analysis also may facilitate the earlier identification and remediation of the disorder. The present study investigated the relationship between two findings having important theoretical implications within the area of reading disability. These are the findings of abnormal hemispheric lateralization and slower rapid "automatized" naming in disabled as compared to normal readers. The present study also will further evaluate the hypothesis that RD is in part due to visual sensory deficits and/or linguistic processing deficits.

Abnormal Hemispheric Lateralization and RD

The history of dyslexia, as suggested by Critchley (1970), can be best understood within an "aphasiology context". While several mid 19th century accounts of reading disorders have been reported, Kussmaul in 1877 is usually credited with reporting the first specific case of "word blindness" in an acquired aphasic (Critchley, 1970). However, it was the French neurologist Jules Dejerine, who is credited with having been the first to report disorders in patients involving solely reading and writing (1891) or just reading (1892) and place the neural locus of these deficits in the posterior regions of the left hemisphere (Mayeux & Kandel, 1985).

One of the earliest models for understanding disorders of reading was presented as part of a much larger theory on language disorders (Bastian, 1897). This model suggested that the neural system for language involved several cortical centers in the left and right hemispheres. The areas thought to be involved included the occipital cortex, angular gyrus, supra-marginal lobe, upper temporal convolution (Wernicke's area), Broca's area, the premotor cortex and the connections among these structures. Bastian's model proposed that disorders of reading and writing were a result of a deficient connection among these brain structures. Bastian (1897) also proposed the existence of a relationship between handedness, the left-hemisphere dominance for language, and language disorders. It also was within this context that several subsequent theories of developmental dyslexia would propose strikingly similar neural deficits of developmental origin.

Approximately 30 years later, Orton (1928) proposed a model for dyslexia emphasizing the abnormal development of hemispheric dominance while de-emphasizing the absence of anatomical regions as being the neural correlates of reading disability. Orton (1928) posited that dyslexia was the result of the left hemisphere's inability to establish dominance for reading performance during development. In a more recent but similar model Bakker and colleagues (1979 & 1987) proposed that dyslexia is due to an untimely shift or overdependence of hemispheric subservience in reading. This theory, which has received little empirical support, proposed that the classification and remediation of reading disability subtypes can be understood according to their hemispheric dominance during reading. According to this theory, normal reading is initially a predominantly right hemisphere function relying heavily upon the visual-spatial parameters of words for recognition. Later in development, at approximately 8 years of age, reading becomes predominantly a left hemisphere process relying more upon the semantic and syntactic aspects of words in reading. An excessive or untimely over-reliance of either processing strategy results in a specific sub-type of reading disability (right hemisphere perceptual analysis of words, P-type; or the left-hemisphere reading strategy, L-type).

Another recent model of dyslexia which reflects an obvious influence of the earlier Bastian (1897) and Orton (1928) models has been posited by Geschwind and Galaburda (1985). This model of hemispheric lateralization proposes that the hemispheric asymmetries in the area of the planum temporale constitute the morphological correlate of the functional left cerebral dominance for linguistic processes. They propose that deviations in this left greater than right (L > R) hemispheric asymmetry of the planum temporale are related to deviations in the development of handedness, the immune system, and certain types of learning and developmental disabilities (dyslexia). They propose further that the normal development of this hemispheric lateralization is dependent in part upon the functional levels of prenatal testosterone. In the initial presentation of this hypothesis, developmental dyslexia was proported to be primarily due to an abnormal under-development of the left hemisphere's planum temporale (Geschwind & Galaburda, 1985). A more recent reformulation of this hypothesis proposes that a lack of neuronal cell death in the right hemisphere results in abnormal processing by the left hemisphere's language areas (Galaburda, 1988). This proposed developmental anomaly is believed to occur prenatally or very early postnatally, since 56% of fetuses show a greater left than right hemisphere planum temporal at 31 weeks gestation (Wada, Clarke, & Hamms, 1975 and Chi, Doolings and Gilles, 1977). While the theories emphasizing abnormal hemispheric asymmetry (i.e., greater symmetry) in RD are intriguing, the empirical support for the functional role of such deficits is tenuous and requires further verification.

Anatomical Studies of RD

Postmortem and Cytoarchitectonic Studies of RD. The search for anatomical markers of developmental reading disability consist mainly of two bodies of research, one of which relies heavily upon postmortem cytoarchitectonic investigations and the other on in-vivo brain imaging (CT/MRI) techniques. The postmortem examination of dyslexic brains provides excellent information about the cortical cell architecture (cytoarchitectonic) and the gross morphological characteristics of the brain. At present, postmortem examinations from eight dyslexic brains have been reported, cytoarchitectonic data being available in only seven of these subjects. The cytological data from these five male and two female subjects revealed numerous neocortical lesions (range 30-150; Galaburda & Kemper, 1978, Galaburda, Sherman, Rosen, Aboitiz, & Geschwind, 1985 and Humphrey, Kaufman & Galaburda, 1990). This number is surprisingly large when in a comparison group of ten non-reading disabled subjects a total of only 4 lesions distributed in only three of the subjects were present (Kaufman & Galaburda, 1989). The distribution of the neo-cortical lesions among the dyslexic subjects was greatest in the temporal-parietal regions and more prevalent in the left than right hemisphere. This finding of a greater occurrence of cortical lesions in the left hemisphere, particularly in the perisylvian area, supports the abnormal left hemisphere hypothesis as posited by Geschwind and Galaburda (1985). In contrast however, a high prevalence of lesions was also observed in the frontal lobes. A finding less congruous with present neural-linguistic models of RD which have emphasized deficits confined to the parietal and temporal brain regions of the left hemisphere (Galaburda, 1988).

A macroscopic examination of the brain morphology in these seven developmentally reading disabled subjects revealed deviations in cerebral asymmetry primarily affecting the perisylvian regions of the left hemisphere. The planum temporale was used as an index of the lateralization of the temporal-parietal region, because it provides a relatively large neural landmark, typically reveals a striking large hemispheric asymmetry, and it provides an excellent demarcation for several cortical areas presumed to play an important role in normal reading and language functioning. In non-reading disabled subjects the planum temporale has been reported to be larger in the left hemisphere approximately 66% of the time (Geschwind & Levitski, 1968; Wada, Clarke, & Hamm, 1975; Galaburda, Sanides & Geschwind, 1978; and Galaburda, LeMay, Kemper & Geschwind, 1978). In the seven developmentally reading disabled subjects examined every subject showed a symmetrical distribution of the planum temporale. As a result of these findings planum symmetry has been identified as one of the anatomical accompaniments of the dyslexic syndrome (Galaburda, 1988). The findings from these postmortem examinations however, must be considered at best preliminary due to the relatively small number of subjects, a poor documentation of reading and intellectual ability, and a failure to screen subjects for co-occuring clinical diagnoses such as attentional deficit disorder (Hynd & Semrud-Clikeman, 1989).

CT and MRI Studies of RD. Both computerized tomography (CT) and magnetic resonance imagery (MRI) are two imaging techniques which provide structural information about the in-vivo brain, with the MRI procedure providing better anatomical resolution. The findings from the CT/MRI research, while possessing less structural resolution about the brain than the postmortem studies, have provided information based on a substantially larger number of dyslexic and control subjects. In these studies the CT/MRI scans of dyslexic brains were evaluated for structural abnormalities and deviations in hemispheric asymmetry. Typically these measures were reported only in reference to the parietal-temporal areas of the brain. The most consistent CT/MRI finding which differentiates dyslexic from non-dyslexic subjects has been a significantly greater degree of abnormal posterior asymmetry in the dyslexic individuals. In non-dyslexic subjects a L > R hemispheric asymmetry of the planum temporale has been reported in approximately 66% of the subjects, a reversed asymmetry (R > L) and symmetry (L = R) having been found in 10% and 25%, respectively (Geschwind & Levitski, 1968; Wada, Clarke, & Hamm, 1975; Galaburda, Sanides & Geschwind, 1978; and Galaburda, LeMay, Kemper & Geschwind, 1978). In contrast, the "normal" L > R posterior hemispheric asymmetry has been observed in approximately 22% of dyslexic individuals, reversed asymmetry and symmetry having been observed in 20% and 58%, respectively (Hier, LeMay, Rosenberger, Perlo, 1978; Haslam, Dalby, Johns & Rademaker, 1981; and Rumsey, Dorwart, Vermess, Denckla, Kruesi & Rapoport, 1986). Thus, it is evident that an abnormal hemispheric distribution in the posterior brain regions is neither necessary nor sufficient for the presence of dyslexia.

It should be noted that only one study has shown evidence of frank brain injury in the scans of dyslexic subjects. This study found gross pathology in 5 of the 25 dyslexic brain scans. However, the examinations were limited to analysis of the ventricles. Also, it reported an inter-rater reliability of only 48% which is of questionable adequacy (Denckla et al., 1985). In summary, these anatomical studies support the view that dyslexia is more a result of developmental pathogenesis than a direct result of physical brain injury. It also appears that despite several methodological inadequacies for which some CT/MRI studies have been criticized (e.g., a lack of inter-rater reliability scores for anatomical assessments, inaccurate determination of morphological landmarks and inadequate diagnostic criteria for subject classification), the similarities among the findings derived from these two techniques (CT/MRI) with the postmortem data are striking (Hynd & Semrud-Clikeman, 1989).

Unfortunately, few attempts to relate the anatomical differences between RD and NRD subjects have been completed. Rosenberger & Hier (1979) provided the first investigation of the relationship between the degree of parietal-temporal asymmetry and intellectual performance in two groups of subjects differing in reading ability. They found that the degree of discrepancy between verbal (VIQ) and performance (PIQ) measures of intelligence on the Wechsler Intelligences Test were inversely related to the degree of L > R planum asymmetry. Unfortunately, a discrepancy in intellectual performance, such that PIQ>VIQ was one of the selection parameters for identifying the reading disabled subjects. Thus, it is not surprising that the degree of planum asymmetry, a measure shown to statistically differentiate the reading groups, also was correlated with VIQ and PIQ discrepancies in these same subjects. However, subsequent attempts to identify a relationship between measures of verbal intelligence and posterior cerebral size have been unsuccessful (Haslam et al., 1981). In a more recent study, Hynd and colleagues (Hynd et al., 1991), examined the neural anatomical differences in several areas of the brain using MRI technology in 11 to 13 year old boys with or without a learning disability (reading disability-RD or attention deficit disorder-ADD). Analyses of the MRI scans failed to differentiate between the groups according to total brain area, although subjects with a learning disability (LD) as compared to those without a learning disability (NLD), did possess significantly smaller right hemisphere anterior width measurements. The MRI scans also indicated that the RD group, as compared to the other groups, had bilaterally smaller insular regions and a smaller left hemisphere planum temporale length. While, ninety per cent of the dyslexic children had either reversed (L < R) or symmetrical (L = R) planum lengths, only 30% of the non-reading disabled subjects failed to show a L > R hemisphere asymmetry in planum length.

Semrud-Clikeman, Hynd, Novey, and Eliopulos (1990) examined the relationship among the MRI scans of ten reading disabled, ten attention deficit disorder/hyperactivity and ten normal control children and several neuropsychological and achievement measures. Behaviorally the RD group performed significantly worse on a battery of rapid naming, phonological and word comprehension measures. Regardless of group membership, subjects with a reversed frontal width asymmetry (L > R) performed significantly worse on tasks of word attack and rapid automatized naming. The data also showed a trend indicating that subjects with smaller insular regions and/or a lack of the normal L > R planum temporale perform more poorly on measures of confrontational and rapid automatized naming.

Physiological Studies of RD

The functional brain activity of dyslexics has been measured using regional cerebral blood flow (RCBF), positron emission tomography (PET) and event-related potentials (ERPs) methodologies. The RCBF and PET imaging techniques provide a functional measure of the brain's activity over several seconds to minutes with spatial resolution on the order of millimeters. In contrast, ERPs measure the functional aspects of the brain over milliseconds with spatial resolution on the order of centimeters. These functional measures of brain activity have the potential to provide unique insight into assessing the relationship between the cognitive and neural deficits associated with reading disability. Unfortunately, the majority of the functional imaging techniques have been applied on a relatively small number of dyslexic individuals during a numerous array of behavioral tasks.

RCBF and PET Studies of RD. The findings from studies utilizing the RCBF and PET methodologies support neural-linguistic models which propose that reading disabled individuals, as compared to normal readers have neural deficits, as indicated by reduced neural activity, in the temporal and parietal brain regions. Unfortunately, these studies have been less consistent regarding the lateralized nature of these functional differences. Specifically, RCBF measures have shown that RD subjects, compared to NRD subjects, have larger L > R posterior brain asymmetry during a semantic classification task (Rumsey, et. al., 1987; and Rumsey & Hamburger, 1990); a bilateral decrease in posterior blood flow activity during a reading task (Hynd et al., 1987); and a decrease in activation in the left superior temporal brain area during an auditory orthographic analysis task in adults classified as poor readers in childhood (Flowers, Wood & Naylor, 1991). Utilizing the PET methodology to investigate the neural mechanisms underlying dyslexia, Gross-Glenn and colleagues (1990) recorded the uptake of 2-deoxyglucose during a reading task in eight normal and six dyslexic readers and revealed several regions of activity which differentiated the groups. Dyslexics had lower metabolic rates in the peri-insular cortex and less asymmetric activation of the frontal lobes during reading. In the mid-temporal and lingual areas the dyslexics showed greater metabolic activity. It should be noted that only the Flowers et al. (1991) study reported data from a sufficiently large sample (n=152) of normal and reading disabled individuals while the other studies recorded from significantly smaller samples (n=4-30 subjects).

ERP Studies of RD. Physiological investigations using event-related potentials (ERPs), while sacrificing spatial resolution to the RCBF and PET methodologies, offer distinct advantages over these techniques and other electrophysiological methodologies. ERPs enable the separate identification and comparison of brain activity to relevant and irrelevant task demands within the same experiment. Group and individual differences may then be examined across several task parameters within a given experiment.

Investigators have used two general approaches in the ERP studies of reading disability (Ollo & Squires, 1986). In the first type, stimuli are presented to the subject and no behavioral response is required. In the second type, stimuli are presented and the subject is required to actively process some parameter of the stimulus (e.g., size, color, and/or meaning) by making an overt response. This latter technique (active task) provides analysis of behavioral responses (e.g., speed and accuracy) and better control of subject state variables (e.g., arousal). In contrast, the prior approach (passive task) allows electrophysiological measures to be collected from subject populations where traditional behavioral responses are more difficult to obtain (e.g., newborns). Duffy and colleagues (Duffy, Denckla, Bartels & Sandini, 1980) examined active and passive task conditions for differentiating reading disabled and non-reading disabled individuals using electrophysiological measures. They found that although, group differences were observed over prefrontal and left temporal-parietal regions during passive task recordings (e.g., at rest), these differences were more prominent during the active task conditions (e.g., auditory word recognition).

Several electrophysiological investigations of reading disability using the active task approach have presented relatively simple stimuli. Connors (1971) in one of the initial electrophysiological investigations of reading disability required subjects to respond manually to bright as compared to dim light flashes. While, behaviorally the reading disabled subjects performed the task without difficulty, the electrophysiological measures showed an attenuation over the left parietal region in the initial 140 to 200 msec (post-stimulus) of the waveform. In an attempt to extend the investigation by Connors (1971) within a developmental framework, Sobotka and May (1977) failed to replicate the earlier findings. They found larger not smaller amplitude for the same measures reported by Connors, in reading disabled as compared to non-reading disabled subjects. While, differences in subject selection procedures could account for these discrepant findings, procedural differences in quantifying the electrophysiological measures also provides a plausible explanation (Sobotka & May, 1977). Sobotka and May (1977) measured the electrophysiological waveform as a difference in amplitude between two successive peaks (peak to peak), while the Connors study measured amplitude from peak to baseline. More recently, in apparent support of the findings reported by Connors, reading disabled as compared to non-reading disabled subjects have been reported to show a longer latency and smaller amplitude positive component occurring 100 msec post-stimulus, in response to contrast-reversal checkerboard stimuli (Solan et al., 1990; and Livingstone et al., 1991).

The active, as compared to the passive task approach also provides the opportunity for recording electrophysiological measures to more complex stimuli which can be theoretically linked to the disorder under investigation. Preston and colleagues examined whether ERP measures collected during a visual word recognition task, as compared to a visual flash task, would provide differential indicants of reading disability (Preston Guthrie, Kirsch, Gertman, & Childs; 1977). They found that while, ERP measures collected during either task failed to significantly differentiate the reading groups, the difference in ERP measures across the two tasks provided such an indicator. The ERP amplitude recorded for a positivity at 200 and 250 to 550 msec post-stimulus over the left parietal region was significantly larger during the word recognition than visual flash task for the non-reading disabled group. In the disabled readers this task difference failed to reach significance. In a similar comparison between symbol versus word processing, groups of reading disabled (RD) and attention deficit disorder subjects (ADD), as compared to a group of non-learning disabled (NLD) subjects, showed smaller P3 amplitude (Holcomb, Ackerman, & Dykman, 1985). The reading disabled group however, showed smaller P3 and Pc component amplitudes to task irrelevant words as compared to task irrelevant symbols, while non-reading disabled subjects (ADD and NLD groups) had equivalent values. These findings support the hypothesis that ERP tasks involving theoretically related, as compared to unrelated, processes with the disorder under investigation will provide the more prominent ERP indicants of the disorder. One further study examined ERP indicants of reading disability using visually presented words (Symann-Louett, Gascon, Matsumiya, & Lombroso, 1977). In this study, reading disabled, as compared to non-reading disabled subjects showed electrophysiological differences over the left parietal regions in response to the words. Unfortunately, the electrophysiological measures (number of deflections in the waveform) evaluated in this study are inconsistent with other quantification techniques and therefore difficult to synthesize with other the research in this area.

Several methodological inadequacies for which some of the early ERP studies on reading disability have been criticized include: poor subject selection procedures; an inadequate number or placement of electrodes; poor control of subject state variables; and inconsistent electrophysiological quantification procedures (Hughes, 1985; and Ollo & Squires, 1986). Despite the methodological inconsistencies among many of these studies, these findings contribute to the general conclusion that individuals with dyslexia possess multiple neural deficits. These deficits are manifested in the ERP waveform as reductions in amplitude frequently occurring within the initial 200 msec after stimulus presentation and in a late positive and/or P3 component. These neural differences also appear more prominent over the left temporal-parietal brain region and during theoretically relevant tasks which require the subjects active performance.

Implementation of the active as compared to the passive recording approach provides the opportunity to examine task performance which is considered theoretically relevant to the disorder or cognitive process under investigation. Recall, that ERPs enable the separate identification and comparison of brain activity to relevant and irrelevant task demands within the same experiment. Group and individual differences may then be examined across several task parameters within a given experiment. Thus, a task can be designed to investigate the selective neural processes of a stimulus parameter when it is considered relevant versus irrelevant. If the task is selected to relate to a specific cognitive process, an appropriately selected "functional" component associated solely with that process may be assumed to reflect the corresponding neurophysiological processes underlying it (Harter, 1991).

Harter and colleagues provided the initial systematic implementation of functional ERP component analysis for investigating the neurophysiological processes underlying reading disability. They recorded ERPs during visually presented tasks designed to investigate the selective neural processing underlying black/white discrimination, letter and phonological recognition, and letter matching abilities in subjects differing in reading ability. Selective neural processes were assessed through an analysis of the topographical distribution and latency changes of an early selection negativity (SN) wave occurring over a period of 180-

260 msec, and an enhanced positivity spanning 300-500 msec (P3) after a centrally presented visual stimulus (Harter, 1991). The results indicated that poor readers compared to normal readers elicit (1) smaller ERPs, as early as 80-120 msec (P1 component) after stimulus presentation (Miller & Harter, 1990 and 1991; and Harter, 1991); (2) show a reduction in negativity (SN) which interacts with task relevance (Harter, Anllo-Vento, Wood, & Schroeder, 1988; Miller & Harter, 1990 and 1991; and Felton & Miller, 1990); and (3) exhibit a reduction in positivity at 300-500 msec (P3) followed by a reduction in negativity at 600-700 msec after stimulus presentation which interacted with task relevance and hemispheric activity (Harter, 1988; Harter, Anllo-Vento, Wood & Schroeder, 1988; Harter, Anllo-Vento & Wood, 1989; Miller & Harter, 1991; and Felton & Miller, 1990). These electrophysiological correlates (#2 and #3) of RD have also been shown to be longitudinally stable, being observed as early as the third grade and which persist into adulthood (Naylor, 1987, Felton & Miller, 1990 and Miller & Harter, 1991 and Anllo-Vento, Miller & Harter, 1990). These findings suggest that there is either reduced or differential neural processing of centrally presented visual information in individuals with a reading disability. This reduction is greater over the left than over the right temporal-parietal region and represents the selection of task relevance regardless of the stimulus parameter being evaluated.

In contrast, on a spatial orienting task, RD subjects did not show a general reduction in ERP amplitude (Harter, 1991 and Harter, Anllo-Vento and Wood, 1989). In this task subjects were required to respond to a target presented eight degrees peripherally, provided its location had been validly cued by a central arrow 600 msec earlier. While the P1 and N1 components to the centrally presented arrow (cue) were reduced in the RD group, these components were enhanced in this same group following a validly cued peripherally presented target (Harter, Anllo-Vento and Wood, 1988 and Harter, 1991). Harter (1991) interpreted these findings along with other neurophysiological and psychophysiological data as indicating that RD subjects are deficient in one or more levels of their occipitotemporal "what" visual processing system but possess either normal or superior occipitoparietal "where" visual processing abilities. Harter further proposed that these "what" visual system deficits persist at both early sensory and later cognitive processing levels in RD. The bilateral reductions in amplitude of the early ERP (P1 and SN) components reflect early sensory deficits whereas reductions in the later ERP components (P3), which are greater over the left hemisphere, reflect later cognitive deficits. These information processing deficits are particularly evident when the selection of a stimulus parameter in the central visual field is required (Harter, 1991).

Visual Perceptual or Verbal Deficits in Reading Disability

Visual Perceptual Deficits and RD

The observation of visual perceptual deficits in individuals with RD is not new to the RD literature. In fact, Orton (1928) drew specific attention to the frequently observed letter reversal and sequencing errors, in positing a theory of incomplete hemispheric dominance in individuals possessing reading disability. Numerous subsequent studies have reported a wide array of visual anomalies and reading skill relationships (for a review see Simons and Glasser, 1988). The perceptual deficit hypothesis however, has been criticized on theoretical and methodological grounds. This criticism typified by Vellutino, (1979) has been in large part, due to the previous failure of perceptual remediation techniques on individuals with reading disability. Vellutino (1979), proposed that an inefficiency in a verbal and not a perceptual mechanism best characterized the processing deficits underlying reading disability.

More recently however, Williams and colleagues have reported findings that a perceptual remediation technique (image blurring) can provide a re-establishment of the normal temporal processing of words in disabled readers (Williams, Molinet & Lecluyse, 1989 and Williams, & Lecluyse, 1990). This finding undermining the first criticism put forth by Vellutino (1979), has resulted in a resurgence of interest in visual anomalies and specific reading ability. It has been suggested that visual processing is accomplished by at least two separate but highly interactive visual systems with distinct anatomical and physiological channels (Ungerleider & Mishkin, 1982). These two visual subsystems have different spatiotemporal characteristics. One referred to as a "transient" channel responds maximally to low spatial frequencies or stimuli of a short duration and a second "sustained" channel which responds maximally to high spatial frequency or more sustained visual information. While, the interaction of these channels in visual perception is not disputed, the clinical implications of their isolated impairment has been extensively reviewed (Bassi & Lehmkuhle, 1990). Individuals with reading disability have demonstrated inferior performance on tasks involving the transient system and normal performance on tasks where the sustained channel is featured (Lovegrove, Bowling, Badcock, & Blackwood, 1980; Badcock & Lovegrove, 1981; Slaghinus & Lovegrove, 1984; Williams & Lecluyse, 1990 and Lovegrove, Garzia, & Nicholson, 1990).

The visually evoked P100 component has been proposed to reflect activity in the transient visual processing system (Previc, 1988). The P100 component has also been shown to differentiate reading and non-reading disabled individuals (Solan, et al., 1990, Harter, 1991 and Miller & Harter, 1991). Furthermore, Livingstone and colleagues have demonstrated that reading group differences in P100 activity, demonstrating longer P100 latencies in the reading disabled group, were specific to low spatial frequency contrasts. Reading group differences were not present at contrasts of higher spatial frequencies (Livingstone et al., In press). These findings are consistent with the hypothesis that individuals possessing a reading disability demonstrate a transient visual system deficit and that the P100 component can provide a neural index of this deficit. Harter, (1990) interpreted a decrease in P100 amplitude, observed in reading as compared to non-reading disabled individuals, to reflect a sensory processing deficit. Later differences in ERP measures, recorded 200 msec or later after stimulus presentation, were considered to reflect later cognitive (non-sensory) deficits. One criticism of the Harter (1991) hypothesis, however was that all the stimuli used in the ERP experiments consisted of stimuli associated with verbal labels (arrows, letters, etc.). Therefore, early reductions in the ERP waveforms to these stimuli, rather than reflecting general sensory deficits, may be indicative of deficits specific to the processing of verbal information. Unfortunately, few studies have examined the influence of conceptual processes on the P100 measure.

Verbal Deficits and RD

Numerous theories of reading disability posit a deficit in phonological processing as the fundamental cause in reading disability (Bradley & Bryant, 1985; Stanovich, 1986 & 1988; Vellutino, 1979; Liberman & Shankweiler, 1985; Wagner & Torgesen, 1987; and Catts, 1989). Wagner & Torgesen (1987) in a critical review of the literature involving phonological processing and reading acquisition have proposed that the phonological deficit hypothesis developed in three relatively independent bodies of research: phonological awareness, phonetic recoding in working memory, and phonological recoding in lexical access. While, some more recent research has supported the independence of these three classes of phonological processes (Felton & Brown, 1990), other findings have shown that performance on measures of phonological awareness appears to be a function of the relative proficiency of phonological processing in working memory (Wagner et al., 1987). There is however, general agreement that phonological recoding in working memory is relatively independent of other measures of phonological processes and general intelligence. One of the major paradigms utilized to assess phonological recoding in lexical access in poor or disabled readers is the Rapid "Automatized" Naming (RAN) tasks developed by Denckla & Rudel, (1976). The RAN tasks, consist of assessing the latency and number of errors observed during a continuous rapid naming procedure.

Disorders of naming and reading disability share a common historical lineage; both having been borne out of the aphasiology literature. Behavioral examination of patients with acquired aphasia frequently display deficits in either naming and reading or both. The deficits are frequently the result of posterior temporal lesions of the left hemisphere, although one case of a surgical lesion in the left frontal hemisphere accompanying a naming deficit for digits has been reported (Anderson, Damasio & Damasio, 1990). Denckla (1972) was the first researcher to empirically investigate the naming ability of children with developmental reading disability. As noted above, Denckla and her colleagues (Denckla & Rudel, 1976) used a procedure termed rapid "automatized" naming (RAN). In this procedure 5 stimulus items within one of four categories (letters, numbers, objects or colors) are randomly ordered to comprise 10 consecutive sets. The subjects rapidly name all 50 stimuli consecutively while oral latency and error measures are recorded. They found that RAN latency and not errors differentiated dyslexic readers from non-dyslexic readers with and without learning disabilities (Denckla & Rudel, 1976).

Subsequently, numerous investigators have reported slower naming fluency among the reading disabled using the RAN procedure.

RAN latency provides a useful behavioral measure for investigating differences in reading ability. RAN latency has been shown to account for unique variance in reading performance even after statistically controlling for individual differences with respect to age, intelligence (Felton & Brown , 1991), short term memory (Bower, Steffy, & Swanson, 1986 and Bower, Steffy & Tate, 1988), phonemic awareness, and/or phonetic recoding in working memory (Blachman, 1984; Wagner et al., 1987 and Felton & Brown, 1990).

The predictive relationship between the naming speed of the different RAN categories (colors, objects, numbers, letters) and reading ability appears to depend in part upon the age of the subjects. In kindergarten and early first grade performance on all the categories of RAN stimuli (colors, objects, letters and numbers) significantly predict reading performance in second (Wolf, Bally & Morris, 1986) and third grade (Felton & Brown, 1991). However, by the end of first grade the RAN stimulus categories (letters and numbers), which have become or are in the process of becoming "automatized" (Stanovich, Cunningham & West, 1983 and Wolf, et. al., 1986), are more strongly related to reading ability than performance on RAN colors or objects (Spring, 1976; Wolf, 1984; Stanovich, Feeman & Cunningham, 1983; Blachman, 1984; Wolf, et. al., 1986; and Felton & Brown, 1991).

In contrast to the RAN findings, researchers utilizing discrete trial naming tasks have not found reliable naming fluency and reading ability relationships (Perfetti, Finger, & Hogaboom, 1978; Stanovich, 1981; Stanovich, Feeman, & Cunningham, 1983; and Stanovich, 1988).

Stanovich (1983) suggests that the continuous performance demands of the RAN task inflates any lexical access differences among reading groups, because it includes several other cognitive processes (attention, short-term memory etc). It should be emphasized that while the single trial latencies for naming provide a much cleaner design for examining lexical access speed than the implementation of the discrete trial design, has been that it's use on relatively small groups of children at or above grade level for reading. In an attempt to address the apparent discrepant findings between discrete and rapid naming measures and reading disability, Wolf (In Press) proposes that the specificity of naming deficits on measures of rapid naming reflect deficient temporal processing mechanisms. A temporal processing deficit hypothesis has also been proposed to explain why the more highly automatized (letters and numbers) information demonstrates the more robust reading group differences. The less automatized symbols (colors and objects) should make less demands on this mechanism and thus fail to differentiate the reading groups. Thus, a temporal processing deficit has been advocated by researchers using tasks examining visual perceptual integrity (Lovegrove et al., 1990 and Williams and Lecluyse, 1990) and linguistic performance (Wolf, In Press).

Unfortunately, few researchers have attempted to more specifically examine the levels of interaction between linguistic and perceptual discrimination performance. The present study consists of an analysis of the brain processes evoked during a discrete trial black/white discrimination task of letter and non-letter patterns. Performance on this task has been previously shown to be highly correlated with RAN task performance in reading and non-reading disabled individuals (Miller & Harter, 1991).

Pilot Study

In an attempt to identify the specificity of visual processing deficits in reading disability, Miller & Harter (1991) examined the longitudinal changes in the neural-behavioral processing abilities of a group of 9 male reading disabled (RD) and 10 male non-reading disabled (NRD) subjects. These subjects were investigated with a battery of cognitive, neuropsychological and electrophysiological measures at two stages of development (average of 10.7 years old and again five years later). ERPs were recorded during a black/white discrimination task involving the discrete presentation of letter and non-letter stimuli. The discrete method of presentation allows for the separate analysis of behavioral data (hits, false alarms and reaction times) and ERPs to letter and non-letter stimuli during a simple black versus white discrimination task. It was hypothesized that if reading disability is due to deficits in visual processing, then these deficits should be present regardless of the stimulus type during a black/white discrimination task. If these deficits instead represent deficits in the language processing then group differences should be specific to the black/white discrimination of letters but not non-letter stimuli.

The results from the pilot study (Miller & Harter, 1991) showed that task performance during the black/white discrimination task was significantly facilitated by the letter as compared to the non-letter stimuli for both reading groups. Task accuracy regardless of stimulus type was significantly correlated with performance on a rapid naming of letters or numbers task (RANL & RANN, respectively). Performance on these rapid naming tasks significantly differentiated the reading groups, with poorer readers performing the task more slowly. Statistical comparisons of the reading groups on the electrophysiological recordings evoked during the black/white discrimination task showed several interesting findings. A reduction of the early ERP components at 80-120 (P1) and 200-220 ms (N1) over the occipital cortex was observed in the RD as compared to NRD group. These early effects interacted with stimulus type (letter vs. non-letter pattern), although the N1 effect was present only at the follow-up investigation. Upon further analysis, the RD group showed significant reductions in several later ERP components at 300-340 ms (P320), 400-440 ms (P420) and 600-700 ms (N700) after stimulus presentation as a function of the type of stimulus being evaluated and the recording hemisphere during the black/white discrimination task. Regardless of reading group membership, the amplitude of the hemispheric difference of the component P420 to letter stimuli was significantly correlated with ERP task accuracy and performance on the rapid naming of letters and digits at both periods of evaluation. A similar relationship for the evoked potentials to non-letter stimuli did not reach statistical significance. Results from this study were interpreted as supporting a theoretical model positing that RD is not solely due to a left posterior hemisphere deficit. Instead, RD appears to be associated with neural deficits at multiple levels of visual processing: first, at an early cortical stage, as reflected by P1 and N1; and second, at a later stage as reflected by P320, P420 and N700 indicants of the differential hemispheric activation of association cortex by letters but not by non-letter patterns. The results from this study, furthermore question a more fundamental assumption that visual information processing at some level can be or should be considered independent of the type of information to be processed. This pilot study, while providing interesting results, possessed a relatively small number of subjects and the participation in the study occurred relatively late in reading acquisition and therefore these results may represent an effect of reading disability and not a cause. A major objective of the present investigation was to assess the generalizability of the results obtained in the pilot study to first grade children just beginning the reading process.

Study Rationale and Hypotheses

Hemispheric Lateralization and Reading Ability

In summary, several neural-linguistic models of dyslexia have emphasized abnormal left hemispheric processing as a neural "marker" of dyslexia. Consistent with these models, the findings from the anatomical investigations of dyslexia suggest that small cytoarchitectonic anomalies and deviations in topography and not large structural abnormalities characterize the brains of dyslexic individuals. The most striking and consistent anatomical and physiological finding is a lack of the normal L > R asymmetry in the posterior brain regions (peri-insular and planum temporale) of dyslexics (Hynd & Semrud-Clikeman, 1989).

Neurophysiological measures have indicated that this finding may be associated with reduced neural activity in the left temporal and parietal regions (Flowers et al., 1991, Harter, 1988; Harter, Anllo-Vento, Wood & Schroeder, 1988; Harter, Anllo-Vento & Wood, 1989; Miller & Harter, 1991; and Felton & Miller, 1990).

It is evident from the estimated frequency of dyslexia (4-6%) and abnormal hemispheric distributions in the posterior brain regions of reading disabled (75%) and non-reading disabled individuals (35%), that the absence of posterior hemispheric asymmetry (L > R) is neither necessary nor sufficient for the presence of dyslexia. Neuro-developmental theories (Geschwind & Galaburda, 1985; and Galaburda, 1988) and postmortem anatomical findings (Wada, Clarke, & Hamms, 1975 and Chi, Doolings and Gilles, 1977) support the development of these posterior brain regions at or near birth. Unfortunately, due to the invasive nature of most brain-imaging techniques direct evidence regarding neural lateralization in individuals early in or before reading experience has not been available. Thus, the important issue of whether abnormal hemispheric lateralization provides a neural marker for the underlying cause of or a consequence of severe reading disability has not been adequately determined.

The primary purpose of this study was to establish whether brain activity recorded in first grade can differentiate children according to their third grade reading performance. Based on the vast literature describing the presence of posterior brain asymmetries at or before birth and a lack of normal (L > R) hemispheric asymmetry in the dyslexic population, it was hypothesized that a reading disabled, as compared to non-reading disabled group of first grade children would demonstrate a more symmetrical hemispheric distribution over the posterior brain regions. It was further hypothesized that these differences would be the result of reduced neural activity over the left than over the right hemisphere and would be present as early as the first grade.

Sensory Deficits and RD

The bilateral and/or left hemisphere structural differences which have been observed in the posterior brain regions of dyslexics, as compared to normal readers, appear to be related to reductions in the processing activity of these areas. These deficits appear to differ according to the type of information presented and the task requirements. While the specificity of the behavioral deficits have been the focus of the cognitive literature on dyslexia, similar investigations utilizing neural-imaging techniques have been much more limited. As the result of a series of ERP investigations of RD, Harter (1991) has reopened the possibility that visual perceptual deficits may characterize some of the deficits involved in reading disability. The major foundation of Harter's visual perceptual deficit hypothesis rests upon an observed reduction in amplitude of early (80-120 msec) "sensory" ERP components. Unfortunately, these differences in neural activity were recorded in response to stimuli possessing verbal labels (arrows and letters) in RD as compared to NRD children. It is plausible, that these differences represent a deficit in conceptual (verbal) and not basic visual processing.

In a preliminary investigation of the stimulus specificity of the visual deficit hypothesis, Miller and Harter (1991), recorded ERPs during a black/white discrimination task of letter and non-letter stimuli in RD and NRD subjects. The electrophysiological findings from this study indicated that the RD group showed longitudinally stable reductions in amplitude and hemispheric activation as a function of stimulus type. These differences were greater over the left than over the right hemisphere and for letter than for non-letter stimuli, supporting the hypothesis that reading disabled individuals possess neural deficits specific to the processing of verbally mediated information. Complementary to these findings, task performance during the black/white discrimination task failed to significantly differentiate the reading groups. Performance for both groups however, was significantly facilitated by the letter stimuli, suggesting an early interaction of semantic processing (stimulus meaning) on a basic visual process (black/white discrimination). Thus, a more detailed investigation was required for adequately interpreting this interaction.

A major purpose of the present investigation was to examine if the previous findings in our laboratory (Miller & Harter, 1991) could be generalized to first grade children. Another closely related purpose was to more precisely determine the level of interaction between stimulus type and black/white discrimination performance. It was hypothesized that the visual processing deficits frequently observed in RD are not due to general deficits in sensory processing but to deficits specific to the processing of verbal information. The brain activity recorded to two stimulus types (letters vs. non-letter patterns) presented during a black/white discrimination task was predicted to provide differential indicants of reading ability, neural deficits being observed in the RD group in response to the black/white discrimination of letters but not of non-letter patterns. It was further hypothesized that the influence of stimulus type on black/white discrimination performance, as indicated in the electrophysiological waveform, would occur at or before the observation of reading group differences.

CHAPTER II

METHOD

Subjects

The subjects included in this study consist of two groups of children, a sample selected in kindergarten as being "at-risk" for later reading difficulties and a stratified random sample of first grade children. These two groups of subjects were selected to represent a wide range of reading, rapid naming and intellectual performance.

"AT-RISK" Sample

The subjects selected for being "at-risk" for later reading problems were selectively screened from the total population (n=991) of kindergarten children in the North Carolina Winston-Salem/Forsyth County school system. The children were screened in the spring of their kindergarten year and all had been exposed to the Writing to Read program developed by IBM, but had not yet been taught using basal readers. Screening procedures, as reported by Felton and Brown (1990) were as follows:

1. Using a 5 point Likert scale, classroom teachers of these children rated them on several variables, including predicted ability to master basic reading skills.
2. Approximately one week after rating the children, teachers administered the Otis-Lennon Mental Abilities Test to their classes. At about the same time, the school system

administered the Metropolitan Reading Readiness Test to all kindergartners and we obtained these scores as well.

3. In order to obtain our at-risk sample, any child who

a) was rated as above-average to superior in potential for success in reading, or

b) had an IQ of below 80 on the Otis-Lennon was not considered for further evaluation.Thus, all children who might potentially be classified as mentally handicapped and those who were judged unlikely to have difficulty in reading were removed from the study, leaving a total of N = 469.

4. Parents of these children were sent letters inviting participation in the study, and 395 responses (84%) were received, all granting approval for participation. Of this number, 365 children were available at the time of testing in late spring of the kindergarten year. These children were evaluated individually with a battery of research instruments (described in Appendix C) in sessions lasting approximately one hour.

5. Children were designated as at risk based on their scores on the research tests administered. Thus, scores from the Metropolitan Reading Readiness Test were not considered in the inclusion criteria. Any child who obtained a score of one standard deviation below the group mean for this sample, and/or who was in the bottom 16th percentile on at least three of the research tests administered was considered to be

potentially at risk for reading disability. These criteria are conservative in that they were applied to a group which had already been restricted by removing from the sample children with low IQ and those rated as above average in potential reading ability. Names of those children who met the inclusion criteria were submitted to the principals of the various schools for approval as being appropriate subjects for a longitudinal study. Criteria for removal included:

a) retention in kindergarten for the following year.

b) family situation such that parental cooperation was expected to be poor.

c) strong possibility of the family moving within the next two years. (pages 43-44)

This procedure yielded a sample of 103 children, of whom 15 moved out of the school system, and two of whom refused further participation. An additional 5 subjects were not available for testing at the end of the first grade, thus leaving a sample of 81 children (51 males and 30 females) with a mean age of 6.2 years. Of this initial group, 62 subjects completed the ERP task during their first and third grade years. The 62 subjects in the "At-Risk" sample were comprised of 23 females and 39 males with a mean age of 6.53 years (range of 5.90 to 7.60 years). The neuropsychological and reading achievement performance for these children has been reported elsewhere (see Brown & Felton, 1990, Felton & Brown, 1990 and Felton & Brown, 1991).

Stratified Random Sample

A random sample of 800 children were selected from the total number (n=3,011) of first grade children in the Forsyth Winston-Salem/Forsyth County school system. Permission to participate in the study was obtained from 485 of these children and their parents or legal guardians. From this sample of 485 first graders, a stratified random sample of 100 subjects were selected for participation in the present investigation. Subjects were stratified on the Peabody Picture Vocabulary Test-Revised Edition (PPVT) and by gender, with a frequency in each standard deviation band proportionally equivalent to the frequencies present in the larger randomly selected distribution (n=485). Of this smaller (n=100) sample 96 children participated in the study, with 4 subjects declining to participate. In this smaller sample, 74 subjects had successfully completed the ERP task while in the first grade and the behavioral testing both in the first and third grades. The 74 subjects in this random sample were comprised of 32 female and 42 male first grade participants with a mean age of 7.17 years (range 6.33 to 8.00 years). The database for the current project was comprised of the first grade electrophysiological (ERP) and the first and third grade behavioral performance measures derived of these 74 subjects. The neuropsychological and reading achievement performance for the larger sample (n=485) has been reported elsewhere (Felton & Wood, 1989 and Felton & Brown, 1991). The Stratified Random Sample will thus be referred to as the Random Sample hereafter.

Subjects in the Random and "At-Risk" sample were administered a research battery of tests to assess reading ability, rapid naming ability, intellectual performance, and the presence of attention deficit disorder (ADD). Briefly, the Woodcock-Johnson Reading Achievement Test (WJRSSA) was administered during the first and third grade levels to assess reading performance. The attention deficit disorder (ADD) portion of the Diagnostic Interview for Children and Adolescents (DICA) was administered when the children were in the third grade to assess the presence of attention deficit disorder. The Rapid "Automatized" Naming (RAN) tasks were administered to assess verbal continuous naming speed for the separate identification of colors, letters, numbers and objects. The Peabody Picture Vocabulary Test-Revised edition (PPVT), a measure of verbal intelligence, and the Wechsler Intelligence Scale for Children-Revised edition (WISC-R) were administered to assess intellectual ability in the first and third grade years, respectively. See Appendix D for a more complete description of these assessment measures.

Third grade performance on the WJRSSA and WISC-R was used for the identification of children with reading disability in the "At-Risk" and Random samples. The presence of a severe reading disability (RD) was ascribed to any child with a reading performance below the 20th percentile for their age (WJRSSA < 88) and a performance of at least 85 on either the Verbal or Performance Scales of the WISC-R. This selection procedure resulted in the identification of 15 subjects in the "At-Risk" sample who qualified for the RD identification. Due to an insufficient number of subjects from the Random Sample Group who met this RD classification (n=3) for creating a RD subgroup within the Random Sample Group these subjects were excluded from further analysis. Two samples of 15 subjects with third grade reading performance above the 20th percentile (WJRSSA > 20) were then selected separately from the "At-Risk" and the Random samples. Subject selection for these two non-reading disabled groups was constrained so that the three groups did not differ in gender, age, PPVT performance or first grade DICA scores. Recall, that these measures used for matching the groups were not used in determining the presence of RD, sample selection and have been previously shown to influence the ability to differentiate good and poor readers using the evoked potential methodology (Harter, 1991). Furthermore, the selection of two non-reading disabled (NRD) groups allows the traditional comparison of disabled readers to a randomly selected NRD sample and an additional comparison of RD subjects and NRD subjects selected as being "At-Risk" for later reading problems. This additional comparison allows a more stringent examination of the hypotheses since it would be expected that the NRD "At-risk" group would consist of subjects with more similar language abilities, except for reading performance, than would be expected in the traditional NRD Random sample and RD comparison.

Procedure

A black/white discrimination task was presented to the subjects in a computer game format. This task was designed to assess the selective processing of letters versus non-letters in conjunction with black/white discrimination performance. In the black/white discrimination task, the relevant (responded too) stimulus parameter was stimulus brightness (black vs. white) and not the stimulus type (letter or non-letter pattern). Points were won and lost depending upon the speed and accuracy with which the subjects responded to the black stimuli. Subjects were required to respond to the target "black" stimuli within 900 msec each time a target stimulus was presented. Responses to "black" stimuli were labeled Hits. Responses to incorrect "white" stimuli within 900 msec were labeled False Alarms (FA). Subjects responded by lifting their right index finger off a reaction time key. Immediately before the game subjects practiced until their responses were correct 75% of the time and they displayed a competent understanding of the game. False Alarms, Hits and RT data for the game was recorded. Points won during the game could be used to buy toys or exchanged for money.

Black-White Discrimination Task

The general procedure consisted of randomly presenting black and white letters (V, K, X, T, Y, W, h, e, a, m, f, n) and non-letter patterns (ASCII characters values 15, 188, 198, 199, 202, 204, 207, 224, 232, 235, 236, 247) on a video monitor. Subjects were required to make behavioral responses to all black stimuli regardless of their type (letter or non-letter).

A computer program utilizing IBM-AT and COMPAC computers, with Scientific Solutions Lab Master interface boards and Color Graphics monitors, were used to present the stimuli. All stimuli, which were 50 msec in duration and subtended 0.7 degrees, were presented against a purple background. The minimum inter-stimulus interval was 1.5 sec. The stimuli were presented on the center of a video monitor 56 cm away from the subject.

<u>Electrophysiological Recordings</u>

Event-Related potentials were recorded for 1000 msec following stimulus onset. Grass AC amplifiers, with high and low half amplitude frequency filters set at 100.0 and .3 Hz respectively, were used to amplify EEGs. Averaged ERPs were obtained from EEG recordings digitized at 50 Hz. International Electro-caps were used to record from the left and right occipital (01 & 02), parietal (P3 & P4), central (C3 & C4) and frontal (F3 & F4) sites. All electrodes were referenced to yoked ears and electrode resistance was kept at less than 10,000 ohms. ERP data were excluded from averaging if any one of the following occurred during a trial: (1) the magnitude of the EEG activity recorded on any channel exceeded the greatest amplitude of noise-free EEG activity observed on all channels with the eyes closed or open, (2) the eye electrode channel contained a voltage greater than 50% of the criterion voltage, or (3) the subject made an error on the behavioral RT task. The number of rejections due to each of these reasons was recorded for statistical analysis.

Data Analysis

The statistical analyses used were selected to permit extraction of the maximum amount of information contained in the data while trying to avoid a loss of statistical power. Apriori analyses were conducted to test the general linear model for reading group differences using the

MANOVA procedure. Appendix E lists the independent and dependent variables (and their abbreviations) which were included for analyses in the study. Posthoc data analyses were performed, controlling for experimenwise alpha rates through the use of the Tukey Studentized Range Method when applicable.

The primary objective of the data analyses was to determine whether the ERP waveform can provide a statistically significant differentiator of individuals during their first grade year who later manifest a reading disability from those who do not. A further consideration was to assess whether the amplitude of the ERP components during a black/white discrimination task interacts with hemispheric activity and/or the type of stimulus (letter or non-letter) as a function of reading ability. If the ERP components were found to significantly differentiate later reading performance in first graders (alpha =.05), then further analyses were performed to assess whether these relationships are statistically independent of other factors previously shown to be highly correlated with reading ability, e.g.,. Intellectual ability, Age and Attention Deficit Disorder (Felton et al., 1987; Felton & Wood, 1989; and Harter et al., 1988).

The data were analyzed from three separate perspectives. The first two sets of analyses were performed separately on the Random and "At-Risk" samples' data collected during the first grade. The first set of analyses examined the first grade electrophysiological and behavioral data from the randomly selected group in order to assess the effect of stimulus type on behavioral and electrophysiological measures of black/white discrimination performance. Such information provided a reference base for interpreting the reading group differences. The second set of data analyses on the first grade electrophysiological and behavioral measures compared a subset of the "At-Risk" sample, (those with a severe reading disability) to two groups of non-reading disabled subjects (one from the "At-Risk" Sample and the other from the randomly selected sample. These analyses were performed to examine the relationship between the electrophysiological waveform and the behavioral measures of reading, RAN and black/white discrimination performance when the subjects were in the third grade. The subjects in these three groups were matched with respect to age, gender and on measures of intellectual and attentional ability.

The separate analyses of the Random and "At-Risk" samples served several important functions. First, since the samples differed in their selection procedures, the alternative procedure of examining both samples collectively would have greatly limited the generalizability of the findings. Second, the comparison of the two subgroups of subjects within the "At-Risk" sample which differed in their reading outcome in the third grade, provided an opportunity for comparing subjects "At-Risk" for a reading disability, who later show normal reading performance to a group of "At-Risk" subjects who later develop a reading disability. Third, separate analyses of the two samples provided an internal replication which helped to assess whether any statistically significant relationship was the result of multiple statistical analyses (e.g., a type 2 error).

A fourth set of analyses on the electrophysiological and behavioral measures was performed solely on the reading and non-reading disabled groups from the third grade "At-Risk" sample. These analyses were performed to examine the relationship between the electrophysiological waveform and the behavioral measures of reading, RAN and black/white discrimination performance. The relationship between ERP measures which differentiated reading disabled and non-reading disabled subjects during the third grade year permitted an assessment of the stability of the ERP findings obtained from these subjects during the the first grade year.

CHAPTER III

RESULTS

Random Sample

First Grade Behavioral Data

Descriptive statistics for the neuropsychological and reading achievement measures for the subjects in the Random sample (n=74) are shown in Table 1. Subjects from the Random sample participated in the second half of their first grade school year resulting in an average age at the time of evaluation of 7.17 years. Normative data for performance on the PPVT, WJRSSA and WISC-R measures (VIQ, PIQ, FIQ), as provided in their respective testing manuals (see Appendix D for descriptions and references), represent age-corrected scaled scores with a mean of 100 and a standard deviation of 15. The data shown in Table 1 indicate that slightly higher than average performance was exhibited for the Random sample by these measures, but the measures were still within one standard deviation of the mean and were normally distributed. In contrast, the rapid "automatized" naming (RAN) measures and the DICA rating scale, produced reveal positively skewed distributions, with relatively more scores below the mean than above it. It is important to note that a positively skewed distribution is frequently observed on timed measures, such as those obtained on the RAN task. First grade performance among the RAN tasks also resulted in substantially longer latencies for the rapid naming of a display of objects (RANO1) as compared to an equal number of colors (RANC1), ($t(73) = -8.11$, $p < .0001$); while shortest latencies were obtained in the naming of letters (RANL1) or numbers (RANN1): (RANC1 vs. RANL1, $t(73) = 9.50$, $p < .0001$; and RANN1 vs. RANL1, $t(73) = 1.37$, $p > .05$).

First Grade ERP Task Performance

Descriptive statistics indicating the performance of the Random sample on the black/white discrimination task are shown in Tables 2 and 3. Table 2 shows the number of trials required for the subjects to learn the task (# Practice) and for the adequate collection of neural responses during the task (# Trials). The score on the black/white discrimination task refers to the amount of monetary reinforcement (cents) provided to the subjects as a function of their task performance. Data regarding task speed and accuracy were subjected to univariate analyses of variance to assess the statistical significance of Stimulus Type (letters vs. non-letter patterns) on the Behavioral Measures (RT, HITS% and FA%). The descriptive statistics for these measures are shown in Table 3. Results from these analyses, performed while controlling for experimentwise alpha rates, revealed significantly shorted reaction times (RT, $F(1,73) = 24.93$, $p < .0001$) and a larger percent of correct identifications (HITS%, $F(1,73) = 6.39$) during the black/white discrimination of letters, compared to the discrimination of non-letter shapes. In contrast, false alarm (FA%) rates on this task did not reflect a letter facilitation effect.

The statistically reliable influence of Stimulus Type on RT and HIT% performance resulted in faster RTs of only 13.47 msec and a higher percentage of hits of 2.74%. These black/white discriminations were also made with relatively high accuracy (average of 95.49 Hits% and 5.51 FA%). A high level of discrimination performance was further indicated by the perfect accuracy in detecting targets (100%= HITS%) and in the withholding of a response to non-targets (0%= FA%) during 23.6% of the target presentations and 11% of the non-target presentations, respectively. This high degree of task accuracy resulted in a negatively skewed distribution of the HIT% measures and a positively skewed distribution for the FA% measures during the Black/White discrimination task, see Table 3.

The validation of the behavioral task performed during the collection of the evoked potentials, is fundamental for defending the use of event-related potentials (ERPs) as a technique for establishing neural-behavioral relationships. Partial correlational analyses performed on the behavioral measures of reading ability (Table 1) and the behavioral measures obtained during the ERP task (Table 3), while statistically removing the linear effects of AGE1, PPVT1 and DICA provide such validation. Results from these analyses, as indicated in Table 4, revealed statistically significant correlations between accuracy on the ERP task and rapid naming and reading performance. The percentage of HITS to letters (HITS%-L) and non-letter patterns (HITS-NL) were statistically correlated with the rapid naming of numbers (HITS%-L, r=-.340 and HITS-NL, r=-.402) during first grade and both the rapid naming of letters (HITS%-L, r=-.300 and HITS-NL, r=-.405) and numbers (HITS%-L, r=-.417 and HITS-NL, r=-.483) during the third grade. Comparisons between task performance measures obtained during ERP data collection and performance on the rapid naming of colors and objects failed to reach statistical significance. The percentage of HITS during the black/white discrimination of letters, but not during such discriminations of non-letter patterns, was also significantly correlated with first grade reading ability (WJRSSA1, r=.240). These findings demonstrate a strong and statistically reliable relationship between the levels of performance on the task used during ERP data collection in the first grade and the levels of performance in first grade reading ability; and also with the rapidity with which numbers and letters could be named during both the first and third grades.

First Grade Electrophysiological Data

Event-Related Potentials (ERPs) for individual subjects were based on a minimum of 24 individual recordings per stimulus condition, resulting in a minimum of 96 trials of electrophysiological recordings for an individual subject. The electrophysiological measures used to quantify the results were identified in a grand averaged waveform from the Random and "At-Risk" samples separately, see Figure 1. A grand averaged waveform consists of the averaged waveform across the four stimulus conditions (Black letters, White letters, Black non-letters, White non-letters) for all the subjects in a given sample. The measures were operationally defined as the largest deflections across the electrode sites within a particular latency range. The latency range for each measure was set as being plus or minus one time bin from the maximum amplitude of a given ERP deflection as indicated in the grand averaged waveform (see Figure 1). The maximum amplitude of the deflections falling within a specified latency window in the electrophysiological waveform was then measured individually for each subject. For example, as shown in Figure 1, the first deflection in the grand averaged waveform occurred at 120 msec post-stimulus onset. This deflection in the averaged waveforms for both samples was a positivity at the occipital electrode and a negativity at the parietal, central, and frontal electrodes. The measurements (P120) obtained from the individual subject recordings consisted of the greatest positive deflection recorded at the occipital electrode sites and the largest negative deflection recorded at the parietal, central, and frontal sites between 100 and 140 msec for all electrode locations, stimulus types and task conditions. These electrophysiological measures, with their respective measurement window and polarity as a function of electrode location, are shown in Table 5. Due to the striking similarity of the latencies of the peaks and troughs among the grand averaged waveforms shown in Figure 1 for the At-Risk and Random samples, the same selection criteria for ERP measures were used for both groups. These measures were operationally defined as P120 (100-140 msec), N220 (200-260 msec), P310 (280-360 msec), P470 (440-500 msec), P550 (500-600 msec), and N700 (640-760 msec). The descriptive statistics for each of these measures summed across their respective stimulus conditions and hemispheres are shown in Table 6. The descriptive statistics for each of these measures confirms the polarity selection shown in Table 4 and reveals that each of these measures represents a relatively normal distribution (skewness values between zero and + or - 1.00).

The electrophysiological data for the Random sample (n=74) were subjected to a multivariate analysis of variance with repeated measures (BMDP, 1988). The variables analyzed were ERP Measures (P120, N220, P310, P470, P550 and N700), Electrodes (Occipital, Parietal, Central, Frontal), Hemispheres (Left and Right), Stimulus Relevance (Relevant=Black, Irrelevant=White), and Stimulus Type (Letters and Non-letter Patterns). The analysis revealed a highly reliable and statistically significant test of the General Linear model with main effects of electrode location for each electrophysiological measure. The vast changes in amplitude and/or polarity as a function of electrode location for each component, as illustrated in Figure 1, mandated the use of subsequent univariate analysis as a function of electrode location for each component. Interpretation of the statistical effects of Stimulus Type, Task Relevance and Hemispheric Activity are therefore, discussed within the context of the different electrode locations for each component. Appendixes F, G and H contain the statistical tables from these analyses.

P120 Measure

The Analysis of Variance revealed a significant main effect of Electrode Location ($F(3,219)= 296.74$, $p<.0001$) for the P120 measure. The amplitude of this measure for all electrodes locations over both hemispheres is shown in Figure 2. Inspection of these data show that the polarity of P120 changed as a function of electrode location. The measure was positive over the occipital brain regions and negative over the parietal, central and frontal brain regions. A trend for this measure to be more negative over the left as compared to over the right hemisphere also reached statistical significance at the parietal electrode sites ($F(1,73)= 4.07$, $p<.05$).

Findings Involving Stimulus Type and Task Relevance. A significant interaction between Hemispheric Activity and Stimulus Type ($F(1,73)= 6.72$, $p<.05$) was found for P120. The amplitude of the measure for all electrode locations, as a function of stimulus type and hemispheric activity are shown in Figure 2. Inspection of these data reveal that at the occipital and parietal locations a more symmetric hemispheric response was obtained to the letter than to the non-letter stimuli (Occipital, $F(1,73)= 7.75$, $p<.01$ and Parietal, $F(1,73)= 4.88$, $p<.05$). Over the frontal regions a significant effect of stimulus type also was found. This effect, shown in Figure 2, reveals a larger and more negative P120 response was obtained to non-letter stimuli ($F(1,73)= 4.32$, $p<.05$), but this difference as a function of hemispheric activity failed to reach statistical significance ($p>.05$).

The variance analysis revealed a statistically significant main effect for P120 as a function of Task Relevance ($F(1,73)= 5.59$, $p<.05$) and an interaction involving Electrode Location, Stimulus Type, and Task Relevance ($F(3,219)= 10.41$, $p<.0001$). These data, as shown in Figure 3, indicate the interaction between stimulus type and task relevance occurred over the parietal, central and frontal brain areas. At the parietal and central sites P120 amplitude was significantly greater to relevant than to irrelevant stimuli (Parietal P120, $F(1,73)= 5.82$, $p<.05$ and Central P120, $F(1,73)= 5.67$, $p<.05$). This effect also was present at the frontal locations, but only for the letter stimuli ($F(1,73)= 10.26$, $p<.005$).

N220 Measure

The multivariate analysis revealed significant main effects for Electrode Location ($F(3,219) = 568.14$, $p < .0001$) and Hemispheric Activity ($F(1,73) = 24.55$, $p < .0001$) for the N220 measure. As shown in Figure 4, N220 was negative in polarity over the occipital region and positive in polarity over the parietal, central and frontal brain regions. Univariate analyses revealed the occurrence of significantly larger amplitudes over the left than over the right hemisphere at the parietal, central and frontal electrode sites (Parietal N220, $F(1,73) = 23.45$, $p < .0001$; Central N220, $F(1,73) = 33.51$, $p < .0001$ and Frontal N220, $F(1,73) = 5.57$, $p < .05$), see Figure 4.

Findings Involving Stimulus Type and Task Relevance. In the multivariate analysis, significant main effects of Stimulus Type ($F(1,73) = 6.28$, $p < .05$) and Task Relevance ($F(1,73) = 35.12$, $p < .0001$) on N220 were obtained, along with interactions involving Electrode Location by Stimulus Type ($F(3,219) = 12.59$, $p < .0001$), Electrode Location by Task Relevance ($F(3,219) = 6.27$, $p < .01$) and Electrode Location by Stimulus Type by Task Relevance ($F(3,219) = 4.20$, $p < .01$). Subsequent univariate analyses provided greater clarity of the interactions involving Electrode Location. As revealed in Figure 5, a larger response to relevant than to irrelevant task conditions was obtained at the parietal, central and frontal sites (Parietal, $F(1,73) = 18.35$, $p < .001$; Central, $F(1,73) = 28.82$, $p < .0001$; and Frontal, $F(1,73) = 47.54$, $p < .0001$). Also, the N220 measure was relatively more positive for the letter than for the non-letter patterns across all electrode sites (Occipital, $F(1,73) = 4.75$, $p < .05$; Parietal, $F(1,73) = 4.74$, $p < .05$; Central, $F(1,73) = 12.53$, $p < .001$; and Frontal, $F(1,73) = 15.12$, $p < .001$).

However, over the occipital brain regions the effect of stimulus type interacted with task relevance such that a statistically significant effect of task relevance was present only in response to letter stimuli (Occipital N220, $F(1,73)= 4.15$, $p<.05$).

P310 Measure

Univariate analyses of repeated measures for the P310 measure revealed statistically significant main effects for Electrode Location ($F(3,219)= 326.15$, $p<.0001$) and Hemisphere Activity ($F(1,73)= 27.35$, $p<.0001$). A significant interaction between Electrode Location and Hemispheric Activity ($F(3,219)= 3.92$, $p<.01$) also was found. Amplitudes of the P310 measure for each electrode site as a function of hemisphere, stimulus type and task relevance are shown in Figure 6. Inspection of these data reveal that P310 amplitude was maximal over the occipital and parietal brain areas where it was positive. By contrast, its polarity over the frontal and central brain areas was negative. Univariate analyses of these data reveal significantly more positive P310 amplitudes over the left than over the right hemisphere for the occipital, parietal and central regions (Occipital, $F(1,73)= 12.01$, $p<.001$; Parietal, $F(1,73)= 4.80$, $p<.05$; and Central, $F(1,73)= 49.24$, $p<.0001$).

Findings Involving Stimulus Type and Task Relevance. Univariate analyses of P310 involving repeated measures revealed statistically significant main effects for Stimulus Type ($F(1,73)= 7.99$, $p<.01$) and Task Relevance ($F(1,73)= 27.41$, $p<.0001$). Significant interactions between Electrode Location and Stimulus Type ($F(3,219)= 2.75$, $p=.06$), and between Electrode Location and Task Relevance (F(3,219)= 14.05, p<.0001) also were found. The data shown in Figure 6, reveal that for the occipital, parietal, and central regions, the amplitude of P310 was significantly more positive in response to non-letter stimuli than to letter stimuli (Occipital, F(1,73)= 9.34, p<.01; Parietal F(1,73)= 13.08, p<.001; and Central F(1,73)= 3.40, p=.07), and for task relevant than for irrelevant task conditions (Occipital, F(1,73)= 34.96, p<.0001; Parietal, F(1,73)= 36.14, p<.0001; and Central, F(1,73)= 14.61, p<.001).

P470 Measure

A Significant main effect of Electrode Location (F(3,219)= 27.42, p<.0001) was obtained for the P470 measure. Inspection of the data shown in Figure 7, indicates that P470 was of positive polarity at all electrode locations, with maximal amplitudes over central and minimal amplitudes over the frontal brain regions. A statistically significant interaction (Electrode Location by Hemisphere (F(3,219)= 5.05, p<.01) also was found (see Figure 7). P470 amplitude was significantly larger over the left than over the right hemisphere at the central region (F(1,73)= 6.99, p<.05), and this asymmetry was reversed over the frontal region (F(1,73)= 4.57, p<.05).

Findings Involving Stimulus Type and Task Relevance. Statistically significant main effects of Stimulus Type (F(1,73)= 9.46, p<.01), and Task Relevance (F(1,73)= 197.13 p<.0001) on P470 were obtained. Significant interactions involving Electrode Location and Task Relevance (F(3,219)= 107.21; p<.0001); Hemisphere and Stimulus Type (F(1,73)= 4.25;

$p<.05$); Hemisphere and Task Relevance ($F(1,73)= 21.19$; $p<.0001$); Stimulus Type and Task Relevance ($F(1,73)= 4.47$, $p<.05$); and Electrode Location by Hemisphere by Task Relevance ($F(3,219)= 5.25$; $p<.01$); also were also obtained. Statistically significant main effects for Stimulus Type and Task Relevance were obtained at all electrode locations. As shown in Figure 7, a significantly larger P470 amplitude was obtained to letter than non-letter stimuli (Occipital P470, $F(1,73)= 8.67$, $p<.01$; Parietal P470, $F(1,73)= 2.93$, $p=.09$; Central P470, $F(1,73)= 6.86$, $p<.05$ and Frontal P470, $F(1,73)= 7.69$, $p<.01$), and to relevant than to irrelevant task conditions (Occipital P470, $F(1,73)= 221.13$, $p<.01$; Parietal P470, $F(1,73)= 242.99$, $p<.0001$; Central P470, $F(1,73)= 183.96$, $p<.0001$ and Frontal P470, $F(1,73)= 13.49$, $p<.001$).

Stimulus Type interacted with Task Relevance over the frontal and central regions. As shown in Figure 7, larger P470 amplitudes to letter than to non-letter stimuli were obtained only during the relevant task condition, and this effect did not interact with hemispheric activity (Central, $F(1,73)= 4.61$, $p<.05$; and Frontal, $F(1,73)= 7.41$, $p<.01$). Statistically significant differences in P470 amplitude as a function of Stimulus Type or Task Relevance interacted with Hemispheric Activity at the occipital, parietal and central brain areas (see Figure 7). The interaction of hemispheric activity with task relevance reflected larger left than right hemispheric activity under relevant task conditions, with more symmetric activity occurring under irrelevant task conditions (Occipital, $F(1,73)= 39.25$, $p<.0001$; Parietal, $F(1,73)= 8.37$, $p<.01$ and Central, $F(1,73)= 11.23$, $p<.01$). The significant interaction of hemispheric activity and stimulus type obtained at occipital and parietal sites manifests the attainment of larger P470 amplitudes to letter than to non-letter stimuli over the left but not over the right hemisphere (Occipital, $F(1,73)= 5.83$, $p<.05$; and Parietal, $F(1,73)= 5.27$, $p<.05$).

P550 Measure

Variance analyses revealed statistically significant main effects for Electrode Location ($F(3,219)=51.87$, $p<.0001$) and an interaction between Electrode Location and Hemispheric Activity ($F(3,219)= 4.17$, $p<.01$) for the P550 measure. The mean amplitude of this measure for each electrode location as a function of stimulus type, task relevance and hemispheric activity is shown in Figure 8. Inspection of these data reveal that P550 was positive at all electrode locations, with maximal amplitude occurring over the central regions and minimal amplitudes occurring over the occipital and frontal brain regions. Its amplitude also was significantly larger over the right than over the left hemisphere at occipital and frontal electrode locations (Occipital, $F(1,73)= 14.99$, $p<.01$ and Frontal, $F(1,73)= 6.99$, $p<.05$).

Findings Involving Stimulus Type and Task Relevance. Univariate analyses for repeated measures of P550 as a function of electrode location revealed a statistically significant main effect of Task Relevance ($F(1,73)=155.02$, $p<.0001$) and significant two way interactions involving Electrode Location and Task Relevance ($F(3,219)= 37.04$, $p<.0001$), Hemispheric Activity and Task Relevance ($F(1,73)= 21.92$, $p<.0001$), and Hemispheric Activity and Stimulus Type ($F(1,73)= 4.69$, p<.05). Statistically significant 3 way interactions involving Electrode Location, Hemispheres and Stimulus Type ($F(3,219) = 4.97$, $p < .01$); Electrode Location, Hemispheres and Task Relevance ($F(3,219) = 8.37$, $p < .0001$); and Electrode Location, Task Relevance, and Stimulus Type ($F(3,219) = 9.53$, $p < .001$) also were found.

Although a statistically significant main effect for Stimulus Type was not obtained ($p > .05$), an interaction between Stimulus Type and Hemispheric Activity did reach statistical significance over the occipital and parietal regions (Occipital, $F(1,73) = 11.79$, $p < .01$ and Parietal, $F(1,73) = 8.14$, $p < .01$). These data, shown in Figure 9, reflect that over the left hemisphere P550 was larger to letter than to non-letter stimuli, while over the right hemisphere differences due to Stimulus Type failed to reach statistical significance ($p > .05$).

A larger response to relevant than to irrelevant task conditions was obtained at all scalp locations (Occipital, $F(1,73) = 100.83$, $p < .0001$; Parietal, $F(1,73) = 180.33$, $p < .0001$; Central, $F(1,73) = 163.60$, $p < .0001$ and Frontal, $F(1,73) = 34.37$, $p < .0001$). This relevance effect, as shown in Figure 9, interacted with stimulus type over the occipital region with a larger P550 being recorded to non-letter than to letter stimuli ($F(1,73) = 7.79$, $p < .01$). Task relevance also interacted with hemispheric activity, with significantly larger relevance effects occurring over the left than over the right hemisphere at the occipital, parietal and central electrode sites (Occipital, $F(1,73) = 21.41$, $p < .0001$; Parietal, $F(1,73) = 19.29$, $p < .0001$; and Central, $F(1,73) = 21.01$, $p < .0001$).

<u>N700 Measure</u>

Univariate variance analyses of the N700 measure resulted in significant main effects for Electrode Location ($F(3,219)=167.68$, $p<.0001$) and Hemispheric Activity ($F(1,73)=7.85$, $p<.01$), and an interaction between Electrode Location and Hemispheric Activity ($F(3,219)= 3.91$, $p<.01$). The averaged data of the N700 amplitude for each electrode location as a function of stimulus type and task relevance are shown in Figure 10. Inspection of these data show the N700 measure was recorded as a negativity over the occipital region and a positivity over the remaining electrode sites. Its amplitude was maximal over the frontal and central brain regions, and minimal over the parietal regions. Significant main effects for hemispheric activity were obtained at occipital and central locations. N700 was greater over the left than over the right hemisphere at the occipital region ($F(1,73)= 14.99$, $p<.001$), while a reverse asymmetry was observed over the central region ($F(1,73)= 4.54$, $p<.05$).

<u>Findings Involving Stimulus Type and Task Relevance.</u> A significant N700 main effect was obtained for Stimulus Type ($F(1,73)= 4.15$, $p<.05$), along with significant two way interactions involving Electrode Location and Task Relevance, ($F(3,219)= 35.35$, $p<.0001$); and Hemispheric Activity and Task Relevance, ($F(1,73)= 11.20$, $p<.01$). Significant three way interactions involving Electrode Location, Hemispheric Activity, and Stimulus Type ($F(3,219)= 4.11$, $p<.01$); Electrode Location, Hemispheric Activity and Task Relevance ($F(3,219)= 6.08$, $p<.001$); Electrode Location, Task Relevance, and Stimulus Type, ($F(3,219)= 4.86$, $p<.001$); and Hemispheric Activity, Task Relevance, and Stimulus Type, $F(1,73)= 7.85$,

p<.01) also were obtained. Since, these three way interactions encompass the main effects and two interactions, of these three way interactions will be described further.

A significant main effect for Task Relevance was obtained at the occipital (F(1,73)= 9.83, p<.01), central (F(1,73)= 19.77, p<.0001), and frontal (F(1,73)= 26.48, p<.0001) regions. This Task Relevance effect consisted of significantly larger N700 amplitudes being recorded during relevant than during irrelevant task conditions. The significant interaction involving Task Relevance and Hemispheric Activity obtained at the central (F(1,73)= 13.54, p<.001) and parietal (F(1,73)= 12.87, p<.001) sites (see Figure 10) reflects the attainment of significantly greater N700 amplitudes for relevant than for irrelevant task conditions over the left but not over the right hemisphere. The significant interaction between Task Relevance and Stimulus Type obtained at the occipital regions (Occipital N700, F(1,73)= 4.61, p<.05) reflects the attainment of larger N700 relevance effects to letters than to non-letter stimuli.

As shown in Figure 10, the significant main effect for stimulus type obtained at frontal brain regions (F(1,73)= 6.24, p<.05), reflects the attainment of greater N700 amplitudes to non-letter than to letter stimuli. The significant interaction between Stimulus Type and Hemispheric Activity obtained at the occipital regions is a manifestation of larger N700 amplitudes having been obtained over the right hemisphere to letters than to non-letter stimuli, with non-significant differences having been obtained over the left Hemisphere (Occipital, F(1,73)= 4.21, p<.05). A significant interaction involving Stimulus Type, Task Relevance, and

Hemispheric Activity over the frontal and occipital electrodes also was obtained (see Figure 10). A post-hoc analysis of this three way interaction revealed that while a significant Task Relevance effect occurred over the right and left occipital and frontal hemispheres, for the left occipital hemisphere this effect occurred only to letter stimuli ($F(1,73)= 4.15$, $p<.05$). Over the left frontal hemisphere a significantly smaller N700 amplitude to task relevant letter than to non-letter stimuli was obtained ($F(1,73)= 4.29$, $p<.05$). Over the right frontal hemisphere, N700 amplitude failed to reach statistical significance as a function of Stimulus Type and Task Relevance.

Reading Group Comparisons

First and Third Grade Behavioral Data

Of the 64 subjects identified in kindergarten as being "At-Risk" for later reading problems, 15 were selected as possessing a severe reading disability (RD) on the basis of two criteria. One was a third grade score of 85 or higher on either the VIQ3 or PIQ3 segments of the WISC-R; the other was a third grade reading performance (WJRSSA3) at or below the 20th percentile (a standard score of 87), based upon normative data provided in the Woodcock-Johnson Psycho-educational test manual (Woodcock & Johnson, 1977). A summary of first and third grade reading and intellectual performance is shown in Table 7. The obtained group mean for third grade reading performance (WJRSSA3) for the RD group was 77.80 (7th percentile). The non-reading disabled "At-Risk" (NRD) and randomly selected (RND) groups had WJRSSA3 group means of 107.40 (68th percentile) and 103.87 (61 percentile), respectively.

Validation of the reading group assignments were ascertained through statistical comparisons of the first and third grade Woodcock-Johnson Reading scores, and the third grade intellectual performance scores (VIQ3, PIQ3, and FIQ3). Significant effects for first (WJRSSA1) and third (WJRSSA3) grade reading performance were obtained. The RD showed significantly lower reading performance in the first and third grade compared to the NRD (WJRSSA1, $F(1,28)= 47.02$, $p<.0001$; and WJRSSA3, $F(1,28)= 106.35$, $p<.0001$) and the RND group (WJRSSA1, $F(1,28)= 39.91$, $p<.0001$; and WJRSSA3, $F(1,28)= 62.52$, $p<.0001$). Differences between the two non-reading disabled groups (RND and NRD) on reading performance failed to reach statistical significance in either the first ($F(1,28)= 0.04$, $p>.05$) or third grade ($F(1,28)= 0.94$, $p>.05$).

Univariate comparisons of the reading groups on third grade intellectual performance (VIQ3, PIQ3, and FIQ3) were performed, controlling for experimentwise alpha rate. The results are displayed in Table 7. No statistically significant differences between the reading groups were found. It is noteworthy however, that the RD group had lower verbal intellectual performance scores (RD, VIQ3 mean=93.60) than did the non-reading disabled groups (NRD, VIQ3 mean=101.13; and RND, VIQ3 mean=96.80) but these differences failed to reach statistical significance. Interestingly, the mean discrepancy between the numerically higher of the verbal or performance intelligence subtest scores and third grade reading performance (VIQ3 or PIQ3 minus WJRSSA3) was 21.2 (12 to 44) for the RD group compared to -2.73 (range= -14 to 12) and -4.53 (range= 13 to -21) for the NRD and RND groups, respectively. While, statistical regression toward the mean could account for the larger discrepancies between reading ability and intellectual performance in the RD group, these findings suggest that the RD subject's group performance was lower than that which might be expected from their respective intellectual abilities.

Due to the influence of gender, age, verbal intellectual ability, and the presence of attentional deficit disorder on the ability to differentiate groups differing in reading ability, using the ERP methodology, the three groups were matched on measures of these constructs (GENDER, AGE1, PPVT1, and DICA). This was done because a matching process had not been implemented in sample selection ("At-Risk" or Random samples) or in the assignment of subjects to reading groups. Each of the three reading groups consisted of 2 female and 13 male subjects. Group performance on these measures is displayed in Table 8. Univariate analyses of these measures showed that the reading groups did not statistically differ on any of these measures.

Statistical analyses conducted to compare reading group performance on measures of continuous rapid naming, while controlling for experimentwise alpha rate are displayed in Table 9. These results may be summarized as follows. During the first and third grades, the RD as compared to the NRD group showed a non-significant trend toward slower performance on all measures of continuous rapid naming. However, the RD group, compared to the RND group, showed significantly slower performance on the rapid naming of letters (RANL1, $F(1,28)= 7.69$, $p<.01$) and numbers (RANN1, $F(1,28)= 11.06$, $p<.01$) during the first grade and this still was the case during the third grade (RANL3, $F(1,28)= 21.97$, $p<.001$; RANN3, $F(1,28)= 15.25$, $p<.001$). Furthermore, slower rapid naming performance for the RD during the rapid naming of objects (RANO3, $F(1,28)= 9.35$, $p<.01$) differentiated the RD group from the RND group. A comparison of the non-reading disabled groups (NRD vs. RND) revealed statistically significant differences only on measures of rapid naming, the rapid naming of numbers being slower in first grade and the rapid naming of both letters and numbers being slower in third grade for the NRD than for the RND group (RANN1, $F(1,28)= 7.75$, $p<.01$; RANN3, $F(1,28)= 7.55$, $p<.01$ and RANL3, $F(1,28)= 8.84$, $p<.01$). Slower rapid naming for the NRD group could represent differences in the selection procedure for the "At-Risk" sample since rapid naming speed was one of the measures used to identify subjects for this sample (see Appendix C).

A statistical comparison of performance measures among the rapid naming tasks revealed interesting reading group differences. Comparisons among the RAN task means shown in Table 9, indicate a trend similar to that of the Random sample's (RND) naming performance shown in Table 1 (i.e., RANL = RANN < RANC < RANO) for the NRD group in first (RANC1 vs. RANL1, $t(14)= 4.75$, $p<.001$, RANL1 vs. RANN1, $t(14)= 0.41$, $p>.05$ and RANC1 vs. RANO1, $t(14)= -4.87$, $p<.001$) and third grade (RANC3 vs. RANL3, $t(14)= 5.05$, $p<.001$, RANL3 vs. RANN3, $t(14)= 0.13$, $p>.05$ and RANC3 vs. RANO3, $t(14)= -$

3.82, p<.01). The RND group, which was a subset of subjects from the Random sample, showed a similar trend among RAN tasks with RANC and RANO while generating the longest naming latencies in the first (RANC1 vs. RANL1, t(14)= 6.92, p<.001, and RANC1 vs. RANO1, t(14)= -3.11, p<.001) and third grade (RANC3 vs. RANL3, t(14)= 8.77, p<.001, and RANC3 vs. RANO3, t(14)= -6.72, p<.0001). Performance among the RAN tasks for the RND group did differ slightly, however, first grade RANN performance being significantly faster than RANL performance (RANL1 vs. RANN1, t(14)= 3.33, p<.01). A similar trend failed to reach statistical significance in the third grade (RANL3 vs. RANN3, t(14)= 0.22, p>.05). Interestingly, in contrast to the non-reading disabled groups, the RD group showed fastest first grade RAN performance for colors as compared to letters (RANC1 vs. RANL1, t(14)= 3.05, p<.01) or numbers (RANC1 vs. RANN1, t(14)= 3.01, p<.01). This finding was no longer present in third grade RAN performance (RANC1 vs. RANL1, t(14)= -0.93, p>.05 and RANC1 vs. RANN1, t(14)= -0.66, p>.05). The RD group did show the expected finding of slower rapid naming of objects in first grade (RANL1 vs. RANO1, t(14)= -4.43, p<.001) and colors and objects in the third grade (RANC3 vs. RANO3, t(14)= -5.05, p<.001).

<u>First and Third Grade ERP Task Performance</u>

Summaries of the ERP task behavioral data are shown in Tables 10 and 11. Univariate analyses were performed on the following measures to assess the degree of performance on the task required for the minimum number of trials in each ERP average as a function of reading group (RD, NRD and RND). These measures were the number of practice trials (#prac), number of trials to criterion (#trials), and total score (score) on the task. The analyses, with experimentwise alpha correction, resulted in no statistically significant group differences as a function of reading group.

In contrast, analyses of task performance (RT, HITS% and FA%) resulted in several measures which differentiated the reading groups. Performance data from the black/white discrimination task were entered as six dependent variables. The three behavioral measures (Behavioral Measures= RT, HIT%, and FA%) were nested within the two levels of stimulus type (Stimulus Type= Letters and Non-letter patterns). Reading group (Reading Group= RD, NRD and RND) was entered as the sole independent variable. A multivariate analysis of variance of these variables yielded main effects for stimulus type (Stimulus, $F(1,42)= 17.38$, $p<.001$), behavioral measures (Measure, $F(2,84)= 2981.20$, $p<.001$) and reading groups (Group, $F(2,42)= 4.28$, $p<.05$). Statistically significant interactions between Measures and Groups ($F(4,84)= 5.15$, $p<.001$), and Stimulus Type and Measures ($F(2,84)= 23.36$, $p<.001$) also were obtained.

Subsequent, analyses of variance were performed to examine stimulus type effects for each measure (Stimulus Type by Measures) and Reading group effects for each measure (Group by Measure), controlling for experimentwise alpha levels. Reaction times during the ERP task were found to be significantly faster for the black/white discrimination of letters than for non-letter patterns (RT, $F(1,44)= 25.68$, $p<.001$). No statistically significant effects were found for stimulus type on either the percentage of hits or false alarms recorded during the task. The data shown in Table 11 indicate a general trend toward slower and less accurate performance during the black/white discrimination task, regardless of stimulus type, for the reading disable (RD) than for either of the non-reading disabled groups (NRD and RND). Statistical analyses, after controlling for experimentwise alpha levels, revealed statistically significant differences in performance between the RD and RND groups. Again, these differences were independent of stimulus type (RT, $F(1,28)= 8.91$, $p<.01$ and Hits%, $F(1,28)= 23.36$, $p<.001$).

Validation of the ERP task was obtained through partial correlational analysis of the task behavioral performance measures (RT, Hits%, FA%) with measures of rapid naming (RAN) and reading ability (WJRSSA), while controlling for the linear effects of subject age (AGE1), verbal intellectual ability (PPVT1), and DICA rating scores (see Table 12). This analysis revealed a significant inverse relationship between the percent of correct identifications of targets (HITS%) for black letters and the rapid naming of numbers (RANN1, $r= -.347$, $p<.01$; and RANN3, $r= -.426$, $p<.001$) and letters (RANL3, $r= -.324$, $p<.01$). A similar relationship was found between HITS% for black non-letter patterns and rapid naming of numbers (RANN1, $r= -.413$, $p<.001$ and RANN3, $r= -.498$, $p<.001$) and letters (RANL1, $r= -.248$, $p<.05$ and RANL3, $r= -.434$, $p<.05$). No significant correlation coefficients were obtained for the rapid naming of colors or objects and task performance. The relatively distinct positive relationship between task accuracy (HITS%) and rapid naming performance of letters and numbers (shorter latency), in contrast to the absence of a relationship for the rapid naming of colors and objects, provides indirect support for a relationship between measures of the rapid naming of letters (RANL) and numbers (RANN) and performance on the ERP task (Hits%). A significant correlation also was observed between task accuracy and first grade reading ability. The black/white discrimination of letters was positively correlated with reading ability in first grade (HITS% and WJRSSA1, r= .280, p<.05) after age, verbal intelligence and DICA ratings were statistically controlled.

Analyses of the ERP third grade task behavioral data are shown in Tables 13 and 14. Univariate analyses of variance were performed on the following dependent variables to assess the amount of experience at the task required to meet the minimum number of trials contained in the averaged ERP data as a function of reading group (RD and RND). These measures were the number of practice trials (#prac), number of trials to criterion (#trials), and total score (score) on the task. Results of the univariate analyses with experimentwise alpha correction, revealed no statistically significant differences among the reading groups.

In contrast, analyses of task performance (RT, HITS% and FA%) revealed several measures which differentiated the reading groups. Performance data from the black/white discrimination task were entered as six dependent variables, with the three behavioral measures (Behavioral Measures= RT, HIT%, and FA%) nested within the two levels of stimulus type (Stimulus Type= Letters and Non-letter patterns). Reading group (Reading Group= RD, NRD and RND) was entered as the sole independent variable. A multivariate analysis of variance yielded main effects for stimulus type (Stimulus Type, F(1,28)= 5.13, p<.05) and behavioral measures (Measure, $F(1,28)= 1807.15$, $p<.0001$). Statistically significant interactions between Stimulus Type and Measures ($F(2,56)= 8.30$, $p<.01$) also were obtained. Subsequent, analyses of variance were conducted to examine Stimulus Type and Reading group effects on each measure while controlling for experimentwise alpha levels. Reaction times during the ERP task were significantly faster for the black/white discrimination of letters than for non-letter patterns (RT, $F(1,28)= 7.69$, $p<.01$). No statistically significant effects were obtained for stimulus type on either the percentage of hits or false alarms recorded during the task. The data in Table 14 also suggest that the RD group tended to perform less accurately during the black/white discrimination task, regardless of stimulus type, than did the non-reading disabled groups (Hits%, $F(1,28)= 5.18$, $p<.05$), although the effect failed to reach statistical significance after controlling for experimentwise alpha rates.

First and Third Grade Electrophysiological Data

The analysis of the first and third grade electrophysiological data in a repeated measures design should provide more statistical power than an independent analysis of the first and third grade data. A repeated measure design reduces the variability due to individual differences in the error term. Individual differences frequently provide the major source of error variance. The assumptions for a repeated measures analysis of variance procedure are (1) independence of observations, (2) multivariate normality and (3) sphericity. When sample sizes are equal, the F statistic is relatively insensitive to violations regarding the first and second assumptions (Kirk, 1982 and Keppel, 1983). The sphericity assumption however, requires that the measures have the same variance and the correlation between the measurements for any two levels of the within factor be equal to the correlation between any two other variables (Jennerick, Sampson & Frane, 1990). Violations of the sphericity assumption result in a severe loss of statistical power and an inflated alpha level (Stevens, 1986). Electrophysiological measures are highly correlated both in time (latency) and space (electrode site) and thus are highly susceptible to violations of sphericity. Comparing electrophysiological recordings across a developmental period adds an extra factor of statistical complexity due to the systematic changes in variance for these measures in early development (Courchesne, 1978 and Kurtzberg et al., 1984). The electrophysiological measures recorded in the first and third grade years were subjected to a test for violation of the sphericity condition in the analysis of variance with repeated measures procedure (BMDP 2V). The test for violation of sphericity was statistically significant ($p<.0001$) and therefore the electrophysiological measures were analyzed separately for the first and third grade years.

The test of the general linear model was conducted using a Multivariate Analysis of Variance procedure which yielded a highly reliable statistically significant difference among the variance of the means, separately for the first and third grade years. Several statistically significant main effects and interactions were obtained which differentiated the three reading groups (RD, NRD and RND). Upon finding a highly reliable statistically significant test of the General Linear model, statistical analysis of the model for each component revealed highly reliable statistically significant effects for each measure except for the P120 measure in the first grade year (P120, F(1,42)= 0.09, p>.05). However, this component was subjected to subsequent analysis due to apriori hypotheses regarding this measure and previous findings indicating its differentiation of reading groups. Subsequent analyses of each electrophysiological measure as a function of electrode site are shown in Appendix G and H for both the first and third grade levels. Third grade data for the RND group were not collected on this task; thus ERP analyses on the third grade data refer to reading group differences between the RD and NRD samples only.

P120 Measure

First Grade Reading Group Differences Involving Stimulus Type and Task Relevance. Univariate analyses for repeated measures revealed statistically significant interactions between Electrode Location and Task Relevance (F(6,126)=2.34, p<.05), and among Electrode Location, Stimulus Type and Task Relevance for the three reading groups (F(6,80)= 4.05, p<.005). Analyses of the first grade P120 measure as a function of electrode location revealed that these interactions reached statistical significance only over the occipital and frontal regions.

Occipital P120. The data reflecting the significant interaction of Stimulus Type, Task Relevance and Reading Group over the occipital regions (F(2,42)= 3.47, p<.05) are shown in Figure 11. Occipital P120 amplitude for the RD group did not vary significantly as a function of hemispheric activity, stimulus type or task relevance. The NRD group however, showed significantly greater P120 amplitudes to letter than to non-letter patterns. This effect was statistically independent of task relevance ($F(1,14)= 4.68$, $p<.05$). By contrast, a significant interaction of Stimulus Type and Task Relevance was found for the RND group; reflecting larger P120 amplitudes to task relevant letter than to task relevant non-letter stimuli ($F(1,14)= 6.63$, $p<.05$). Analyses of the third grade Occipital P120 measure failed to significantly ($p>.05$) differentiate the reading groups (RD and NRD).

Frontal P120. Analysis of P120 amplitude over the frontal brain regions yielded statistically significant main effects between Hemispheric Activity ($F(2,42)= 3.53$, $p<.05$) and Task Relevance ($F(2,42)= 5.46$, $p<.01$) for the reading groups. These data, shown in Figure 12, indicate that for the RND group the same effect was obtained over the frontal and occipital regions; namely, a significant Stimulus Type by Task Relevance interaction (Frontal P120, $F(1,14)= 6.69$, $p<.01$). In contrast, analyses of the Frontal P120 measure for the NRD and RD groups revealed substantially different statistical results than were obtained for these groups over the occipital region. For the RD group, a significant interaction involving Stimulus Type, Task Relevance and Hemispheric Activity was obtained ($F(1,14)= 10.44$, $p<.01$), with smaller left hemisphere amplitude recorded in response to relevant non-letter stimuli than to any of the other experimental conditions over either hemisphere. Analyses of Frontal P120 for the NRD group produced significant main effects of Hemispheric Activity ($F(1,14)= 6.20$, $p<.05$) and Task Relevance ($F(1,14)=$

6.39, p<.05) revealing significantly larger Frontal P120 amplitudes to relevant than to irrelevant task conditions, and over the left than over the right hemisphere. A significant interaction involving Hemispheric Activity, Task Relevance and Stimulus Type also was found for the NRD group. These data, shown in Figure 12, indicate that smaller Frontal P120 amplitudes were recorded over the right hemisphere in response to irrelevant non-letter stimuli than in response to any of the other experimental conditions over either hemisphere (F(1,14)= 11.27, p<.01).

Third Grade Reading Group Differences Involving Stimulus Type and Task Relevance. An interaction of Electrode Location, Hemispheric Activity, Stimulus Type, and Task Relevance provided a statistically significant differentiator of the reading groups (F(6,168)= 3.25, p<.005). Subsequent univariate analyses by electrode site revealed a significant interaction of Hemispheric Activity and Task Relevance for Central P120 amplitude. A significant interaction of Hemispheric Activity, Stimulus Type, and Task Relevance for the frontal electrodes also was found.

Central and Frontal P120. As indicated in Figure 13, both groups (RD and NRD) showed a non-significant trend towards larger Central P120 activity over the left than over the right hemisphere in response to irrelevant task conditions (p>.05). A larger Central P120 amplitude also was recorded over the left than right hemisphere for task relevant information but this effect reached statistical significance only for the RD group (F(1,28)= 5.26, p<.05). Over the frontal regions, the NRD group showed larger P120 amplitudes to relevant than to irrelevant task conditions, and this effect was greater over the left than right hemisphere for letter stimuli. In contrast, a main effect for Task Relevance failed to reach statistical significance for the RD group. The RD group, however, did show significantly greater frontal P120 amplitudes to non-letter stimuli over the left than over the right hemisphere, but only in response to task relevant conditions ($F(1,28)= 4.82$, $p<.05$); see Figure 13.

Other Findings Involving Reading Group Differences. Analyses of the third grade P120 measure revealed a significant interaction between Hemispheric Activity and Reading Group ($F(1,28)= 8.37$, $p<.01$). Univariate analyses of this effect as a function of electrode location indicated greater Temporal-Parietal P120 amplitudes over the right than over the left hemisphere for both reading groups ($F(1,28)= 30.76$, $p<.0001$); see Figure 14. This hemispheric difference was significantly greater for the RD than NRD subjects (Temporal-Parietal P120, $F(1,28)= 9.38$, $p<.005$).

N220 Measure

First Grade Reading Group Differences Involving Stimulus Type and Task Relevance. Univariate analyses of the N220 measure revealed a significant interaction of Electrode Location, Hemispheric Activity, Task Relevance and Reading Group for both the first and third grade data. In the first grade a statistically significant main effect for Task Relevance with larger N220 amplitudes to relevant than to irrelevant task conditions, was found over the parietal, central and frontal regions. This relevance effect interacted with hemispheric activity as a function of reading group at the parietal region. These data, shown in Figure 15, reflect a significant task relevance effect over both hemispheres for the

NRD group, over the left hemisphere for the RND group, and over the right hemisphere for the RD sample ($F(2,42)= 3.93$, $p<.05$).

Third Grade Reading Group Differences Involving Stimulus Type and Task Relevance. Univariate analysis of the third grade N220 amplitudes revealed a significant main effect of Task Relevance over central, lateral central, frontal and lateral frontal brain regions, with greater N220 amplitudes having occurred in response to relevant than to irrelevant task conditions. The interaction of Hemispheric Activity and Task Relevance, which differentiated the reading groups in first grade over the parietal region, also reached statistical significance over the central and lateral-frontal regions for the third grade data. The data shown in Figure 16 depict a task relevance effect over the left and right hemisphere for both reading groups (Central P120, $F(1,28)= 47.80$, $p<.0001$ and Lateral-Frontal P120, $F(1,28)= 15.96$, $p<.0005$). This task relevance effect, however, was significantly larger over the right hemisphere for the NRD than for the RD group (Central N220, $F(1,28)= 6.08$, $p<.05$ and Lateral-Frontal N220, $F(1,28)= 5.56$, $p<.05$).

P310 Measure

First Grade Reading Group Differences Involving Stimulus Type and Task Relevance. Univariate analyses of repeated measures revealed significant differences for the P310 measure for the reading groups were in the first but not in the third grade. At the first grade level, significant reading group differences were found over the occipital and frontal brain areas.

Occipital P310. Over the occipital brain regions a main effect of Task Relevance differentiated the reading groups ($F(2,42)= 4.09$, $p<.05$). This effect, illustrated in Figure 17, shows that the better reading groups (NRD and RND) had a larger evoked response to task relevant conditions than did the RD group. Furthermore, the RND group showed larger P310 amplitudes to irrelevant task conditions than either the RD or NRD group, thus resulting in a smaller task relevance effect (relevant minus irrelevant) for the RND group.

Frontal P310. Over the frontal brain regions a significant interaction of Stimulus Type and Reading Group was obtained ($F(2,42)= 2.93$, $p=.06$). This effect, also indicated in Figure 17, shows the RD group had significantly reduced P310 amplitudes to non-letter patterns than to letter stimuli. This main effect of Stimulus Type did not reach statistical significance for the other reading groups.

P470 Measure

A main effect of reading group was revealed through statistical analysis of the P470 measure for both the first ($F(8,78)= 2.28$, $p<.05$) and third ($F(7,22)= 15.63$, $p<.001$) grade data, see Figure 18. In the first grade, this effect of larger P470 amplitude for the non-impaired readers (RND and NRD) reached statistical significance over the occipital ($F(2,42)= 4.11$, $p<.05$) and parietal ($F(2,42)= 4.60$, $p<.05$) cortical regions. At the third grade level, a significant reduction in P470 amplitude for the RD group, as compared to the NRD group, reached statistical significance over the occipital ($F(1,28)= 5.33$, $p<.05$), parietal ($F(1,28)= 9.71$, $p<.005$), temporal-parietal ($F(1,28)= 5.45$, $p<.05$), and lateral-central ($F(1,28)= 15.39$, $p<.001$) regions. Interestingly, at the first grade level, a statistically significant reduction in P470 amplitude was present for the RD and NRD groups compared to the RND group over the frontal region ($F(2,42)= 4.03$, $p<.05$). However, at the third grade level, P470 amplitudes over the frontal region approached statistical significance for differentiating the RD and NRD groups ($F(1,28)= 3.53$, $p=.07$).

First Grade Reading Group Differences Involving Stimulus Type and Task Relevance. The reduction in P470 amplitude as a function of Reading Group interacted with Stimulus Type and Task Relevance over the central region. This effect, shown in Figure 19, differentiated the RD and NRD groups from the RND group. Inspection of these data reveal that all the reading groups showed significantly larger P470 amplitudes to relevant versus to irrelevant task conditions ($F(1,42)= 124.34$, $p<.0001$). The RD and NRD groups, however, showed a larger relevance effect to letter than to non-letter stimuli, while the RND group showed a significantly larger relevance effect to the non-letter than to the letter stimuli ($F(2,42)= 3.64$, $p<.05$).

Third Grade Reading Group Differences Involving Stimulus Type and Task Relevance. An analysis of variance revealed interactions of Electrode Location by Stimulus Type ($F(6,128)= 2.80$, $p<.05$) and Electrode Location, by Hemispheric Activity by Stimulus Type ($F(6,168)= 2.24$, $p<.05$) which differentiated the reading groups. Univariate analysis by electrode location revealed that these effects were significant over the parietal and lateral-central regions. The Lateral-Central P470 measure differentiated the NRD and RD groups as a function of stimulus type ($F(1,28)= 6.91$, $p<.05$). These data, shown in Figure 20, reflect a significantly larger amplitude to the letter than to the non-letter stimuli for the NRD group. A main effect of stimulus type failed to reach statistical significance for the RD group. Over the parietal region an interaction involving Stimulus Type and Hemispheric Activity differentiated the RD and NRD groups ($F(1,28)= 4.80$, $p<.05$). These data, shown in Figure 20, illustrate that the NRD group showed significantly larger right than left hemispheric activity in response to the letter stimuli, and approximate hemispheric symmetry in response to non-letter patterns. In contrast, the RD group failed to show a significant difference in hemispheric activity in P470 amplitude regardless of stimulus type.

Analysis of variance revealed a significant main effect of Task Relevance for all electrodes locations ($F(7,22)= 16.23$, $p<.0001$). A statistically significant interaction of Task Relevance and Hemispheric Activity was also found for all the electrode locations, except over frontal and lateral-frontal regions. At the central electrodes this interaction of Task Relevance and Hemispheric Activity differentiated the reading groups. As shown in Figure 21, the RD and NRD groups showed a Task Relevance effect over both hemispheres but the NRD group showed a larger Task Relevance effect over the right hemisphere than did the RD group ($F(1,28)= 7.79$, $p<.01$). A Task Relevance by Stimulus Type interaction also differentiated the reading groups over the frontal region. This effect, also shown in Figure 21, reveals that the RD group showed a task relevance effect for letter and non-letters stimuli. The NRD group, in contrast, showed a significant effect of task relevance only in response to letter stimuli ($F(1,28)= 4.20$, $p<.05$).

P550 Measure

Univariate analyses of the first and third grade P550 measure revealed a longitudinally stable main effect of Reading Group, with significantly smaller P550 amplitudes for the RD group at both the first ($F(8,78)= 2.28$, $p<.05$) and third grade levels ($F(7,22)= 5.27$, $p<.01$). These data, shown in Figure 22, reveal a significant reduction in P550 amplitude for the RD group, compared to over the parietal electrodes ($F(2,42)= 4.60$, $p<.05$) for the first grade data; and over the parietal ($F(1,28)= 9.74$, $p<.01$), temporal parietal ($F(1,28)= 10.70$, $p<.01$), central ($F(1,28)= 6.01$, $p<.01$), and lateral central ($F(1,28)= 22.89$, $p<.001$) regions for the third grade data. The first grade frontal and occipital P550 amplitude also provided a unique contrast between the RND and NRD groups. The NRD and RD groups showed a significant reduction in Frontal P550 amplitude in comparison to the RND group ($F(1,42)= 4.40$, $p<.05$), while over the occipital electrodes the NRD group showed significantly larger P550 amplitude than either the RND or RD groups ($F(1,42)= 4.21$, $p<.05$). Interestingly the only negative P550 measure for either group occurred for the RD group over the temporal-parietal region.

The analysis of variance procedure also revealed a statistically significant main effect of Hemispheric Activity for the P550 measure at both the first and third grade, see Figure 23. At the first grade level, significantly larger (more positive) Occipital P550 amplitudes were recorded over the right than over the left hemisphere ($F(1,42)= 5.27$, $p<.05$); over the central regions this hemispheric difference was reversed, with larger (more positive) P550 amplitudes occurring over the left than over the right hemisphere ($F(1,42)= 6.75$, $p<.01$). At the third grade level, P550 amplitude was significantly more positive over the right than left hemisphere for the occipital ($F(1,28)= 7.29$, $p<.05$) and temporal-parietal ($F(1,28)= 10.42$, $p<.01$) electrodes. The hemispheric difference in Temporal-Parietal P550 amplitude interacted with Reading Group in the third grade. The NRD group showed a positive amplitude Temporal-Parietal P550 measure with a nonsignificant trend toward larger left than right hemisphere amplitude. In contrast, the RD group as compared to the NRD group showed a significant reduction in Temporal-Parietal P550 amplitude and this reduction in amplitude was greater over the right than over the left hemisphere ($F(1,28)= 5.97$, $p<.05$). The RD group therefore, showed a negatively recorded Temporal-Parietal P550, with a larger and more negative right than left hemisphere amplitude.

Third Grade Reading Group Differences Involving Stimulus Type and Task Relevance. A significant main effect of Task Relevance, with larger P550 amplitudes to relevant than to irrelevant task conditions, was recorded over the occipital ($F(1,28)= 8.04$, $p<.01$), temporal-parietal ($F(1,28)= 12.69$, $p<.005$), parietal ($F(1,28)= 41.01$, $p<.0001$), central ($F(1,28)= 91.97$, $p<.0001$), and frontal ($F(1,28)= 24.11$, $p<.001$) brain regions. A significant interaction of Task Relevance and Hemispheric Activity significantly differentiated the RD and NRD groups. The data shown in Figure 24 indicate larger Central P550 amplitudes to relevant than to irrelevant task conditions over the left but not over the right hemisphere ($F(1,28)= 37.02$, $p<.0001$). This effect is significantly larger in the NRD as compared to RD subjects ($F(1,28)= 5.72$, $p<.05$).

N700 Measure

The N700 measure, as shown in Figure 25, showed a central maximum and a reversal in polarity between the occipital (-) and central (+) electrode locations. The third grade N700 measure provided a statistically significant differentiator of the reading groups as a function of hemispheric activity over the temporal-parietal and lateral-central electrodes. These reading group differences, also shown in Figure 25, reveal a main effect of greater activity over the right than over the left hemisphere for both reading groups ($F(1,28)= 11.09$, $p<.01$). Reading group differences in hemispheric activity for the temporal-parietal region interacted with reading group, with significantly larger right than left hemispheric amplitudes for the RD than for the NRD group ($F(1,28)= 5.98$, $p<.05$). The lateral-central N700 measure, also shown in Figure 25, showed greater right than left hemispheric activity for the NRD group. The RD group showed the reverse hemispheric asymmetry ($F(1,28)= 4.27$, $p<.05$).

First Grade Reading Group Differences Involving Stimulus Type and Task Relevance. Univariate analyses of the N700 measure revealed significant interactions of Stimulus Type by Task Relevance by Hemispheric Activity ($F(2,42)= 4.89$, $p<.05$), and Stimulus Type by Task Relevance ($F(2,42)= 3.33$, $p<.05$) which differentiated the reading groups at the first grade level. Univariate analysis of variance by electrode location revealed that these interactions reached statistical significance over the parietal and frontal regions.

Parietal N700. While a significant main effect of task relevance was found for the occipital ($F(1,42)= 5.76$, $p<.05$), central ($F(1,42)= 5.76$, $p<.05$) and frontal ($F(1,42)= 5.76$, $p<.05$) electrodes, it was the region of polarity transition over the parietal cortex which significantly differentiated the reading groups. Parietal N700 amplitude (see Figure 26) showed a significant Task Relevance by Hemispheric Activity interaction for all the reading groups, with a significantly larger amplitude to relevant than to task irrelevant conditions over the left but not over the right hemisphere ($F(1,42)= 19.58$, $p<.001$). This Task Relevance by Hemispheric Activity effect interacted with Stimulus Type to differentiate the reading groups. As shown in Figure 26, the left hemisphere task relevance effect described above, occurred for both letter and non-letter stimuli in the RD group. This effect was specific to non-letter stimuli in the NRD and RND groups ($F(2,42)=4.89$, $p<.05$).

Frontal N700. Over the frontal region, the main effect of Task Relevance significantly interacted with Stimulus Type such that larger N700 amplitude to relevant than to irrelevant task conditions were recorded to the letter as compared to the non-letter patterns ($F(1,42)= 6.75$, $p<.05$). This enhanced relevance effect to letter stimuli was present for the RD and NRD but not for the RND group ($F(2,42)= 3.33$, $p<.05$), see Figure 27.

CHAPTER IV
DISCUSSION

Visual-perceptual deficit models of dyslexia (e.g., Lovegrove et al., 1990 and Williams & LeCluyse, 1990) and linguistic deficit models of dyslexia (e.g., Vellutino, 1979 and Stanovich, 1988) appear to be antithetical. The purpose of the present study was (1) to investigate in more detail the nature of neural processing deficits found in individuals with reading disability and (2) to examine whether these neural deficits are present early in reading development. It was further suggested that the obtained results could then be applied to provide support consistent with either a visual-perceptual or linguistic deficit model of dyslexia.

The present investigation recorded event-related potential (ERP) and behavioral measures during a black/white discrimination task of letter and non-letter patterns. A group of children, selected in kindergarten as being "At-Risk" for later reading problems, were diagnosed as being either reading disabled (RD) or non-reading disabled (NRD) in the third grade. These two groups of children participated in this experiment during both their first and third grade years. The groups were matched in age and on measures of intellectual and attentional ability. A third group of randomly selected first grade children also participated in the experiment in order to provide a reference base for interpreting the reading group differences between the two experimental groups. Furthermore, measures of continuous rapid naming (RAN) were obtained in order to evaluate the relationship between linguistic performance and performance on the black/white discrimination task.

Random Sample

Behavioral Data

The results of this study indicate that rather than showing the perceptual independence of black/white discrimination abilities from conceptual processes, black/white discrimination performance was significantly influenced by the type of stimulus to be evaluated (letter or non-letter pattern). Recall that the experimental task required the discrimination of stimuli on a physical parameter (black/white) which was indicated by a timed motor response. The present findings showed significantly faster (13.5 msec) and more accurate (2.7%) black/white discrimination performance for letter as compared to non-letter stimuli. These results do not appear to be an artifact of the experimental conditions since a high level of task accuracy was obtained and the average reaction time (522.25 msec) was well within the 900 msec allowed during the experimental task. Thus, for a group of randomly selected first grade subjects the behavioral measures demonstrated a significant influence of stimulus meaning on the ability to perform a black-white discrimination task within the initial 550 msec after stimulus presentation.

In a previous study with older reading disabled and non-reading disabled subjects (Miller & Harter, 1991), a similar letter facilitation effect was observed during a black/white discrimination task. Miller & Harter,

(1991) reported that subjects at two points in development - ages ranging from 9.8 to 11.1 years old and again five years later (average age 15.99 years) - showed faster and more accurate black/white discrimination performance for letter as compared to non-letter patterns. The average reaction times reported by Miller and Harter, (1991), at both the initial and later evaluations (335.7 and 348.9, respectively), were substantially faster than those obtained in the present study. The findings obtained in the present study, when considered with these previous findings, suggest that the influence of stimulus type on black/white discrimination performance can be demonstrated in children as early as the first grade and throughout the high school years (Miller & Harter, 1991).

The results from the present investigation also suggest that the letter facilitation effect reflects, at least in part, the automatic selective processing of these stimuli during the black/white discrimination task. The subjects in the present investigation showed faster processing for the rapid naming of letters and numbers than for colors or objects, a finding consistent with previous research examining rapid naming ability (Wolf, In press). Regardless of the type of stimulus, measures of black/white discrimination performance from these randomly selected first grade children were positively correlated with reading ability and measures of rapid naming of letters and numbers. In obtaining these rapid naming measures alphanumeric stimuli were used to represent letters and numbers, as was the case for the black/white discrimination task. Correlations between measures of black/white discrimination performance and the rapid naming of colored blocks (colors) or line drawings (objects) failed to reach statistical significance. Thus, alphanumeric information (letters and non-letters) appears to have been processed automatically by the randomly selected first grade participants in the study.

The group of subjects that participated in the black/white discrimination task reported by Miller and Harter (1991) also performed a letter/non-letter pattern discrimination task in a study previous reported by Felton and Miller (1990). The data from these two studies revealed slower reaction times of approximately 40 msec when the subjects made letter/non-letter pattern discriminations compared to when they made a black/white discrimination of these same stimuli. These findings suggest that the "facilitative" selective processing of the letter stimuli observed during the black/white discrimination task is different from that which is required in performing a letter/non-letter pattern discrimination of these stimuli.

It should be emphasized that the present investigation was not intended to thoroughly examine the various physical and/or semantic levels of stimulus differences among the letter and non-letter patterns. The experimental task reported here consisted of only two stimulus types (letter and non-letter patterns). It is important to point out that despite attempts to present letter and non-letter patterns of similar size, differences within each stimulus group did exist. Furthermore, the electrophysiological recording procedure used in the present investigation did not allow for inspection of the waveforms for the different stimuli within a stimulus group (e.g., letter or non-letter patterns). Thus, errors on the task could have occurred in a non-random fashion as a function of a physical parameter (size or spatial frequency) within the different stimulus classes. Further investigations with better control over the various physical and semantic stimulus parameters are required to better determine the nature of the interaction between stimulus type and black/white discrimination abilities.

Electrophysiological Data

The results of the electrophysiological data provided information complementary to the behavioral data regarding the black/white discrimination of letter and non-letter patterns. The electrophysiological data obtained in the present study indicated that task relevance and/or the meaningfulness of the stimuli presented produced complex interactions on the ERP waveform throughout the recording epoch.

Findings Involving Task Relevance and Hemispheric Activity

A main purpose of the present investigation was to further examine the effects of task relevance on the activity levels of the two hemispheres as reflected in the ERP waveform. It was predicted that differences in the ERP waveform as a function of task relevance would be manifested throughout the recording epoch, and that such differences would be greater over the left than over the right hemisphere.

The obtained results confirm both of these hypotheses. Recall that the task instructions defined black stimuli as task relevant and white stimuli as task irrelevant. In the present study all of the ERP measures (P120, N220, P310, P470, P550 and N700) were found to be greater to relevant (black) than to irrelevant (white) stimuli. Hemispheric differences also were observed throughout the recording epoch. Early differences consisted of short latency (200-340 msec) cerebral asymmetries which were unrelated to the selective processing of target relevance, with greater N220 and P310 activity over the left than over the right hemisphere. Longer latency ERP differences consisted of posterior cerebral asymmetries involving P470 and P550 and were related to target relevance. The effect of target relevance being greater over the left than over the right hemisphere for these measures.

The effects of task relevance on the ERP measures are consistent with the behavioral data indicating that first graders with "normal" reading skills can selectively attend to black versus white stimuli. The behavioral reaction times revealed that the first grade subjects could perform the black/white discrimination task with a high degree of accuracy (average 95.4% Hits and 5.51% FA) and speed (522.25 msec RT). The task relevance effects on Parietal P120 and N700 indicated that the neural activity associated with black/white selection became active as early as 100-140 msec and continues as late as 640-760 msec (N700) after stimulus presentation. These data are consistent with other findings (see review by Regan, 1989) demonstrating that selective attention effects are manifested in the amplitude changes of the early occurring visually evoked P100 component (P120 in the present study). Previous research has also shown that influences of selective attention can be manifested within 50 msec after stimulus presentation in the somatosensory (Desmedt et. Al, 1985), auditory (McCallum et Al., 1983) and visual modalities (Eason, Oakley & Flowers, 1983 and Oakley & Eason, 1990). Such early influences were not observed in the present study, probably due to the slower sampling rate that was employed.

In the present study, several cerebral asymmetries observed between 200 and 600 msec after stimulus presentation interacted with task relevance. The N220 measure showed greater overall activity over the left than over the right hemisphere and for relevant than irrelevant task conditions. A larger task relevance effect over the left than over the right hemisphere was also obtained for N220. In comparison, the longer latency cerebral asymmetries (posterior P470 and P550) were observed as a function of task relevance. Larger activity over the left than over the right hemisphere was obtained for task relevant stimuli whereas a more symmetrical (P470) or reversed asymmetry (P550) was obtained for task irrelevant stimuli. These findings suggest that the selective processing of task relevance recorded during a black/white discrimination task, as manifested in the amplitudes of N220, P470 and P550, are lateralized over the left hemisphere.

The results obtained for the N220, P470 and P550 measures are consistent with previous findings by Harter and colleagues (for a review see Harter & Aine, 1984), interpreted by them as reflecting the effects of target selection (N2 component) and evaluation (P3 component) on the visually evoked potential. The N2 measure has been shown to reflect variation in target discrimination performance when physical parameters (color, size, location, word, etc.) of the same "target" stimuli are identified as task relevant (Harter & Aine, 1984). The amplitude of the P300 component has been interpreted by some to reflect neural activity indexing the subjective probability and task relevance associated with a stimulus, and frequently is recorded during or after the behavioral response (Donchin & Coles, 1988). The P3 component has been previously reported to be of greater amplitude over the left hemisphere during semantic matching (Thatcher, 1977), letter judgement (Neville, 1980), and black/white discrimination tasks (Harter et Al., 1989); however, it has also been observed to be greater over the right hemisphere during the presentation of spatial task information (Neville, 1980 and Harter et Al., 1990).

The greater neural activity reflected by these measures (N2 and P3 components) over the left hemisphere also is consistent with the contention that these measures reflect activity occurring in the inferotemporal cortex (Harter and Aine, 1984), an area shown during single unit recordings in monkeys to selectively fire as a function of the behavioral relevance of a stimulus (Fuster, 1990). The selective processing reflected in such activity is considered to represent object and pattern recognition processes believed to be essential in left hemisphere mediated language processing (Harter, 1991). The data from multiple depth electrode recordings in humans suggests that activity in the inferior and medial temporal lobes, particularly the hippocampus and amygdala, also contribute to but are not the sole source of these longer latency potentials (Wood et Al., 1984 and Stapleton & Halgren, 1987).

Findings Involving Stimulus Type

The influence of stimulus type (letter or non-letter patterns) on behavioral task performance was generally consistent with the effects observed throughout the ERP epoch. An unexpected result, however, was the influence of stimulus type on the shorter latency ERP measures. Stimulus type was not predicted to affect the short latency P120 measure, since previous research has emphasized the stimulus driven, obligatory nature of the P1 component (Picton & Hillyard, 1988). The amplitude of this component has been proposed to be contingent largely upon the physical and not semantic characteristics of the evoking stimulus. In the present investigation this influence was particularly surprizing, since the type of stimulus (letter or non-letter) pattern was not task relevant.

The results of the present study showed changes in P120 amplitude as a function of electrode site and experimental condition. P120 amplitude, recorded over the frontal regions, showed a larger response to relevant than to irrelevant letter stimuli, but these amplitude differences failed to reach significance for the non-letter patterns . This finding provides evidence for the selective neural processing of letter stimuli within the initial 140 msec of the task. Over the occipital and parietal regions of the left hemisphere, the amplitude of P120 differed for both letter and non-letter stimuli. Furthermore, measures of P120 amplitude obtained in the first grade year were negatively correlated with the latency to perform the rapid naming of letters (RANL) and numbers (RANN) tasks obtained in the first and third grade years (see Table 15)*. Correlations between measures of P120 amplitude and the rapid naming of colors or objects failed to reach statistical significance. This statistical relationship provides additional support for the hypothesis that the letter facilitation effect observed in the behavioral performance of the black/white discrimination task was present in the neural activity as early as 120 msec after stimulus presentation. Future research investigating the origin of the neural generators responsible for these early electrophysiological components are needed in order to relate the functional properties of the P1 component(s) to their underlying neural substrates.

The results obtained for the N2 (N220) and P3 (P470 and P550) components as a function of stimulus type demonstrated greater overall neural activity for letter than/ non-letter stimuli. Furthermore, for these measures stimulus type (1) interacted with task relevance, demonstrating an enhanced task relevance effect for letter stimuli while showing a reduction (Central P470) or absence of any relevance effect (Occipital N220) for the non-letter patterns; and (2) interacted with hemispheric activity, demonstrating an asymmetric hemispheric distribution (L > R) in response to letters but a more symmetrical hemispheric distribution was observed in response to non-letter patterns. These differences in hemispheric asymmetry were associated with a larger neural response to task relevant letters than task relevant non-letter patterns over the left

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* Note: Appendixes I and J contain correlational tables examing the relationship between the electrophysiological measures and performance on the rapid naming (RAN) and reading (WJRSSA) tasks for the Random Sample and Reading Group comparisons, respectively.

hemisphere (Posterior P470 and P550). In contrast to the findings for the P120 measure, the later ERP measures (N220, P470 and P550) were significantly correlated with reading performance (see Table 16). As indicated in Table 16, Left Central P550 amplitude obtained in the first grade year was positively correlated with reading performance (WJRSSA) in the first and third grade years. A similar trend for Right Central P550 amplitude failed to reach statistical significance ($P>.05$). The relationship between N220 and P470 amplitudes and reading performance was present only for the difference between the hemispheres and not for the absolute amplitude in either hemisphere. This relationship was such that greater activity over the left than over the right hemisphere was related to better reading performance in the first (Central-Parietal N220 and Parietal P470) and third grade years (Central-Parietal N220).

The findings from the present study regarding the N2 and P3 components are consistent with Harter's interpretation that these components reflect the active, on-going selective neural processing associated with stimulus type selection and evaluation (Harter, 1990). Harter and colleagues (Harter & Aine, 1984 and Harter, 1990) have suggested that the N2 and P3 components also reflect a left hemisphere specialization for pattern and object recognition processes. Consistent with this hypothesis, the N2 measure in the present study reflected a task relevance effect which was greater over the left hemisphere for both letter and non-letter stimuli. The N2 measure, however, was significantly modified by the type of stimulus, with greater amplitudes recorded to letter than to non-letter patterns. Contrary, to the hypothesis put forth by

Harter, the left hemisphere lateralization for the P3 measure appeared to be dependent upon the type of stimulus being evaluated. This dependence is manifested by the fact that the task relevance effect for letter stimuli was greater for the left hemisphere, whereas for non-letter patterns the effect was more symmetrical over the two hemispheres.

The P310 and N700 measures, although they were not selected "apriori" as measures of interest, findings associated with these measures can provide interpretive insights. In the present study, similar to the findings for N220, P470, and P550, greater neural activity for relevant than irrelevant task conditions was observed for both P310 and N700. In contrast to the findings for these other measures however, P310 and N700 activity were of greater magnitude for the non-letter than for the letter stimuli. In the present investigation, P310 reflected two main effects with larger amplitudes being recorded under relevant than under irrelevant task conditions and for non-letter than for letter stimuli. The P310 measure, therefore, in the present investigation, reflects the selective neural processing of task relevant information which is greater for non-letter than letter stimuli. The P310 measure, appears analogous to the Nc component first reported by Courchesne (1977). The Nc component is developmentally the earliest recorded endogenous ERP component, and has been observed in four month old infants when visual stimuli are used (Courchesne, Ganz, & Norcia, 1981), and in full term neonates when auditory stimuli are used (Kurtzberg, et al., 1986). The Nc component furthermore, has been proposed to reflect the neural activity within the cortical-reticular system, and is considered to be associated with the ability to allocate or modulate attentional resources (Courchesne, 1990). Consistent with these interpretations, the obtained results showed that P310 reversed in polarity over the parietal region. P310 therefore appears to reflect, at least in part, neuronal activity over the parietal region, a brain region considered important in the allocation of attentional processes for the detection and selective processing of information (Posner & Petersen, 1990). Since, the non-letter patterns were unfamiliar but task relevant to the subjects these findings are consistent with the view that the Nc (P310) component reflects the allocation of attentional resources for novel (Courchesne, 1990) and/or meaningful stimuli (Symmes & Eisenhart, 1971).

The Pc component (N700), differed with respect to stimulus type, hemispheric activity and task relevance. In response to task relevant, non-letter patterns, a larger task relevance effect was recorded over the left than over the right frontal regions. A reduced task relevance effect was also recorded over the left occipital regions for the non-letter patterns. These amplitude differences between anterior and posterior recordings suggest a more anterior dipole orientation of the neural generators responsible for the neural activity to task relevant non-letter patterns. The Pc component has been proposed to reflect neural activity associated with the categorizing of events and/or redefining existing hypotheses regarding the task (Courchesne, 1978). The results from the present investigation suggest that by the end of one recording epoch, the ability to categorize a novel stimulus may enhance performance on subsequent trials. The neural activity associated with this categorization appears to be lateralized over the left hemisphere, and may reflect the attachment of semantic or verbal labels to the novel information.

It must be emphasized that the experimental task reported here consisted of only two stimulus types (letter and non-letter patterns). Similar experiments using various stimulus types and task relevant parameters will be necessary to determine if the results reported above apply only to the processing of letter and non-letter patterns during a black/white discrimination task.

Reading Group Comparisons

A main purpose of the present study was to determine further the level(s) of neural processing deficits in individuals with reading disability. It was hypothesized that the visual processing deficits observed in individuals with reading disability would be more specific to the processing of linguistic stimuli. These deficits were also proposed to be present as early as the first grade and that they would persist into the third grade.

Behavioral Data

The results of the present study indicate that, rather than demonstrating inferior performance specific to the processing of letters, reading disabled subjects demonstrated slower and less accurate black/white discrimination performance for both letter - and non-letter patterns. In the first grade, the reading disabled (RD) as compared to the randomized non-reading disabled group (RND) demonstrated slower and less accurate performance on the black/white discrimination task for both stimulus types. Differences between these groups on reaction time (64.8 msec) and task accuracy (9.2%) can't be attributed to group differences in the letter facilitation effect (RT = 13.2 msec and Hits = 1.5 %) since the latter failed to differentiate the reading groups. In both the first and third grades, measures of reaction time failed to differentiate the reading disabled (RD) from the "At-Risk" non-reading disabled group (NRD); however, task accuracy did provide such a differentiation.

Previous studies examining black/white discrimination performance in individuals with reading disability failed to find significant task performance differences. (Harter et al., 1989 and Miller & Harter, 1991). Failure to identify such differences in the older reading disabled subjects could have been due either to the failure to control for significant differences in group intellectual performance or to developmental differences in task difficulty. Another possibility is that there are in fact no differences, and the absence of such differences reflects a developmental shift in the nature of the skills underlying reading disability and/or task performance.

It is important to note that results obtained from the comparison of the RD and NRD children represent a comparison of subjects selected as being "At-Risk" for developing reading problems and who subsequently develop divergent levels of reading proficiency. It seems likely that the non-reading disabled group from the "At-Risk" sample (NRD) was comprised of some individuals who compensated for or overcame their poor reading potential. The results obtained from this group might provide new insights with regard to mechanisms of compensatory reading development. Consistent with the compensatory development hypothesis, black/white discrimination and rapid naming performance for the non-reading disabled subjects from the "At-Risk" sample fell between that of the other two groups ("At-Risk" reading disabled group (RD) and the randomized non-reading disabled (RND) group). It is quite possible however, that the intermediate performance of the "At-Risk" NRD group, in comparison to the other two groups, represents statistical regression toward the mean.

Rapid naming performance for all three reading groups was consistent with previous research indicating slower rapid naming ability in individuals possessing a reading disability, beginning as early as the first grade (Blachman, 1984; Wolf, 1984; Wolf et al., 1986; Felton et al., 1987) and continuing into adulthood (Felton, Naylor & Wood, 1990). In the present study, the RD and NRD groups from the "At-Risk" sample, as compared to the randomized non-reading disabled group (RND), demonstrated slower and more variable performance for the rapid naming of numbers and letters in both the first and third grades. Also, as was the case in the present study, performance differences among reading groups on the rapid naming of colors or objects tend to be inconsistent and are more difficult to ascertain in subjects beyond the first grade (for a review see Wolf, In press).

The finding of a letter facilitation effect during the black/white discrimination task for all three reading groups in the present study is consistent with previous studies demonstrating similar automatic processing abilities for letters and words in poor and better readers

(Guttentag & Haith, 1978 and 1979; and Stanovich, Cunningham & West, 1981). Wolf (In press) has proposed that a failure in fast temporal processing accounts for the rapid naming deficits observed in reading disability. The specificity of these rapid naming deficits are proposed to be more observably stable for information which is highly automatized (letters and numbers), thus making more demands upon the deficient temporal processing mechanism (Wolf, In Press).

It was noted in the results section that a larger amount of variability was present among the performance of the reading as compared to the non-reading disabled groups on the behavioral measures. The diversity of performance in the reading disabled individuals supports the hypothesis raised in previous studies that there are distinct subgroups of reading disabled children characterized by different patterns of deficits. However, this could not be directly tested in the present study due to the small number of reading disabled subjects.

The present rapid naming and black/white discrimination findings fail to support the contention that individuals with reading disability exhibit visual processing deficits specific to the processing of linguistic material. Reading group differences on these measures are more consistent with theories positing a more generalized deficit in visual processing. The findings in the present study support this theoretical alternative in that deficits in rapid naming and black/white discrimination performance were present as early as the first grade and persisted into the third grade.

The letter facilitation effect recorded during the black/white discrimination task supports the notion of an "automatic" interaction between the semantic and physical properties of information during visual perception. While, under certain experimental conditions the visual perceptual or linguistic nature of this interaction can be emphasized, the usefulness of this distinction in models of reading disability or perception appears at best tenuous. However, the interaction between visual perceptual and linguistic processing provides a framework for incorporating the findings of reading disabled individuals benefiting from various visual perceptual (William & LeCluyse, 1990) and linguistic interventions (Felton et al., 1990).

Electrophysiological Data

The main purpose of the electrophysiological investigation was to provide information regarding the nature of the neural deficits associated with reading disability. In addition to the predictions described previously for the behavioral data, it was predicted that reductions in scalp recorded neural activity in children with reading disability would be reflected in a positivity between 80-140 msec (P1), a negativity between 180 and 260 msec (N2) and a positivity between 300 and 600 msec (P3 or P300) after stimulus presentation as a function of the task conditions. It was predicted further, that the RD as compared to the NRD group from the "At-Risk" sample, would exhibit over the posterior brain regions (1) a more symmetrical hemispheric distribution, and (2) a reduction in amplitude which would be greater over the left than over the right hemisphere.

P120 Measure

The P120 measure reflected group differences between the reading disabled (RD) and non-reading disabled (RND and NRD) groups over the anterior (Frontal) and posterior (Occipital and Temporal-Parietal) brain regions for both the first and third grade years. Both brain areas manifested similar differences between the reading groups even though they were of opposite polarity. The polarity reversal therefore, was considered to reflect different sides of the same dipole generator contributing to this measure. Since, the P120 measure exhibited an amplitude maximum over the Occipital and Lateral-Parietal electrode sites, group differences obtained over these brain areas will be discussed further.

Occipital and Lateral-Parietal P120. The P120 measure was maximal over the occipital area when the children were in the first grade and over the lateral parietal area when they were in the third grade. During both the first and third grade years, the RD group showed no significant differences for Occipital P120 amplitude as a function of the experimental task conditions. In contrast, the NRD group produced larger amplitudes to letter than to non-letter patterns and the RND group showed a significant relevance effect for letter but not for non-letter patterns. The amplitude changes in the P120 measure suggested progressively more selective neuronal activity for the RD, NRD and RND groups respectively.

Relating these results to task performance, the groups with the faster and more accurate performance scores showed earlier selective neural processing. This effect however, was only in response to the letter stimuli. For the third grade, reading group differences were observed as a function of differences in hemispheric activity. The RD group showed a significant reduction in Temporal-Parietal P120 amplitude over the right hemisphere, compared to the NRD group. The RD group also had a more symmetrical hemispheric distribution than the "At-Risk" NRD group which showed greater amplitude over the right than left hemisphere. P120 asymmetries were also present over the occipital (L > R) and lateral parietal (R > L) electrode sites for this group.

The differences in P120 amplitude for the reading disabled (RD), as compared to the non-reading disabled (NRD and RND) groups were present as early as the first grade and persisted into the third grade. Therefore, it does not appear that the early presence of neural processing differences, suggested by P120 amplitude differences, can be attributable to divergent reading experiences. The observation of more symmetrical hemispheric activity in the RD, as compared to the NRD group over the lateral parietal region, is consistent with previous anatomical studies of dyslexic brains suggesting abnormal cell assemblies and greater hemispheric symmetry in the peri-sylvian region than in normal children (Hynd & Sermud-Clikeman, 1991).

Recall that the average motor response for all three reading groups was 531.7 msec. Thus, the P120 measure represents neural activity occurring about 400 msec earlier. Such activity is interpreted as reflecting the earliest recorded brain response associated with target selection for letters in the non-reading disabled groups (NRD and RND).. The short latency P1 component has been suggested to reflect, at least in part, activity of the thalamo-cortical connections in the visual system (Schroeder et al., 1991). Thus, the RD P120 effect observed in the present study is consistent with previous electrophysiological findings demonstrating that individuals with reading disability show an amplitude reduction or latency increase for the P1 component (Solan et al., 1990; Harter, 1991, Miller & Harter, 1991 and Livingstone et al., In Press) and anatomical studies demonstrating smaller thalamic cells in individuals with reading disability (Livingstone, et al., In Press).

N220 Measure

At the parietal sites for the first grade data and the central sites for the third grade data the N220 measure was of positive polarity, in contrast to the negative polarity observed at more posterior regions. For each grade level, the N220 measures obtained at these areas of polarity inversion differentiated the reading groups as a function of hemispheric activity and task relevance. At both the first and third grade levels, each reading group manifested larger activity over the left than over the right hemisphere and larger activity to task relevant than to irrelevant stimuli.

It was, however, the interaction of hemispheric activity with task relevance which differentiated the reading groups.

Central-Parietal N220. For the first grade level, the selective neural activity over the left hemisphere, as manifested by N220 amplitude, in particular which differentiated the reading groups. The RD group, as compared to the NRD and RND groups, showed a reduction in the Parietal N220 task relevance effect over the left hemisphere. At the third grade level, a reduced N220 task relevance effect over the right hemisphere also differentiated the reading groups ("At-Risk" RD & "At-Risk" NRD groups).

Previous studies have demonstrated a reduction in positivity at approximately 240 msec (P240) after stimulus presentation over the central brain regions in children (Harter, Diering & Wood, 1988) and adults (Naylor, Wood & Flowers, 1989) with reading disability, as compared to normal readers. This reduction was larger over the left than over the right hemisphere in reading disabled children and symmetrical in reading disabled adults. Naylor et al. (1989), hypothesized that the right hemisphere amplitude of this measure in reading disabled children may be indicative of their potential for remediation.

In general, the findings obtained in the present study are consistent with the earlier findings regarding the N220 measure and reading disability. At the first grade comparison, when the subjects were at the beginning of reading acquisition, N220 amplitude (Harter's and Naylor's P240 measures) over the left hemisphere differentiated the reading groups ("At-Risk" RD vs. "At-Risk" NRD and Random RND groups). However, a reduction in N220 over the right hemisphere differentiated the reading groups ("At-Risk" RD vs. "At-Risk" NRD) at the third grade comparison. The larger right hemisphere task relevance effect, manifested in the "At-Risk" NRD group when at the third grade level, could reflect neural activity associated with compensatory processes acquired since their "At-Risk" selection completed in kindergarten.

In contrast to previous studies (Harter et al., 1989 and Naylor et al., 1989), the present investigation showed that a reduction in N220 amplitude for the reading disabled group, as compared to the non-reading disabled groups (NRD and RND), was dependent on the selective neural processing of task relevance. The scalp distribution, latency and significant task relevance effect for the N220 measure are consistent with the suggestion that this measure is equivalent to a component (N2) believed to reflect the selective processing of stimulus features (Harter & Aine, 1984). In subjects without RD, the present findings suggest that these selective neural processes are more lateralized over the left than right hemisphere In subjects with RD, the neural activity reflected in N220 suggests a different cortical organization or neural deficit related to the selective processing of task relevance for individuals with a reading disability. Furthermore these differences in scalp recorded neural activity were present as early as the first grade, still present at the third grade level and are consistent with the hypothesis that individuals with RD have a neural deficit in the left central-parietal brain region (Galaburda, 1990).

P470 and P550 Measures

Results obtained for the P470 and P550 measures, over the posterior brain regions, are consistent with previous findings and theories regarding the late positive P3 or P300 components. These measures taken together, are therefore considered to be equivalent to the P3 component, and will be identified as such in the following discussion.

Central-Parietal P470 and P550. In the first and third grade levels, the RD group showed a significant reduction in P3 amplitude, compared to the non-reading disabled groups (NRD & RND). The reduction was greatest over the central and parietal brain regions and was present regardless of differences in hemispheric activity, task relevance or stimulus type. This main effect of reduced neural activity, as manifested by P3, could reflect a smaller number of or a less organized discharge of neuronal cell assemblies contributing to the scalp recorded potential at this latency.

The P3 component over the Parietal-Central region also demonstrated several cerebral asymmetries reflecting greater activity over the left than over the right hemisphere at the third grade level. These cerebral asymmetries were recorded separately as a function of task relevance (Central P3) and stimulus type (Parietal P3) for the NRD group. Larger activity was recorded over the left than over the right hemisphere for letter than for non-letter patterns (Parietal P3) and for task relevant than task irrelevant stimuli (Central P3) for the NRD group. For the RD group, the P3 component showed a significant reduction in functional cerebral asymmetry. This reduction was greater over the left than over the right hemisphere, and resulted in more symmetric hemispheric distribution for the RD group.

The findings of longitudinally stable reductions in P3 amplitude over the parietal and central brain regions for the RD group are consistent with previous research on individuals with a reading disability (Preston et al., 1977; and Harter et al., 1988a). The reduction in P3 amplitude, which presumably reflects reduced selective neural processing during both active (task relevance) and passive (stimulus type) conditions is consistent with previous findings in individuals with reading disability (Harter et al., 1988b and 1989). These findings suggest that a reduction in central-parietal P3 may constitute a longitudinally stable neural marker of reading disability. The P3 amplitude effects for the RD group demonstrated a reduction in left hemisphere activity and a more symmetrical distribution in posterior brain activity, compared to "normal" readers. These findings for the P3 measure are consistent with previous anatomical and functional measures showing left posterior hemisphere anomalies and planum temporale symmetry in individuals with dyslexia (Hynd & Sermud-Clikeman, 1990).

Visual-Perceptual vs. Verbal Deficits and RD

Reading disabled individuals have been shown to demonstrate possessing deficits on visual-perceptual (Williams & LeCluyse, 1990, Lovegrove et al., 1990 and Harter, 1991) and verbal processing tasks (Vellutino, 1979 and Stanovich, 1988). The present findings suggest that RD subjects perform a black/white discrimination task less well than age and intellectually matched controls. These differences in discrimination performance fail to support a strong form of the visual-perceptual deficit hypothesis. The performance differences observed for the RD, as compared to NRD group, were not severe enough to limit the RD group's ability to successfully perform the discrimination task as would be predicted in a strong form of the visual-perceptual deficit hypothesis. In comparison, the early interaction of stimulus type on discrimination performance suggests that the performance differences observed for the RD group might be better characterized as reflecting a deficiency in verbal processes. Thus, the inferior black/white discrimination performance for the RD group would be considered to result from the automatic processing of the verbal aspects of the stimulus being discriminated. This interpretation is consistent with previous research demonstrating that it is the ability to translate symbol to sound relationships that individuals with RD have the most difficulty (Vellutino, 1979, Lieberman & Shankweiler, 1985; and Morrison, 1987). The present findings do not provide information regarding the specificity of this deficit, particularly whether these deficiencies are specific for phonetic to symbol associations (Vellutino, 1979) or represent a more general deficit in learning to apply the rules of sound-symbol associations (Morrison, 1987). Future investigations are required to determine the nature and development of the sound-symbol computations which underlie these processes in normal and disabled readers.

It is important to also note that the present findings showed reading group differences on tasks which used alphanumeric information (black/white discrimination task and rapid naming measures). Recall, that by the first grade the subjects had already substantial knowledge regarding the alphabet. The present findings demonstrating that on tasks where the processing of alphanumeric information was either actively (rapid naming) or passively (black/white discrimination task) provided the more robust reading group differences are consistent with previous research demonstrating that alphabetic knowledge is an important sub-process to master early in the development of reading ability (Blachman, 1984 and Liberman & Shankweiler, 1985).

Furthermore, the present findings suggest that therapeutic approaches that emphasize visual-perceptual techniques may provide limited success in helping to remediate individuals possessing a reading disability. A verbal or language training approach appears to provide a more logical course for providing intervention for the disabled reader. Furthermore, the present findings suggest that future investigations examining the visual-perceptual deficit hypothesis and RD, should attempt to control for the degree of verbal requirements either in their stimuli or response requirements to decrease the possibility of finding reading group differences as a function of the verbal task commands.

It should be emphasized that the behavioral and electrophysiological differences in reading disabled, as compared to non-reading disabled subjects observed in the first grade year, do not necessarily confirm nor negate the view of a biological predisposition for developing a reading disability. Subjects in the present study were in the spring semester of their first grade year when the initial electrophysiological and behavioral recordings were obtained. At this point in school, the subjects had already received substantial experience related to the reading process. For example, subjects in the present study displayed a significant level of alphabet and number knowledge while performing the rapid naming tasks. Recall, that performance on the rapid naming tasks of letters and numbers significantly differentiated the reading groups. Furthermore, group differences in reading exposure, training or pre-reading skills acquire in the classroom, home and/or daycare were not ascertained, and could also account for the observed reading group differences for letter as compared to the non-letter patterns on the black/white discrimination task.

SUMMARY AND CONCLUSIONS

One goal of the present investigation was to identify if reading group differences during the black/white discrimination of letters and non-letter patterns would support theories positing a visual perceptual or verbal processing deficit in reading disability. The behavioral and electrophysiological findings demonstrated an interaction of stimulus type on black/white discrimination performance for both normal and disabled readers. This interaction occurred relatively early within the information processing requirements of the task, as manifested through both the behavioral (525 msec) and electrophysiological (100-140 msec) measures. While acknowledging that under certain experimental conditions a distinction between perceptual and linguistic processes may be useful, the present behavioral and neurophysiological data fail to support such a distinction in theories of reading disability. The obtained results, demonstrating that a physical discrimination of a visually presented stimulus can be facilitated by a semantic feature of the stimulus, are more consistent with interactive models of visual perceptual and linguistic deficits involved in reading disability (Fletcher & Satz, 1978).

In the present investigation, letter and non-letter stimuli were briefly presented (50 msec) at visual fixation during a black/white discrimination task. The electrophysiological measures are therefore considered to reflect the neural activity in the geniculo-striate and inferotemporal visual processing system, since they represent the activity of neural regions receiving their major input from the central visual field. The electrophysiological data are consistent with previous ERP research suggesting that the selective processing of information is not accomplished by a single neural mechanism. The interaction of stimulus type on black/white discrimination performance was present in the neural activity across different areas of the brain and at different latencies. The electrophysiological data further suggest that the influence of stimulus type on black/white discrimination is present in neural activity at the level of the thalamo-coritcal projections to striate cortex (P1 component), and that its influence continues to be manifested at the level of the visual projections to the occipitotemporal brain areas (N2 and P3 components). Task relevance effects for the N2 and P3 components were more evident over the left than over the right hemispheres and for letter than for non-letter patterns. Thus, these measures would appear to reflect active and on-going selective processes during a black/white discrimination task which are more lateralized over the left than over the right hemisphere. Future investigations are required to more precisely determine the mechanisms underlying the letter facilitation effect at the neural and cognitive levels of description.

The data presented here suggest deficits in the visual processing of both linguistic and non-linguistic information in individuals with reading disability. The behavioral findings revealed, that on the average the reading disabled subjects showed slower rapid naming for colors, objects, numbers and letters than did non-reading disabled subjects. The more "automatically" processed alphanumeric information resulted in the more robust differences between disabled and non-disabled reading groups. Slower and less accurate performance during the black/white discrimination task also differentiated the reading disabled from the non-reading disabled groups. These differences were present at both the first and third grade evaluations.

The electrophysiological data obtained in the present study provided complementary information to the behavioral findings regarding the types of neural processing deficits associated with reading disability. The RD as compared to the NRD groups, showed several longitudinally stable differences in neural activity over the posterior regions. These deficits are best characterized as reductions in neural activity within the geniculo-striate (P1 component) and occipitotemporal visual system (N2 and P3 components). The longer latency components (N2 and P3) reflect differences in hemispheric activity between the reading groups. These effects showed that for non-reading disabled individuals, the N2 and P3 components findings suggest a left hemispheric specialization for processing task relevant and letter stimuli. These effects were significantly reduced in the RD group, with the reductions being greater over the left than over the right hemisphere, and therefore resulting in a more symmetrical distribution in brain activity for the RD group, as compared to the non-reading disabled groups. These findings are consistent with the hypothesis that RD is associated with a neural deficit in the left posterior brain region (Flowers et al., 1991) and that posterior hemispheric symmetry can provide a neural marker for reading disability (Galaburda, 1988).

In conclusion, the above study provides support for the early interaction between semantic and physical stimulus parameters during visual perception. This interaction between visual perceptual and conceptual processes provides a framework for incorporating visual perceptual (Williams & Lecluyse, 1990) and linguistic deficit (Vellutino, 1979 and Stanovich, 1988) models of reading disability, which had been previously considered antithetical. A thorough description of the mechanisms underlying this interaction should lead toward a more integrated and comprehensive understanding of the developmental mechanisms underlying reading disability.

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APPENDIX A

TABLES 1 TO 16

Table 1. Reading and Intellectual Performance for the Random Sample (n=74).

VARIABLE	MEAN	S.D.	SKEWNESS	RANGE.
AGE1	7.17	0.38	0.09	6.33-8.00
WJRSSA1	107.14	16.17	-0.30	69.00-135.00
WJRSSA3	105.81	14.93	-0.29	69.00-135.00
DICA	32.89	4.38	1.16	28.00-46.00
PPVT1	102.36	18.19	-0.03	54.00-139.00
VIQ3	109.72	18.07	-0.10	62.00-150.00
PIQ3	106.22	15.92	0.20	75.00-149.00
FIQ3	108.88	17.91	0.14	68.00-154.00
RANL1	39.91	14.56	3.20	21.00-123.00
RANN1	38.43	10.25	1.44	22.00-70.00
RANC1	54.78	11.58	0.73	33.00-90.00
RANO1	80.30	30.73	2.16	43.00-220.00
RANL3	28.41	7.48	2.35	19.00-63.00
RANN3	28.41	7.43	2.00	18.00-64.00
RANC3	44.43	11.85	2.98	28.00-115.00
RANO3	60.29	18.52	2.00	35.00-135.00

Table 2. Measures of Acquiring and Completing an Acceptable Performance on the ERP Task for the Random Sample of First Graders (n=74).

VARIABLE	MEAN	S.D.	SKEWNESS	RANGE .
# Practice	16.62	4.87	0.97	16.00-32.00
# Trials	203.61	53.69	0.40	128.00-288.00
Score	163.22	51.29	0.57	76.00-284.00

Table 3. First Grade ERP Task Performance for the Random Sample (n=74) Reported as Mean (Standard Deviation).

VARIABLE	MEAN	S.D.	SKEWNESS	RANGE.
Reaction Time *				
Letters	510.51	60.77	0.56	403.10-687.40
Non-Letters	523.98	60.76	0.45	395.80-702.40
RTSD	123.32	16.68	0.48	82.90-182.10
Hits% *				
Letters	96.12	5.49	-3.21	66.70-100.00
Non-Letters	94.86	6.94	-3.17	56.70-100.00
False Alarms%				
Letters	5.74	4.87	1.55	0.00-25.00
Non-Letters	5.28	5.02	1.67	0.00-27.00

* Main effect for stimulus type $p<.001$

Table 4. Partial Correlations Between First Grade ERP Task Performance and Measures of Continuous Rapid Naming (RAN) and Reading Abilities (WJRSSA), After the Linear Effects of Age, Verbal Intelligence and Attentional Ratings Have Been Removed in a Random Sample of First Grade Children (n=74).

FIRST GRADE ERP TASK PERFORMANCE

	LETTERS			SHAPES		
	RT	HIT	FA	RT	HITS	FA.
RANL1	NS	-.131	NS	NS	-.208	NS
RANN1	NS	-.340	NS	NS	-.402	NS
RANC1	NS	NS	NS	NS	NS	NS
RANO1	NS	NS	NS	NS	NS	NS
RANL3	NS	-.300	NS	NS	-.405	NS
RANN3	NS	-.417	NS	NS	-.483	NS
RANC3	NS	NS	NS	NS	NS	NS
RANO3	NS	NS	NS	NS	NS	NS
WJRSSA1	NS	.240	NS	NS	NS	NS
WJRSSA3	NS	NS	NS	NS	NS	NS

r=.232 p<.05
r=.302 p<.01
r=.380 P<.001

Table 5. Selection of the Electrophysiological Measures for the Random and "At-Risk" Samples.

		POLARITY FOR ELECTRODE LOCATION			
MEASURE	LATENCY	O1&O2	P3&P4	C3&C4	F3&F4
P120	(100-140 msec)	+	-	-	-
N220	(200-240 msec)	-	+	+	+
P310	(280-340 msec)	+	-	-	-
P470	(440-500 msec)	+	+	+	+
P550	(500-600 msec)	+	+	+	+
N700	(640-760 msec)	-	-	-	-

Table 6. Descriptive Statistics for the Electrophysiological Components for the Random Sample (n=74).

VARIABLE	MEAN	S.D.	SKEWNESS	RANGE.
OCCIPITAL				
P120	7.43	3.99	0.32	-0.19 to 17.74
N220	-12.57	7.17	-0.45	-31.29 to -0.65
P310	9.08	4.96	-0.19	-5.20 to 20.70
P470	6.32	3.95	0.28	-2.95 to 18.70
P550	0.88	3.63	0.00	-7.01 to 9.94
N700	-4.04	4.20	-0.37	-15.55 to 4.86
PARIETAL				
P120	-1.26	2.31	-0.01	-6.54 to 4.33
N220	7.98	4.46	-0.31	-4.38 to 17.88
P310	8.81	3.70	-0.22	-2.06 to 15.94
P470	6.86	4.26	-0.01	-3.83 to 16.61
P550	3.77	3.84	0.10	-6.35 to 13.74
N700	0.49	3.94	0.00	-9.85 to 11.13
CENTRAL				
P120	-2.65	2.18	-0.22	-8.94 to 3.25
N220	11.47	4.69	-0.09	-0.56 to 21.54
P310	-1.87	3.34	-0.39	-10.10 to 4.85
P470	7.72	4.49	0.09	-0.99 to 18.88
P550	6.99	3.88	0.25	-2.00 to 17.74
N700	5.87	3.75	0.16	-3.46 to 16.35
FRONTAL				
P120	-3.66	2.52	-0.11	-10.50 to 4.09
N220	12.12	4.10	0.51	4.75 to 26.40
P310	-5.73	4.48	0.99	-13.43 to 12.66
P470	3.69	4.42	0.87	-4.65 to 18.15
P550	3.34	4.15	0.85	-4.64 to 17.18
N700	5.35	4.43	0.80	-3.73 to 18.03

Table 7. Reading and Intellectual Performance as a Function of Group Assignment. Group Averages (n=15) for the Reading Disabled and Non-Reading Disabled Subjects From the "At-Risk" Sample (RD and NRD, Respectively) and the Non-Reading Disabled Subjects From the Random Sample (RND) Reported as Mean (Standard Deviation).

Assignment Variable	READING GROUP RD	NRD	RND
WJRSSA1 #	81.47(8.31)	104.33(9.89)	103.40(12.05)
WJRSSA3 #	77.80(6.53)	107.40(9.00)	103.87(10.19)
VIQ3	93.60(11.54)	101.13(7.55)	96.80(11.67)
PIQ3	95.53(12.59)	99.33(9.71)	94.73(8.23)
FIQ3	93.93(11.37)	99.93(7.83)	95.27(9.27)

# Indicates a significant main effect for reading group between RD vs. NRD and RND groups at p<.001.

Table 8. Group (n=15) Descriptions on the Matching Variables (Age, Intellectual Performance and DICA Ratings) as a Function of Reading Group Assignment for the Reading Disabled and Non-Reading Disabled Subjects From the "At-Risk" Sample (RD and NRD, Respectively) and the Non-Reading Disabled Subjects From the Random Sample (RND) Reported as Mean (Standard Deviation).

Matching Variable	RD	NRD	RND
AGE1	6.83(0.42)	6.58(0.43)	6.97(0.42)
PPVT1	91.07(12.66)	94.07(15.00)	93.20(15.50)
DICA	37.13(3.29)	35.93(3.88)	35.67(5.43)

Table 9. Reading Group (n=15) Performance on Measures of Rapid Naming for the Reading Disabled and Non-Reading Disabled Subjects From the "At-Risk" Sample (RD and NRD, Respectively) and the Non-Reading Disabled Subjects From the Random Sample (RND) Reported as Mean (Standard Deviation).

1ST Grade Performance	RD	NRD	RND
RANL1 *	81.87(61.70)	48.80(14.82)	40.60(6.71)
RANN1 * #	75.47(46.53)	47.67(16.09)	36.20(4.62)
RANC1	69.20(15.74)	62.40(12.12)	58.00(11.46)
RANO1	116.40(45.32)	89.67(22.13)	91.27(40.90)

3RD Grade Performance	RD	NRD	RND
RANL3 ** #	43.60(12.99)	35.47(11.53)	27.33(4.87)
RANN3 ** #	42.80(14.22)	35.20(9.97)	27.07(4.76)
RANC3	56.93(15.17)	50.67(13.70)	45.33(7.72)
RANO3 *	81.33(21.13)	64.73(13.50)	60.20(12.49)

* Indicates a RD vs. RND reading group differences p<.01

** Indicates a RD vs. RND reading group differences p<.01

\# Indicates a NRD vs. RND reading group differences p<.001

Table 10. First Grade Measures of Acquiring and Completing an Acceptable Performance on the ERP Task as a Function of Reading Group Assignment. Group (n=15) Averages for the Reading Disabled and Non-Reading Disabled Subjects From the "At-Risk" Sample (RD and NRD, Respectively) and the Non-Reading Disabled Subjects From the Random Sample (RND) Reported as Mean (Standard Deviation).

Variable	RD	NRD	RND
# Trials	224.0(41.5)	214.2(48.9)	216.5(60.7)
# Practice	28.5(20.4)	20.3(11.3)	17.1(4.1)
Score	152.3(40.9)	166.7(43.6)	185.0(57.9)

Table 11. First Grade Reaction Time and Task Accuracy Performance on the ERP Behavioral Task as a Function of Reading Group Assignment. Group (n=15) Averages for the Reading Disabled and Non-Reading Disabled Subjects From the "At-Risk" Sample (RD and NRD, Respectively) and the Non-Reading Disabled Subjects From the Random Sample (RND) Reported as Mean (Standard Deviation).

Variable	RD	NRD	RND
Reaction Time * ##			
Letters	555.3(66.8)	529.6(51.3)	490.0(50.9)
Non-Letters	567.9(66.6)	543.5(55.3)	503.7(54.5)
RTSD #	138.0(16.6)	131.4(14.4)	122.9(11.6)
Hits% * ### @			
Letters	88.3(8.0)	94.3(6.4)	96.5(2.7)
Non-Letters	86.9(7.5)	92.8(6.9)	97.0(1.9)
False Alarms%			
Letters	5.7(4.2)	5.3(4.6)	7.2(4.5)
Non-Letters	6.3(3.6)	4.7(5.4)	5.0(4.1)

* Main effect for stimulus type p<.001
\# Main effect for Reading group comparison (RD vs RND) p<.05.
\## Main effect for Reading group comparison (RD vs RND) p<.01.
\### Main effect for Reading group comparison (RD vs RND) p<.001.
@ Main effect for Reading group comparison (RD vs NRD) p<.01.

Table 12. Partial Correlations Between First Grade ERP Task Performance and Measures of Continuous Rapid Naming (RAN) and Reading Abilities (WJRSSA), After the Linear Effects of Age, Verbal Intelligence and Attentional Ratings Have Been Removed in Three Groups (RD, NRD and RND Groups) of First Grade Subjects Differing in Reading and/or Selection Procedures (n=45).

FIRST GRADE ERP TASK PERFORMANCE

	LETTERS			SHAPES		
	RT	HIT	FA	RT	HITS	FA
RANL1	NS	NS	NS	NS	NS	NS
RANN1	.305	-.330	NS	NS	-.402	NS
RANC1	.344	NS	NS	.305	NS	NS
RANO1	NS	NS	NS	NS	NS	NS
RANL3	.316	-.363	NS	NS	NS	NS
RANN3	NS	NS	NS	NS	NS	NS
RANC3	NS	NS	NS	NS	NS	NS
RANO3	.414	-.441	NS	.364	-.401	NS
WJRSSA1	-.315	.395	NS	NS	.441	NS
WJRSSA3	-.364	.434	NS	-.319	.530	NS

r=.304 p<.05
r=.393 p<.01
r=.490 P<.001

Table 13. Third Grade Measures of Acquiring and Completing an Acceptable Performance on the ERP Task as a Function of Reading Group Assignment. Group (n=15) Averages for the Reading Disabled and Non-Reading Disabled Subjects From the "At-Risk" Sample (RD and NRD, Respectively) Reported as Mean (Standard Deviation).

Variable	RD	NRD
# Trials	202.7(63.0)	200.5(38.2)
# Practice	37.7(12.3)	43.3(19.9)
Score	170.4(54.5)	167.1(35.5)

Table 14. Third Grade ERP Task Performance as a Function of Reading Group Assignment. Group (n=15) Averages for the Reading Disabled and Non-Reading Disabled Subjects From the "At-Risk" Sample (RD and NRD, Respectively) Reported as Mean (Standard Deviation).

Variable		RD	NRD
Reaction Time	*		
Letters		486.4(66.7)	469.6(41.6)
Non-Letters		498.8(68.6)	480.0(44.2)
RTSD	#	120.5(14.0)	108.6(12.3)
Hits%	#		
Letters		97.1(2.4)	98.4(1.8)
Non-Letters		95.9(4.1)	98.1(2.2)
False Alarms%			
Letters		5.5(4.7)	5.1(6.0)
Non-Letters		3.4(2.4)	5.5(4.9)

* Main effect for stimulus type p<.001
# Main effect for Reading group comparison (RD vs NRD) p<.05.

Table 15. Spearman Rank Correlation Coefficients Between First Grade P120 Amplitudes and Measures of Continuous Rapid Naming (RAN) and Reading Ability (WJRSSA) in a Random Sample of First Grade Children (n=74).

P120 AMPLITUDE

	RANL1	RANN1	RANC1	RANO1	WJRSSA1
O1	-0.218	-0.217	NS	NS	NS
O2	-0.263	-0.303	NS	NS	NS
P3	NS	NS	NS	NS	NS
P4	-0.243	-0.259	NS	NS	NS
C3	NS	NS	NS	NS	NS
C4	NS	NS	NS	NS	NS
F3	NS	NS	NS	NS	NS
F4	NS	NS	NS	NS	NS

	RANL3	RANN3	RANC3	RANO3	WJRSSA3
O1	-0.312	-0.237	NS	NS	NS
O2	-0.359	-0.368	NS	NS	NS
P3	NS	NS	NS	NS	NS
P4	NS	NS	NS	NS	NS
C3	NS	NS	NS	NS	NS
C4	NS	NS	NS	NS	NS
F3	NS	NS	NS	NS	NS
F4	NS	NS	NS	NS	NS

$r=.232$ $p<.05$
$r=.302$ $p<.01$

Table 16. Spearman Rank Correlation Coefficients Between First Grade N2 (N220) and P3 (P470 and P550) Amplitudes and Measures of Reading Ability (WJRSSA) in a Random Sample of First Grade Children (n=74).

	WJRSSA1			WJRSSA3		
	N220	P470	P550	N220	P470	P550
O1	NS	NS	NS	NS	NS	NS
O2	NS	NS	NS	NS	NS	NS
P3	NS	NS	NS	NS	NS	NS
P4	NS	NS	NS	NS	NS	NS
C3	NS	NS	0.328	NS	NS	0.294
C4	NS	NS	0.218	NS	NS	0.223
F3	NS	NS	NS	NS	NS	NS
F4	NS	NS	NS	NS	NS	NS
P3- P4	0.240	0.238	NS	0.253	NS	NS
C3-C4	0.260	NS	NS	0.253	NS	NS

r=.232 p<.05
r=.302 p<.01

APPENDIX B

FIGURES 1 TO 27

FIGURE 1: COMPONENT SELECTION

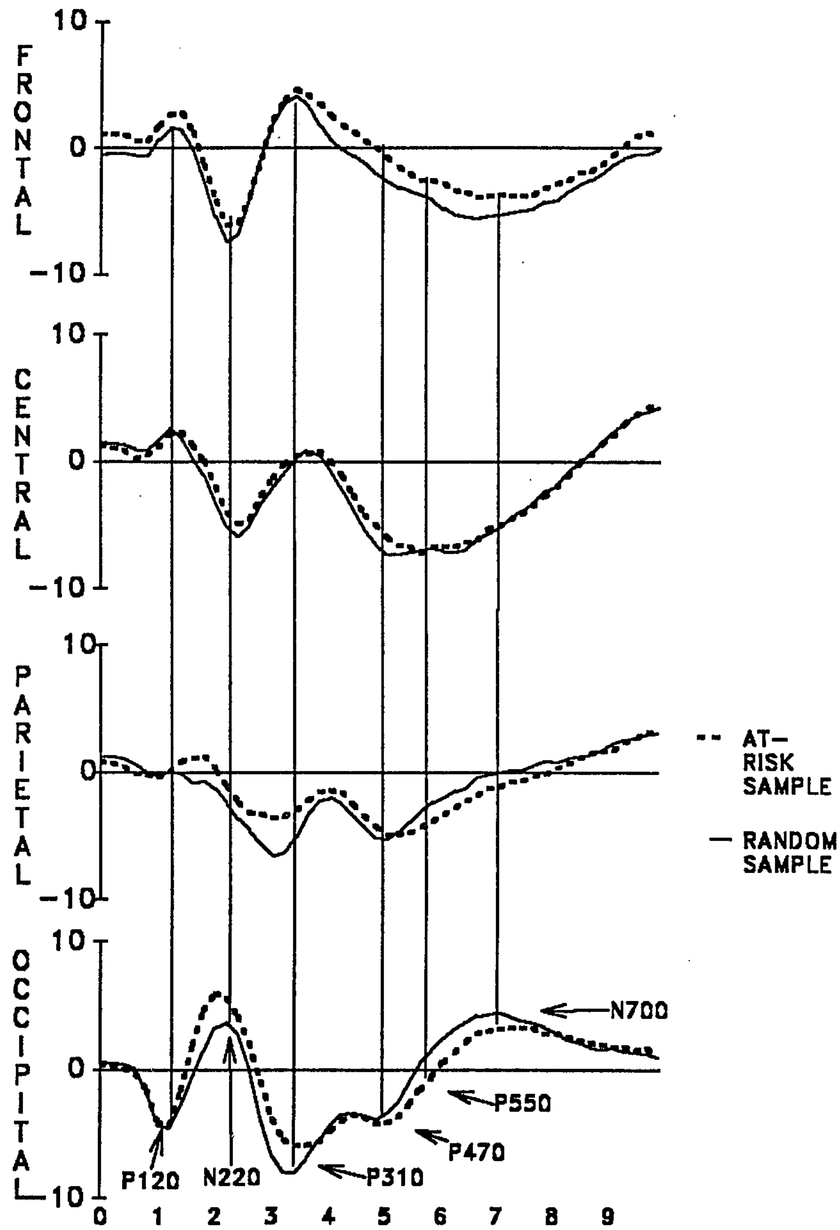


FIGURE 2: P120 AMPLITUDE

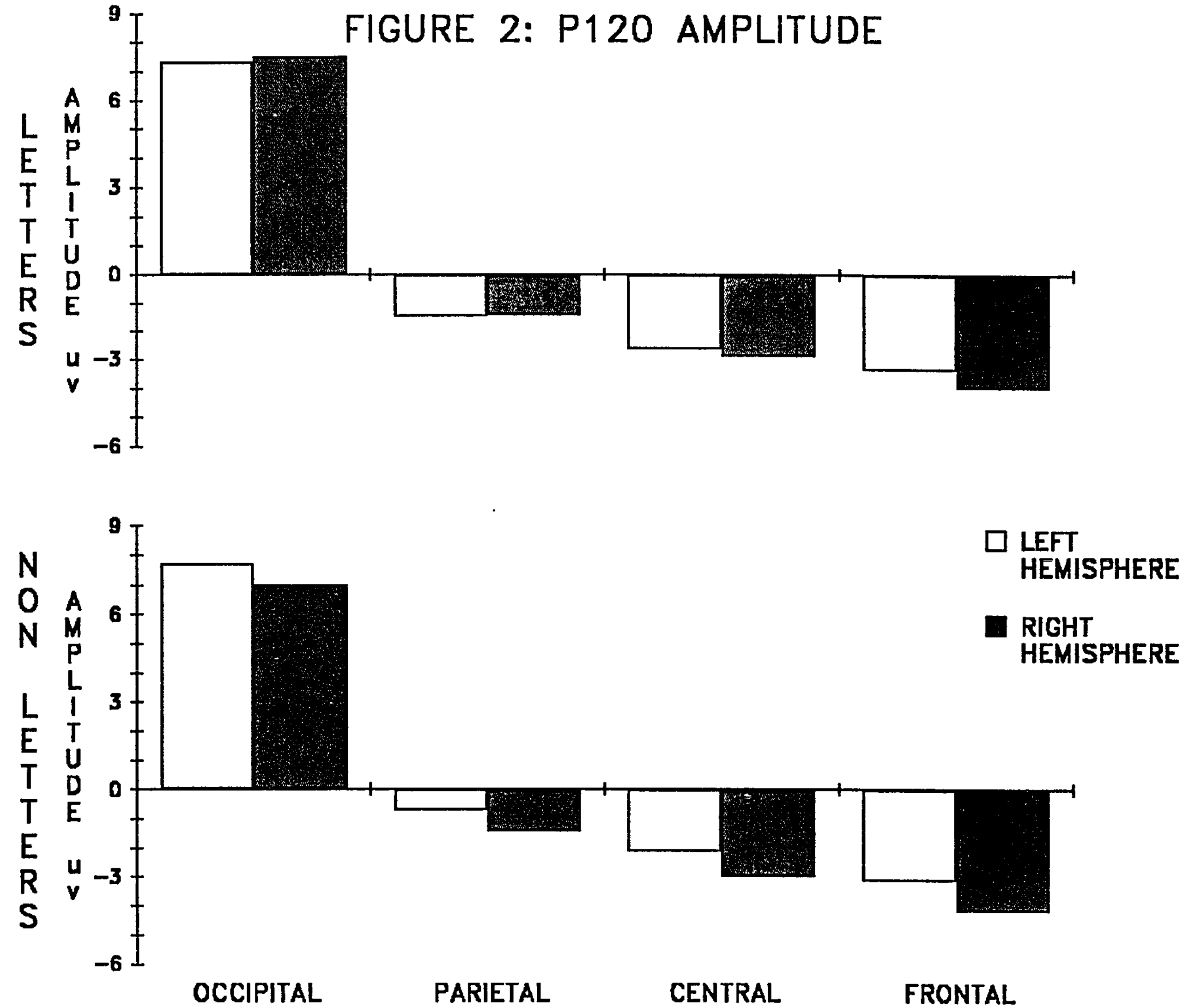


FIGURE 3: P120 AMPLITUDE

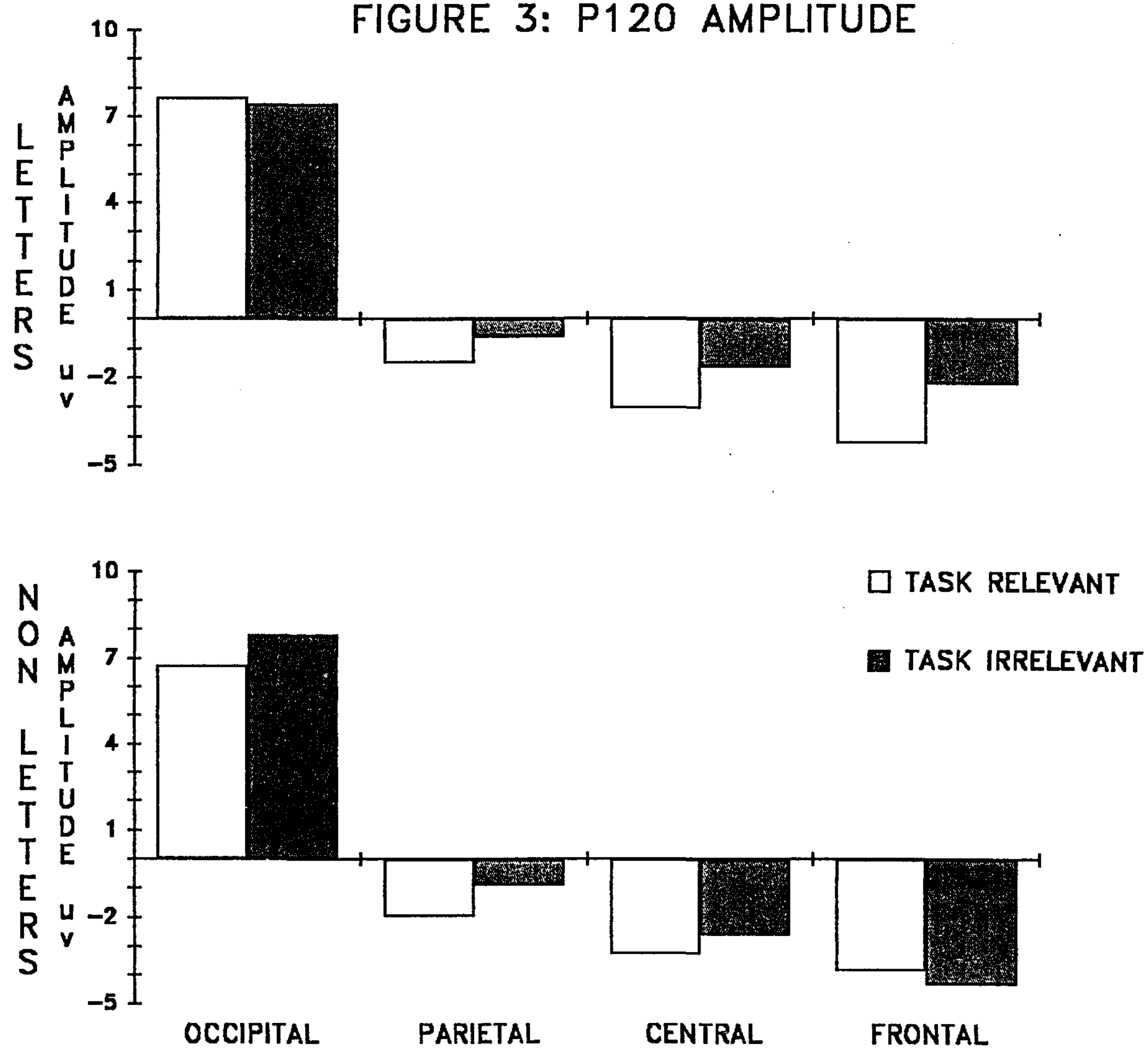


FIGURE 4: N220 AMPLITUDE

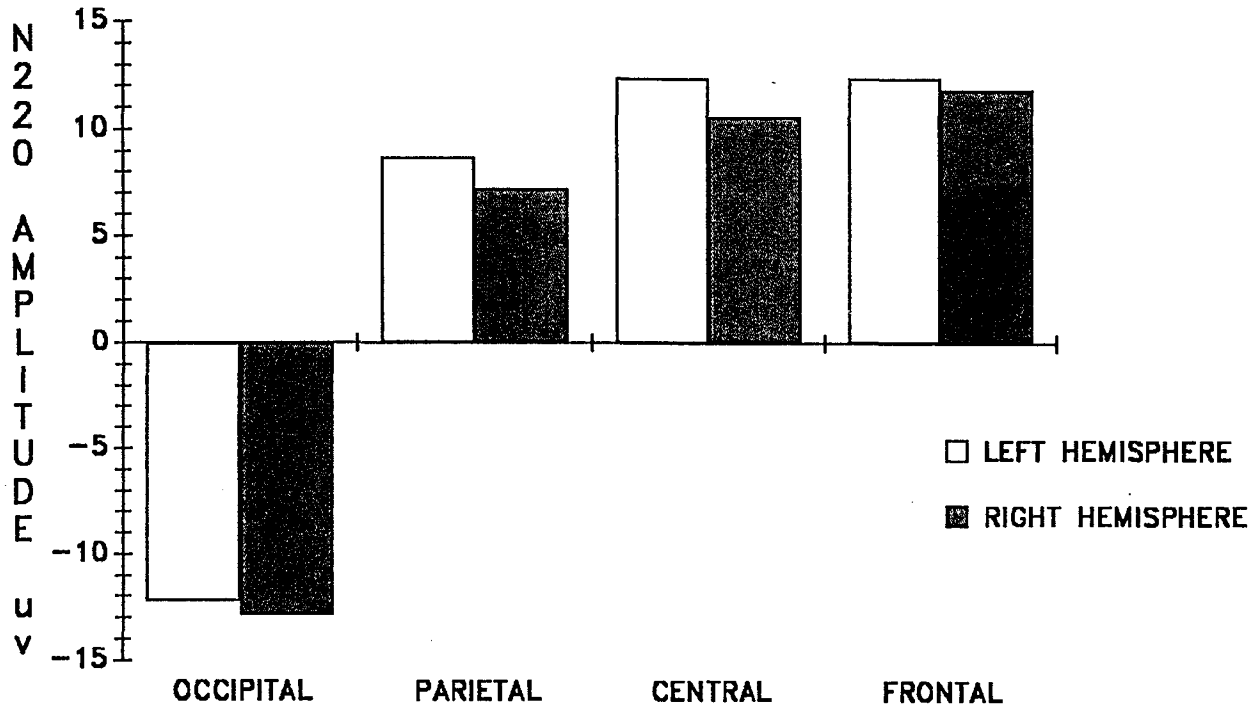


FIGURE 5: N220 AMPLITUDE

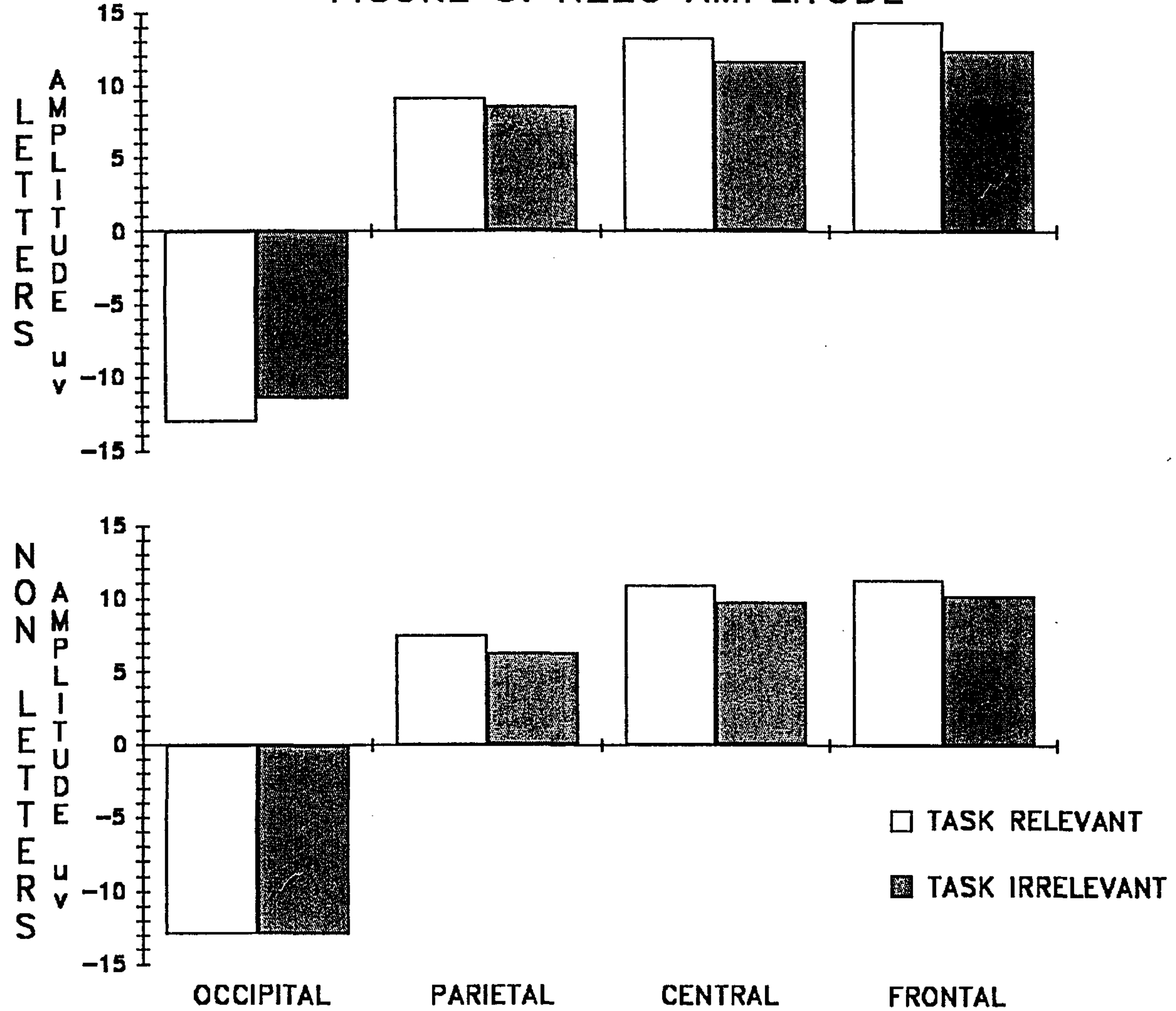


FIGURE 6: P310 AMPLITUDE

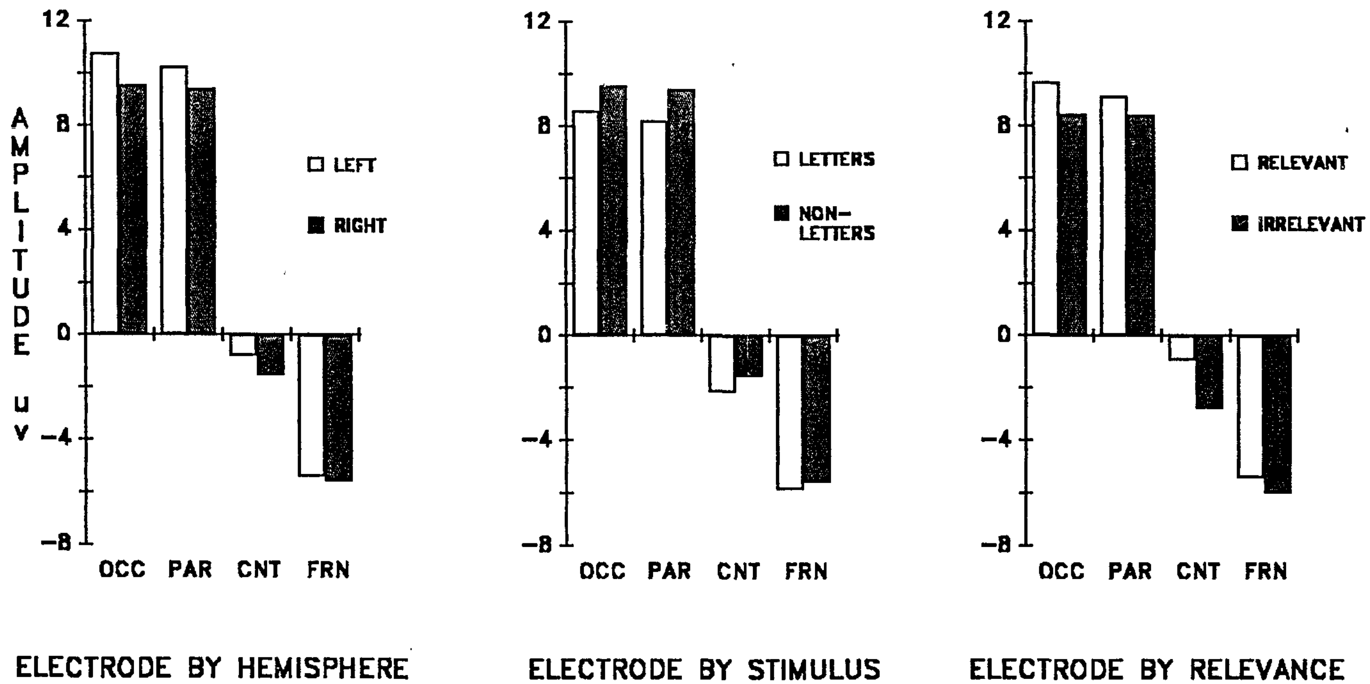


FIGURE 7: P470 AMPLITUDE

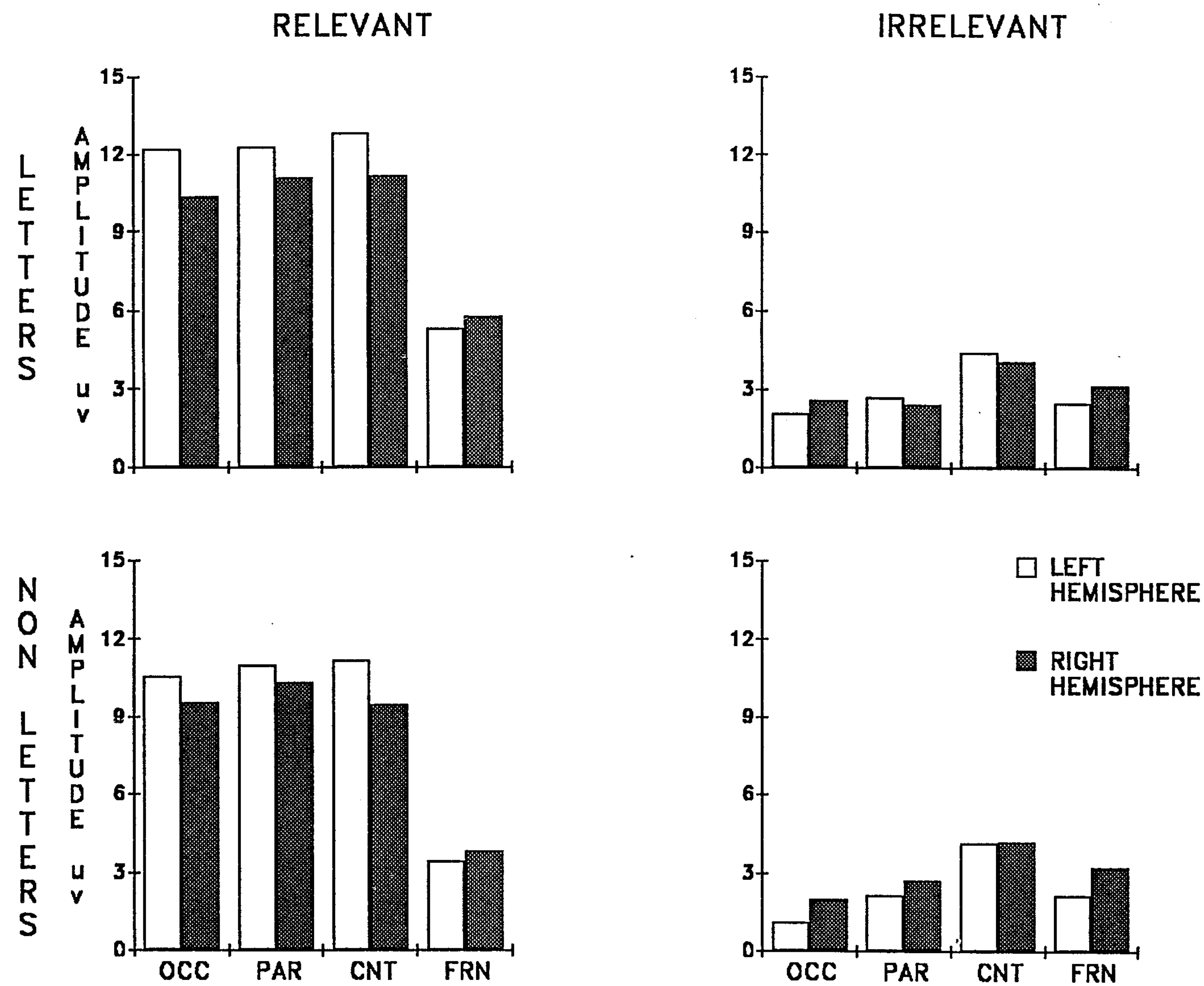


FIGURE 8: P550 AMPLITUDE

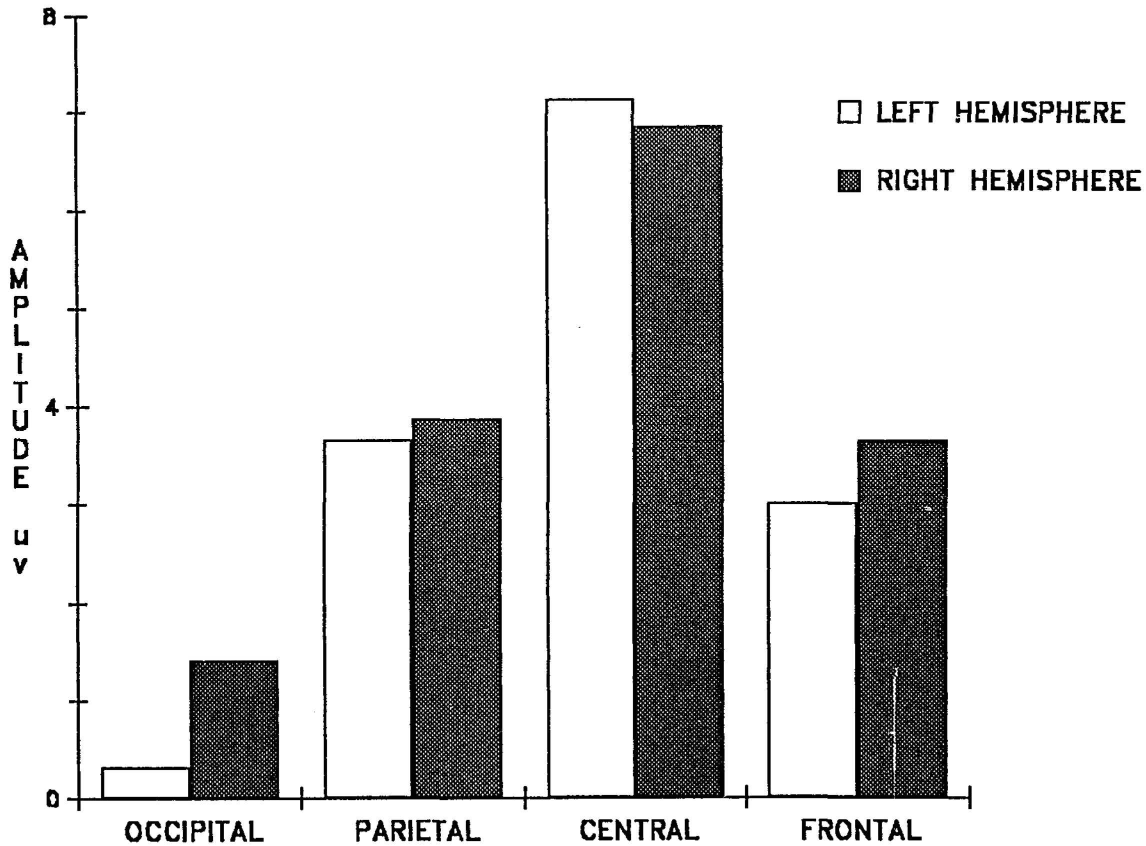


FIGURE 9: P550 AMPLITUDE

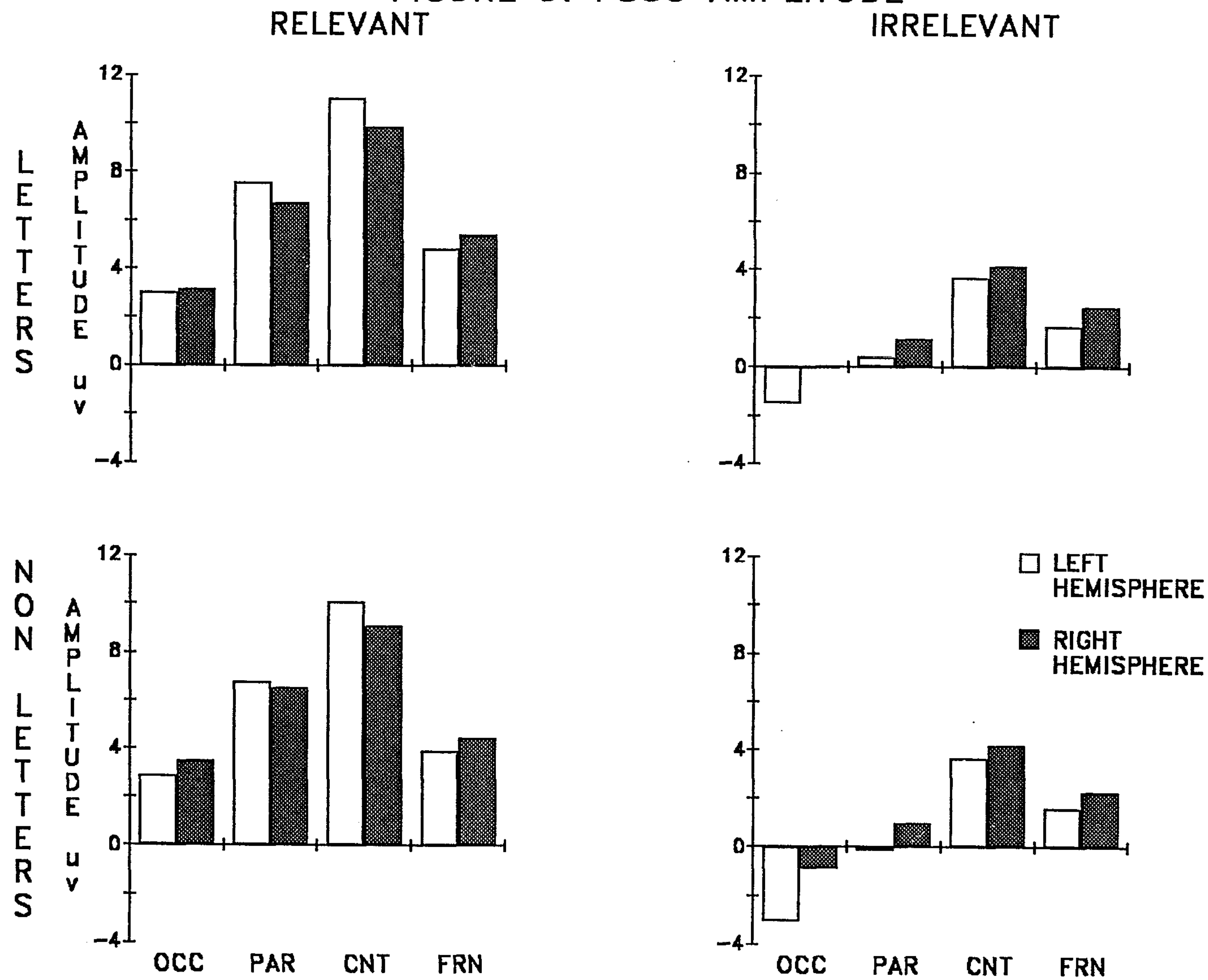


FIGURE 10: N700 AMPLITUDE

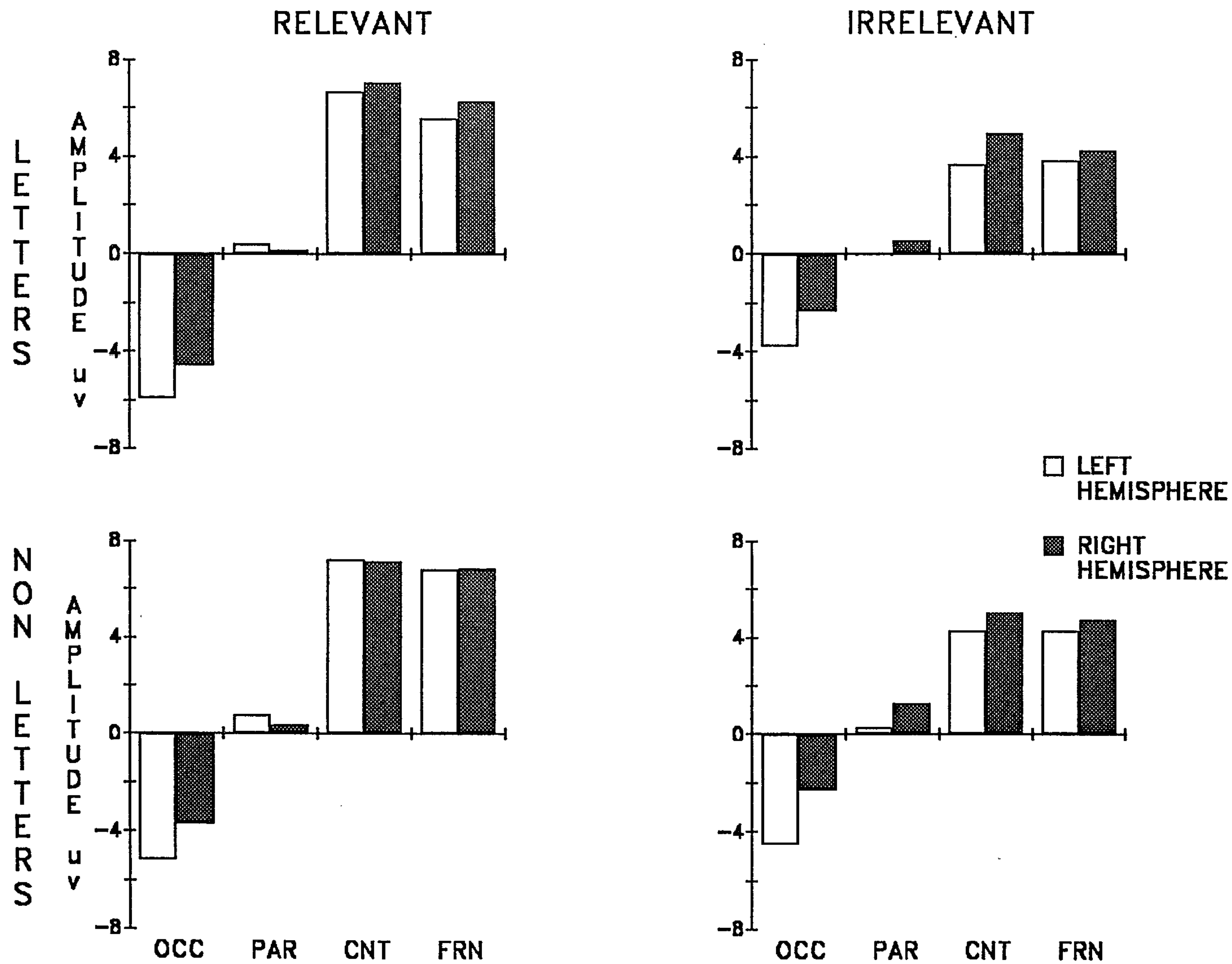


FIGURE 11: OCCIPITAL P120 AMPLITUDE

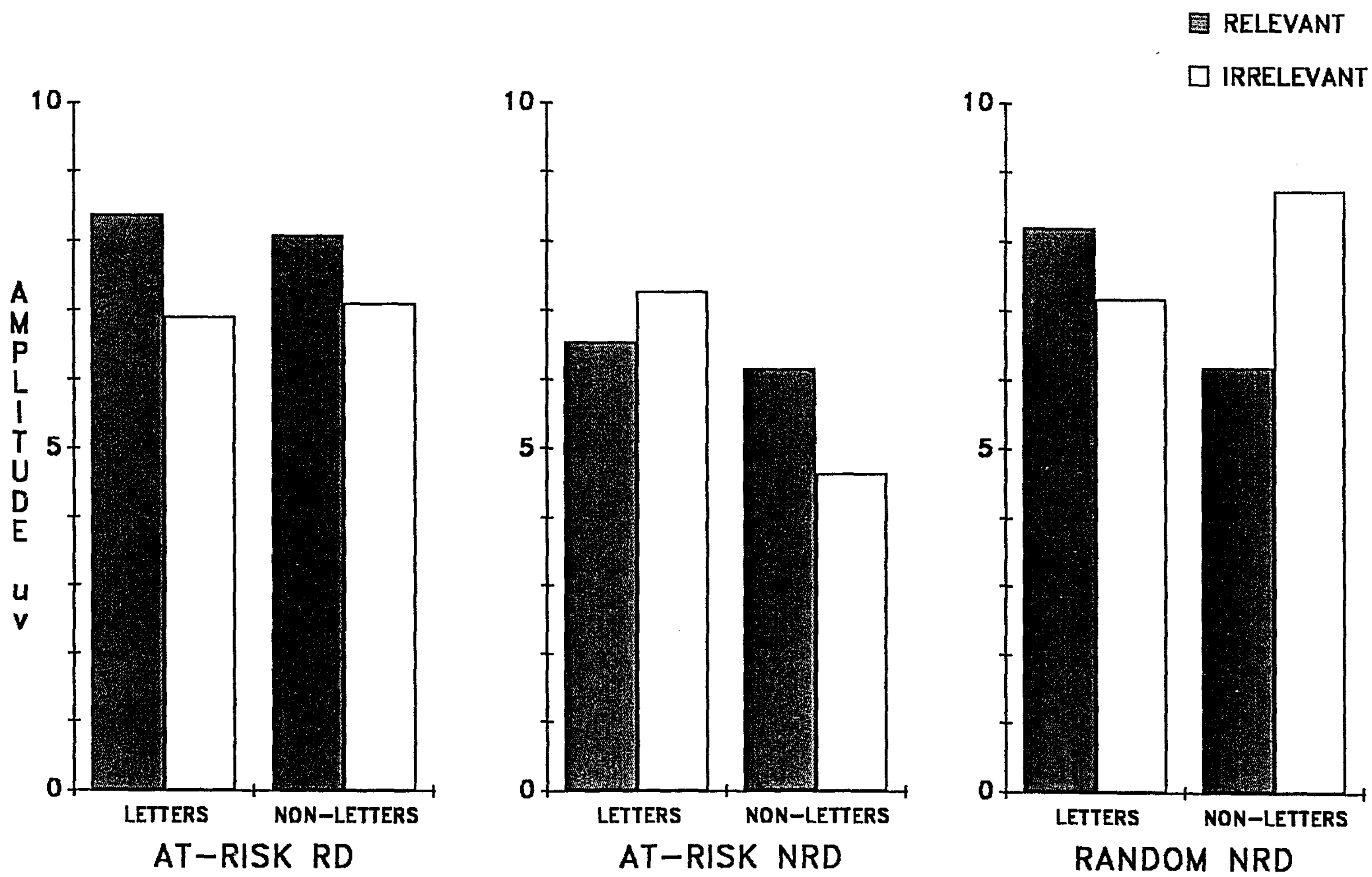


FIGURE 12: FRONTAL P120 AMPLITUDE

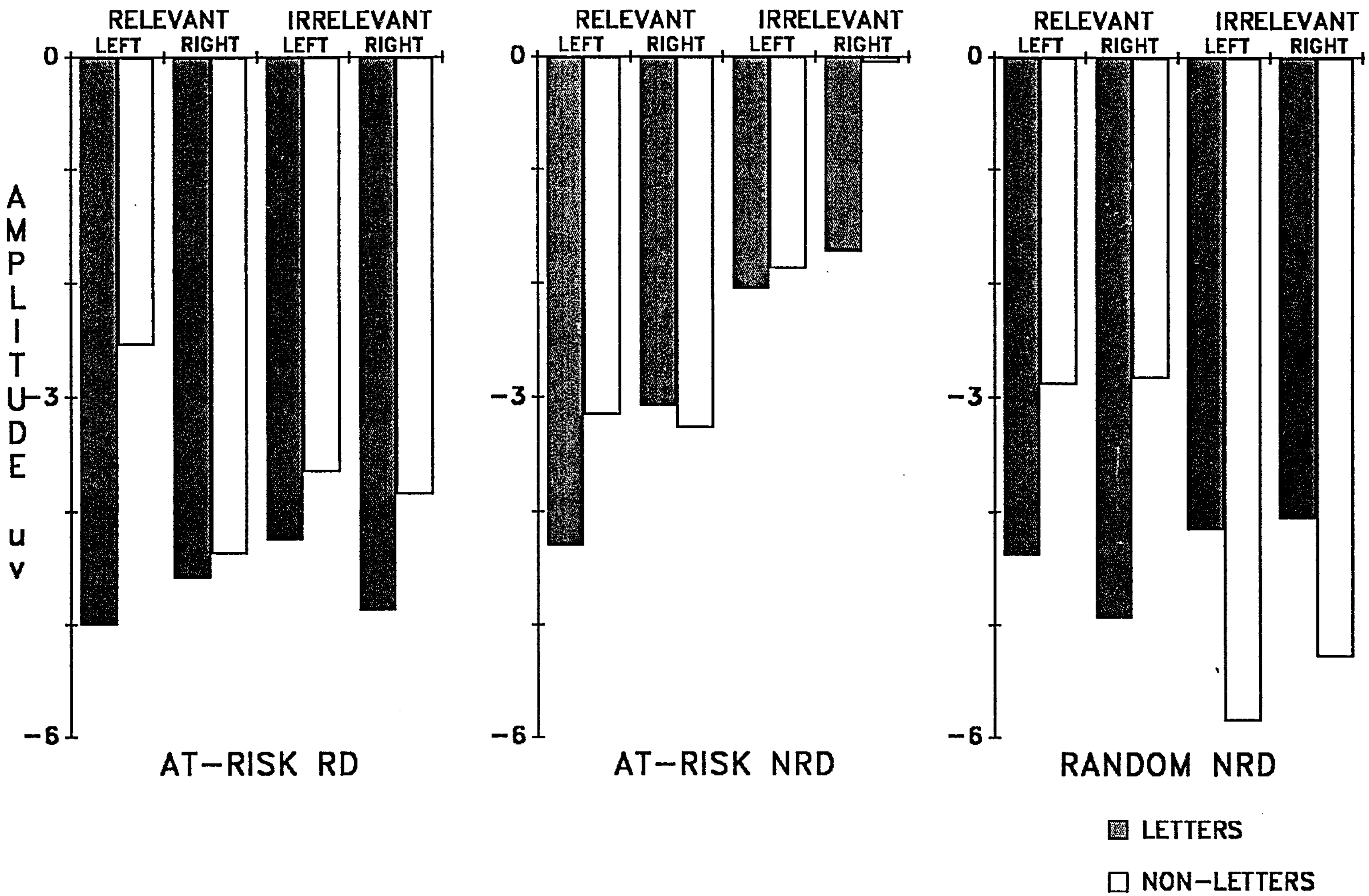


FIGURE 13: CENTRAL AND FRONTAL P120 AMPLITUDE

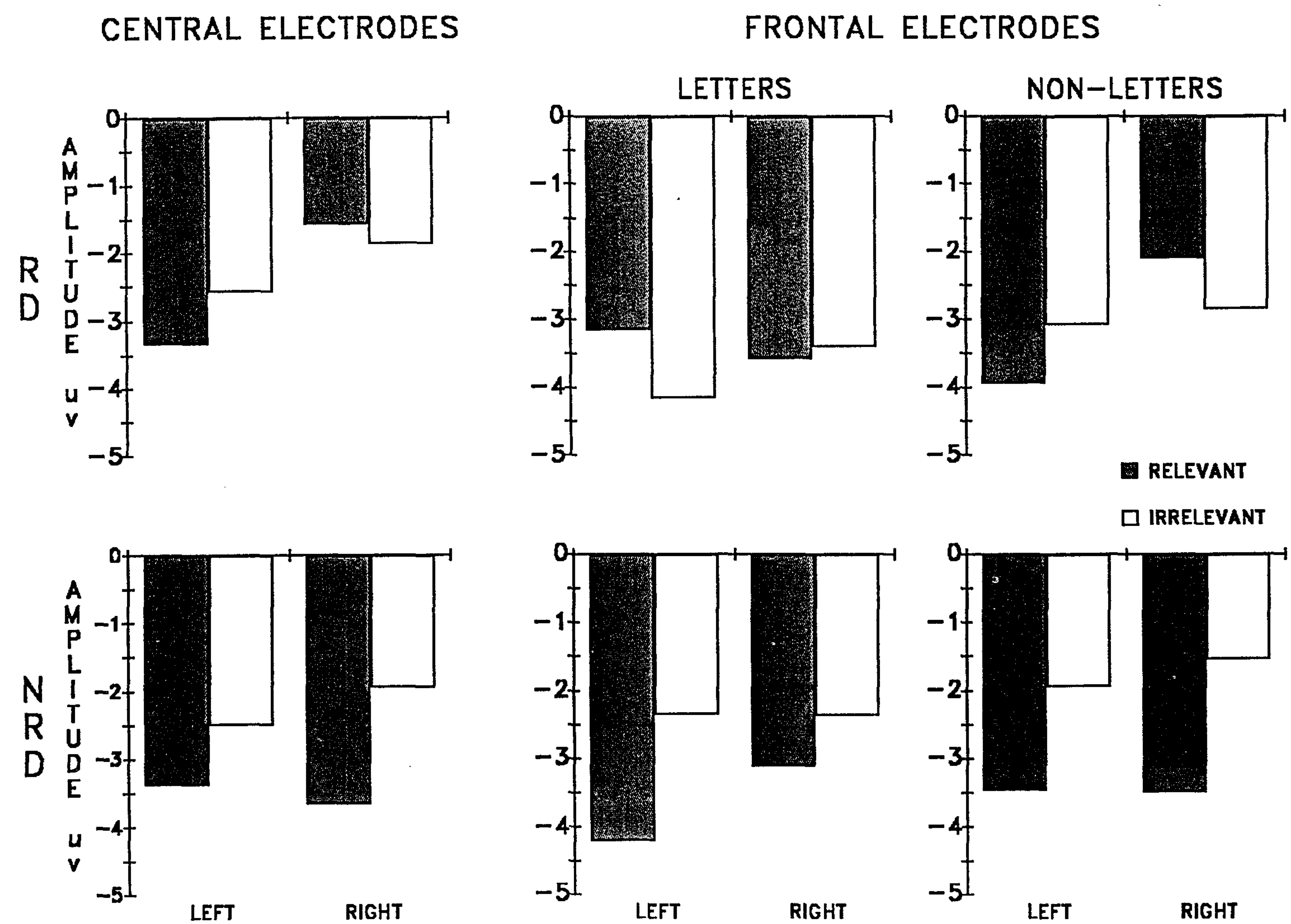


FIGURE 14: P120 AMPLITUDE

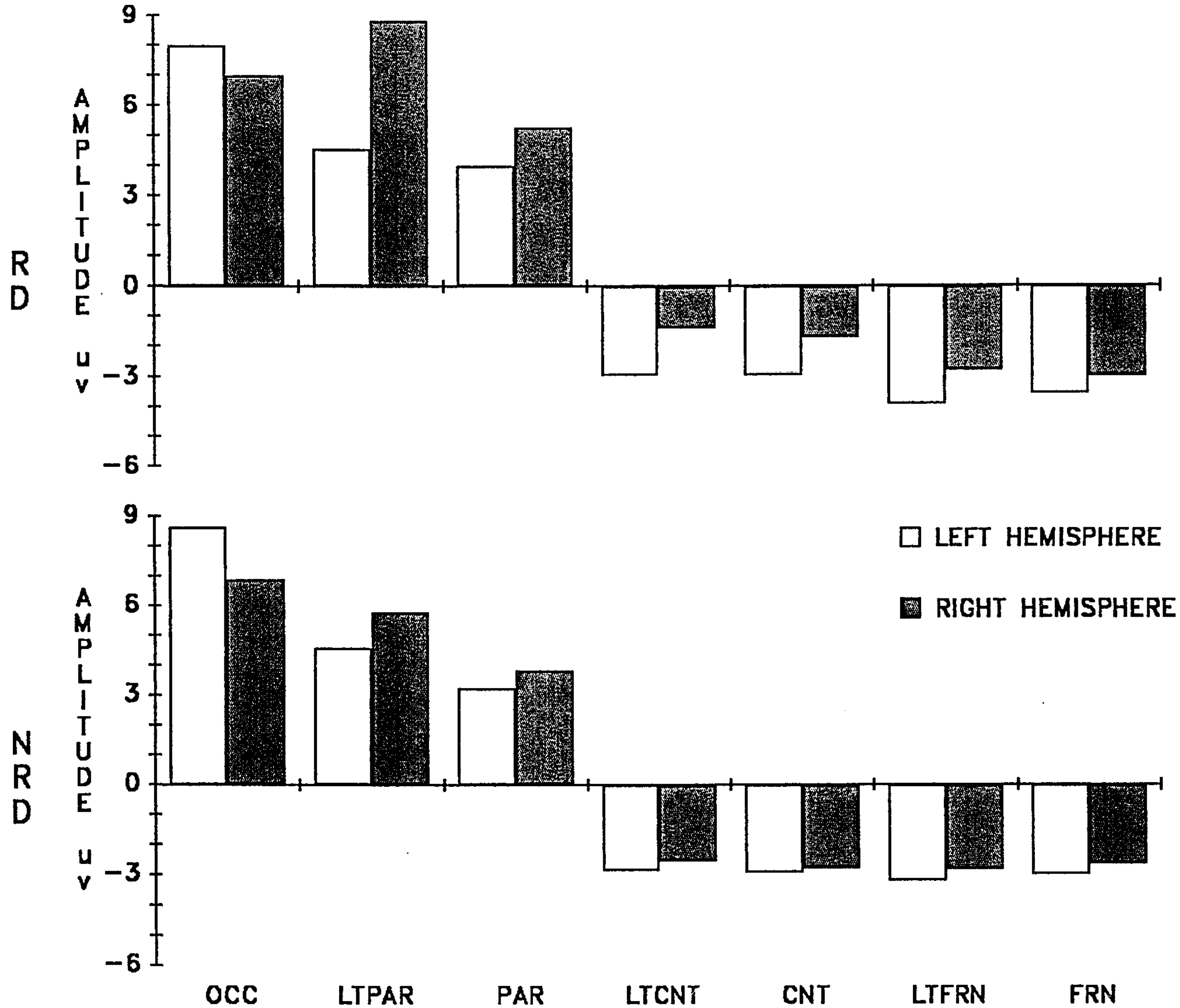


FIGURE 15: PARIETAL N220 AMPLITUDE

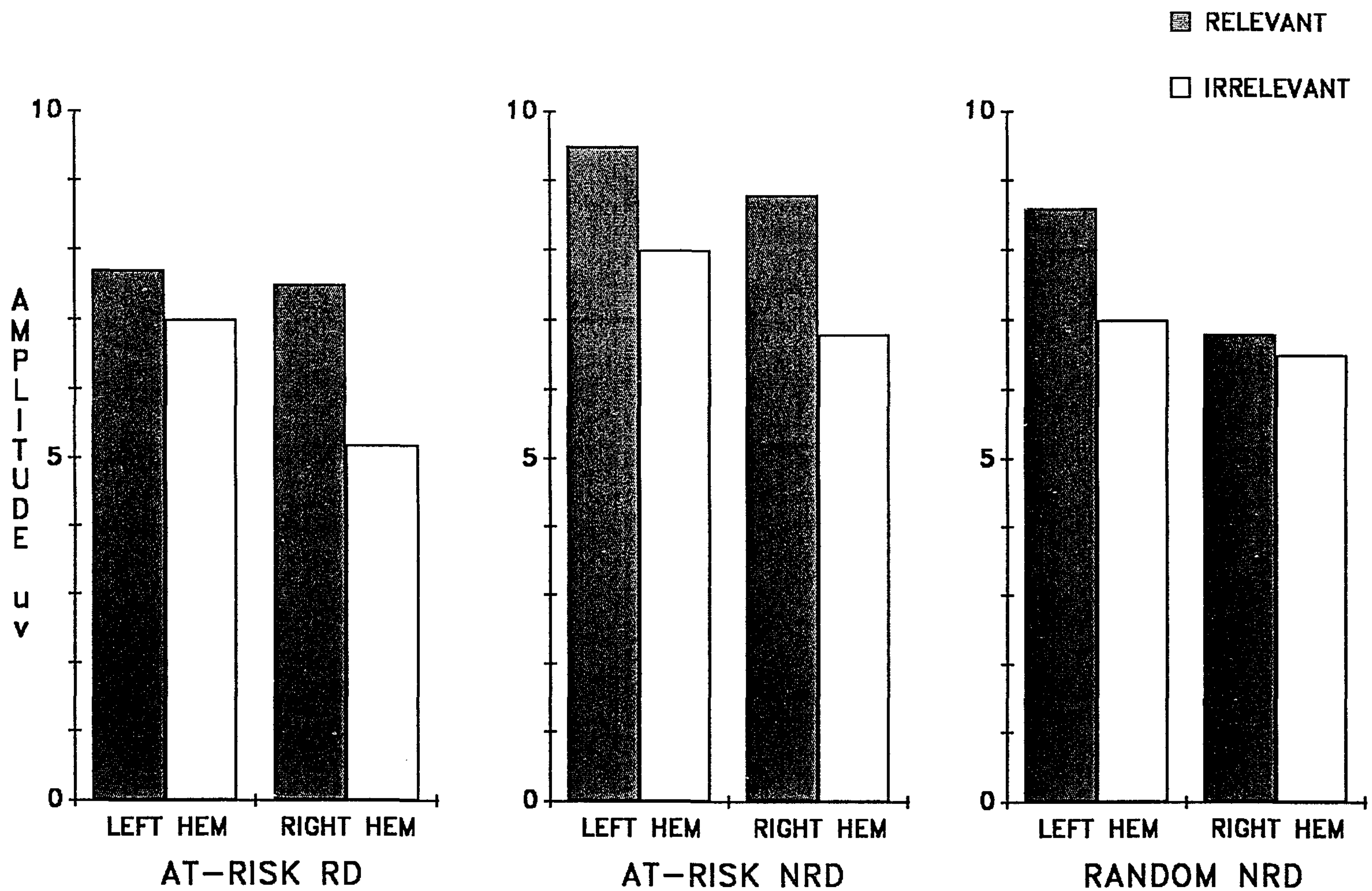


FIGURE 16: CENTRAL AND LATERAL FRONTAL N220 AMPLITUDE

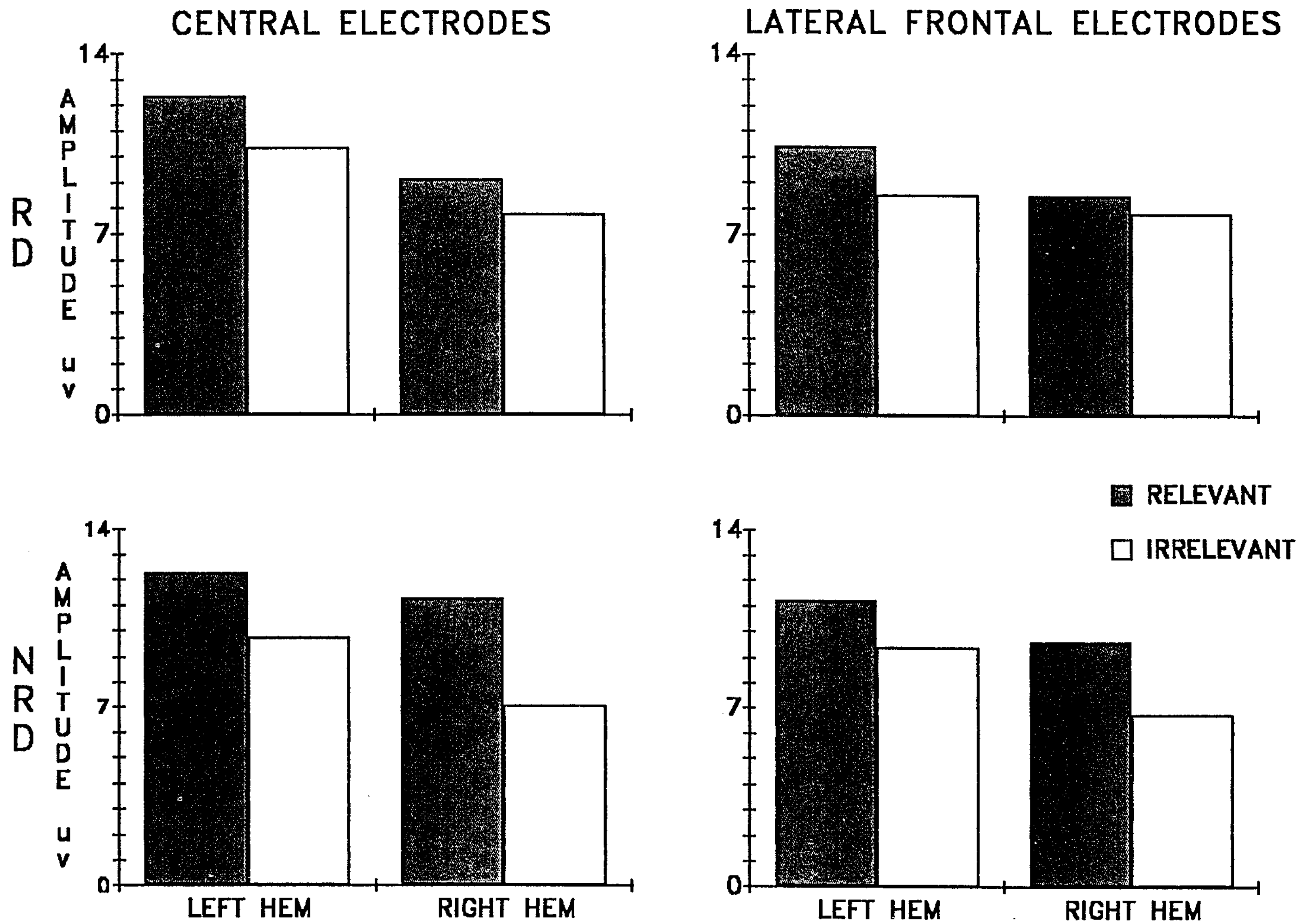


FIGURE 17: FRONTAL AND OCCIPITAL P310 AMPLITUDE

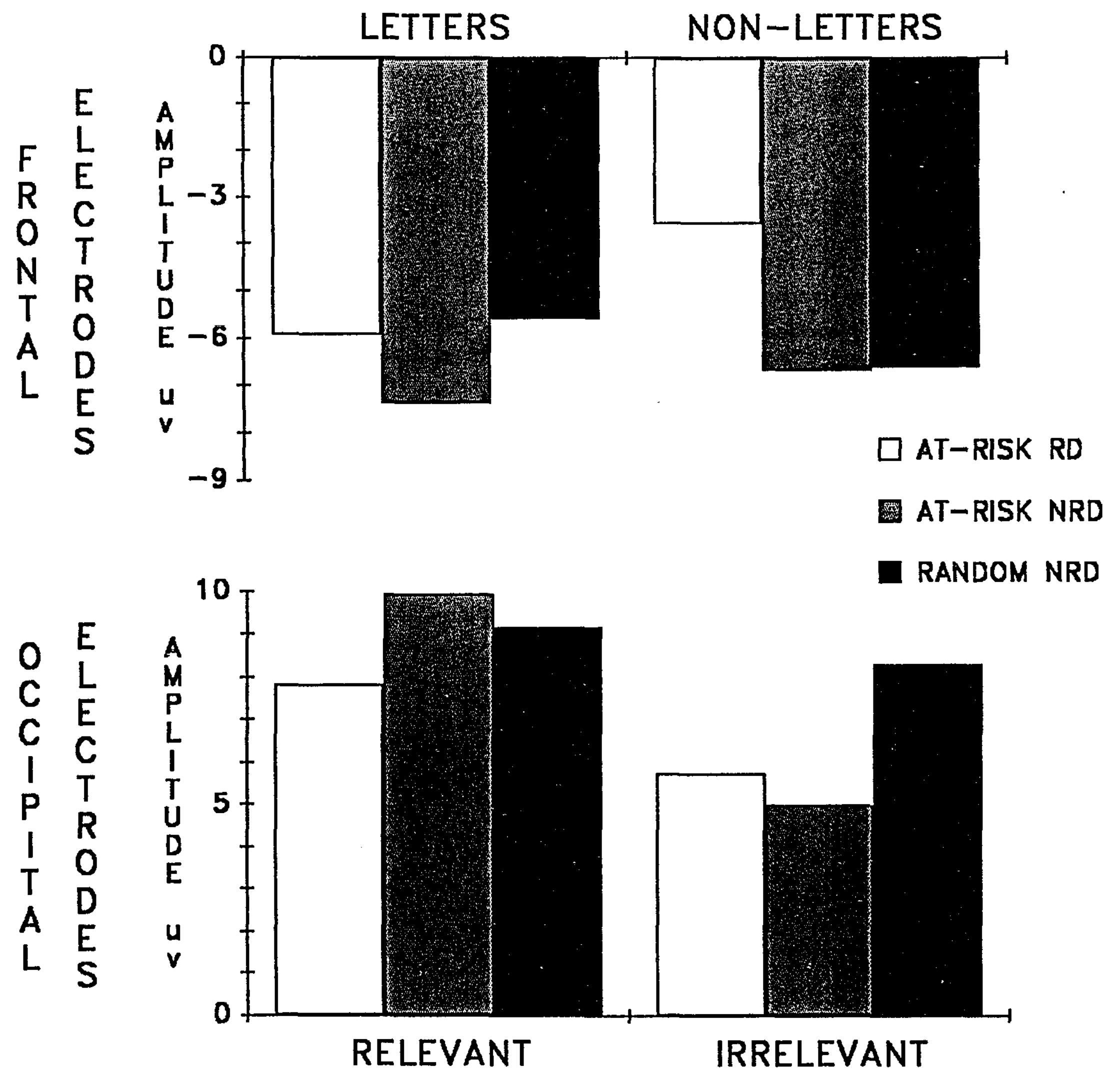


FIGURE 18: P470 AMPLITUDE

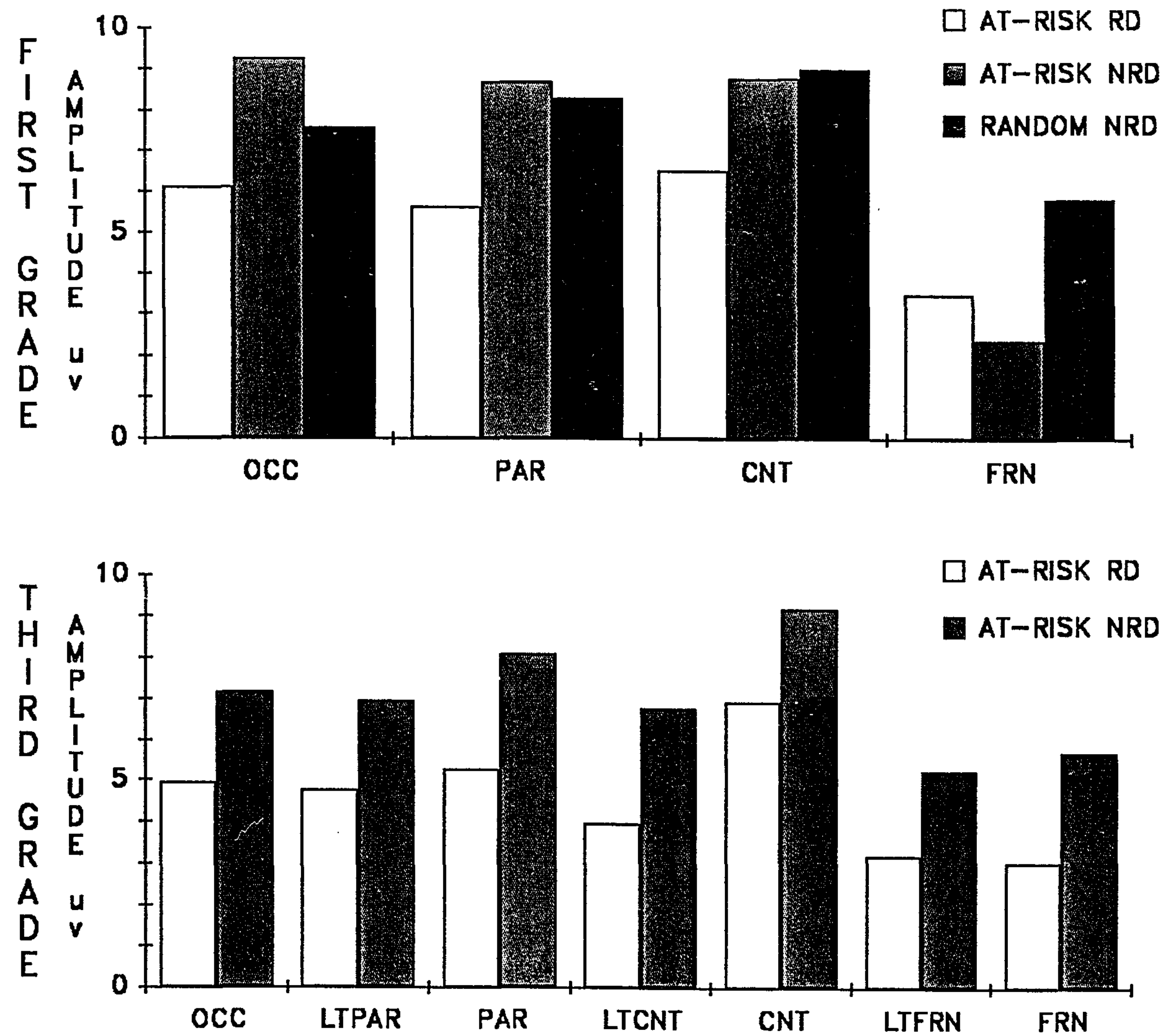


FIGURE 19: CENTRAL P470 AMPLITUDE

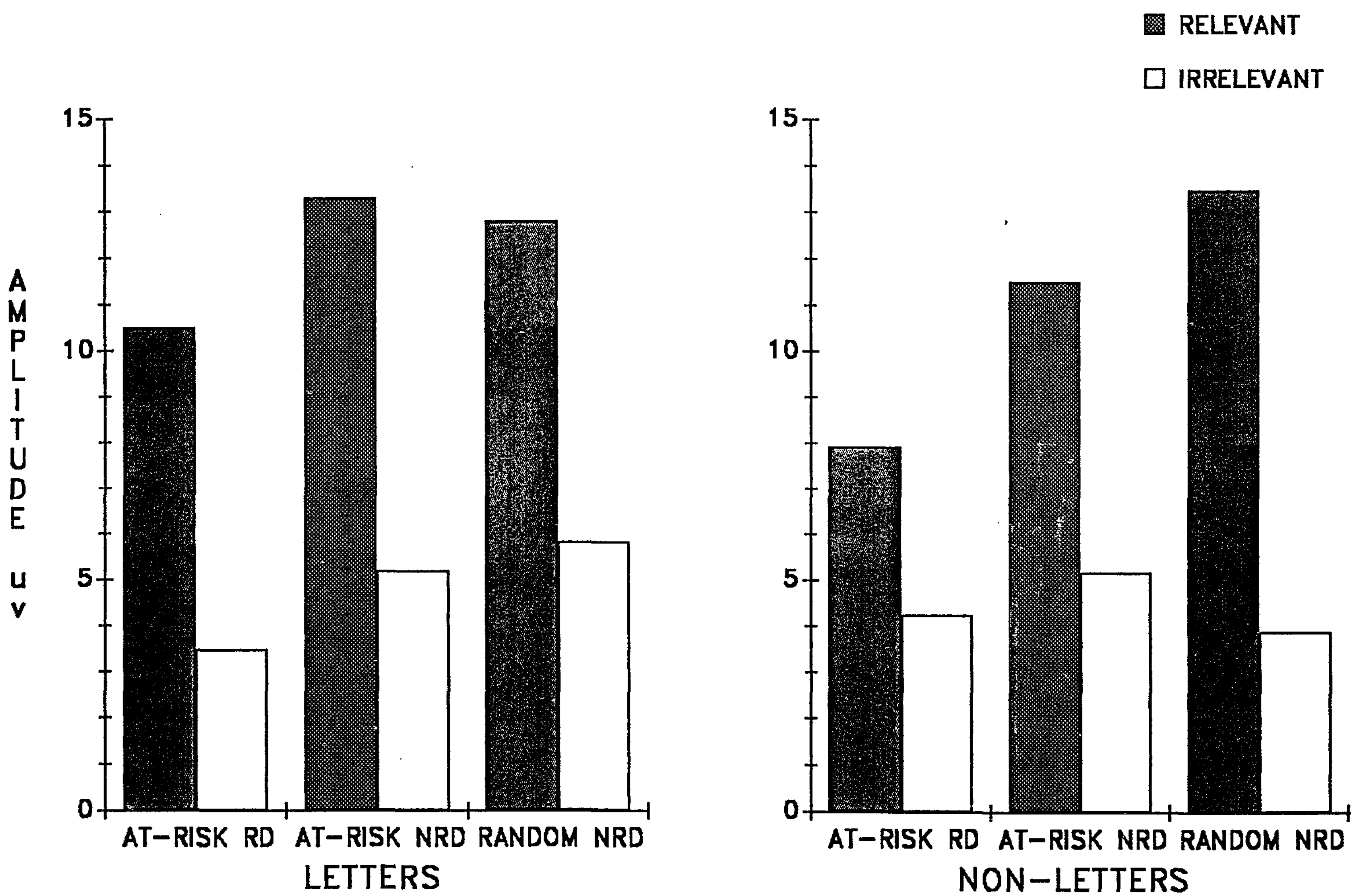


FIGURE 20: PARIETAL AND LATERAL CENTRAL P470 AMPLITUDE

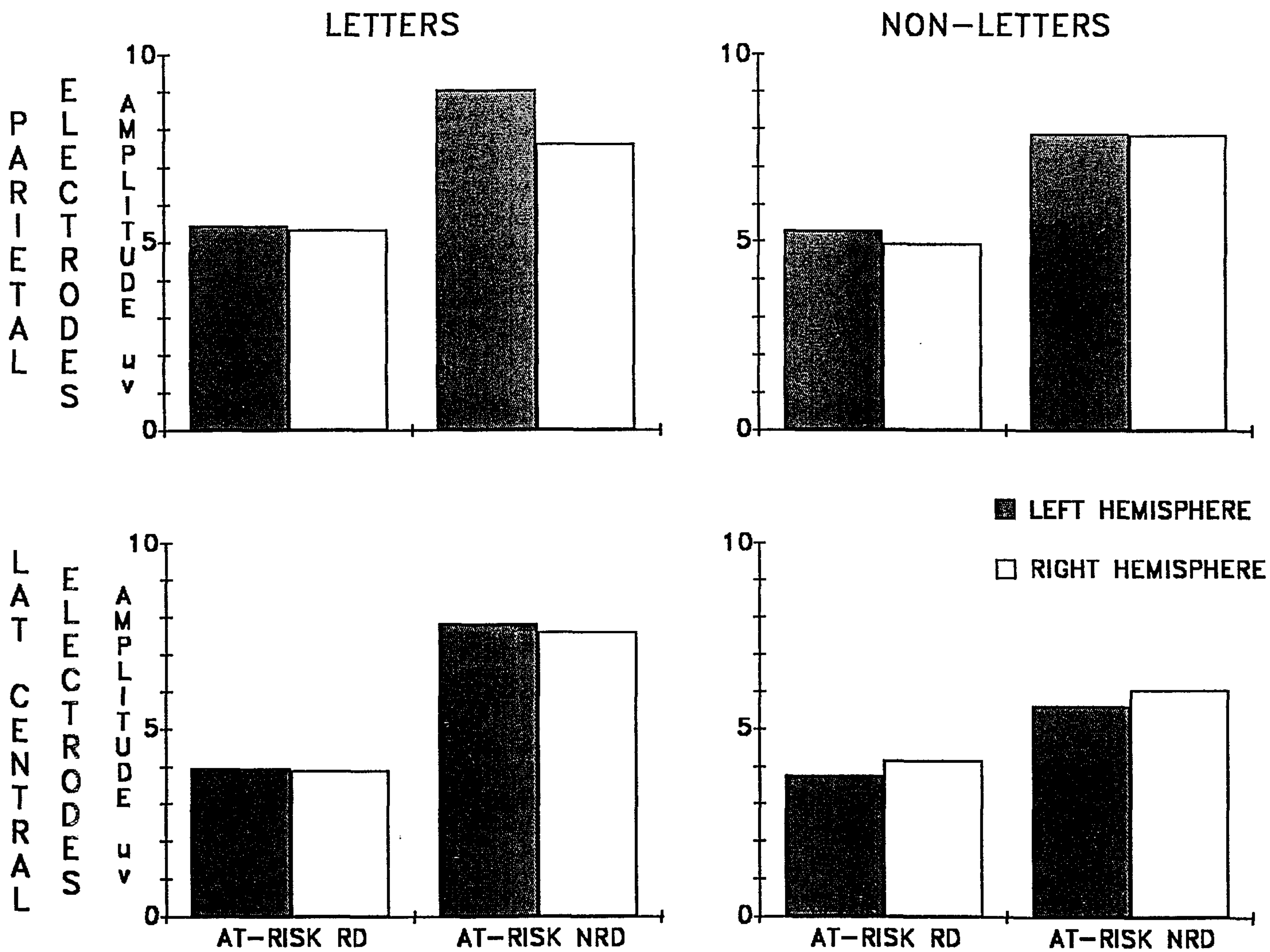


FIGURE 21: CENTRAL AND FRONTAL P470 AMPLITUDE

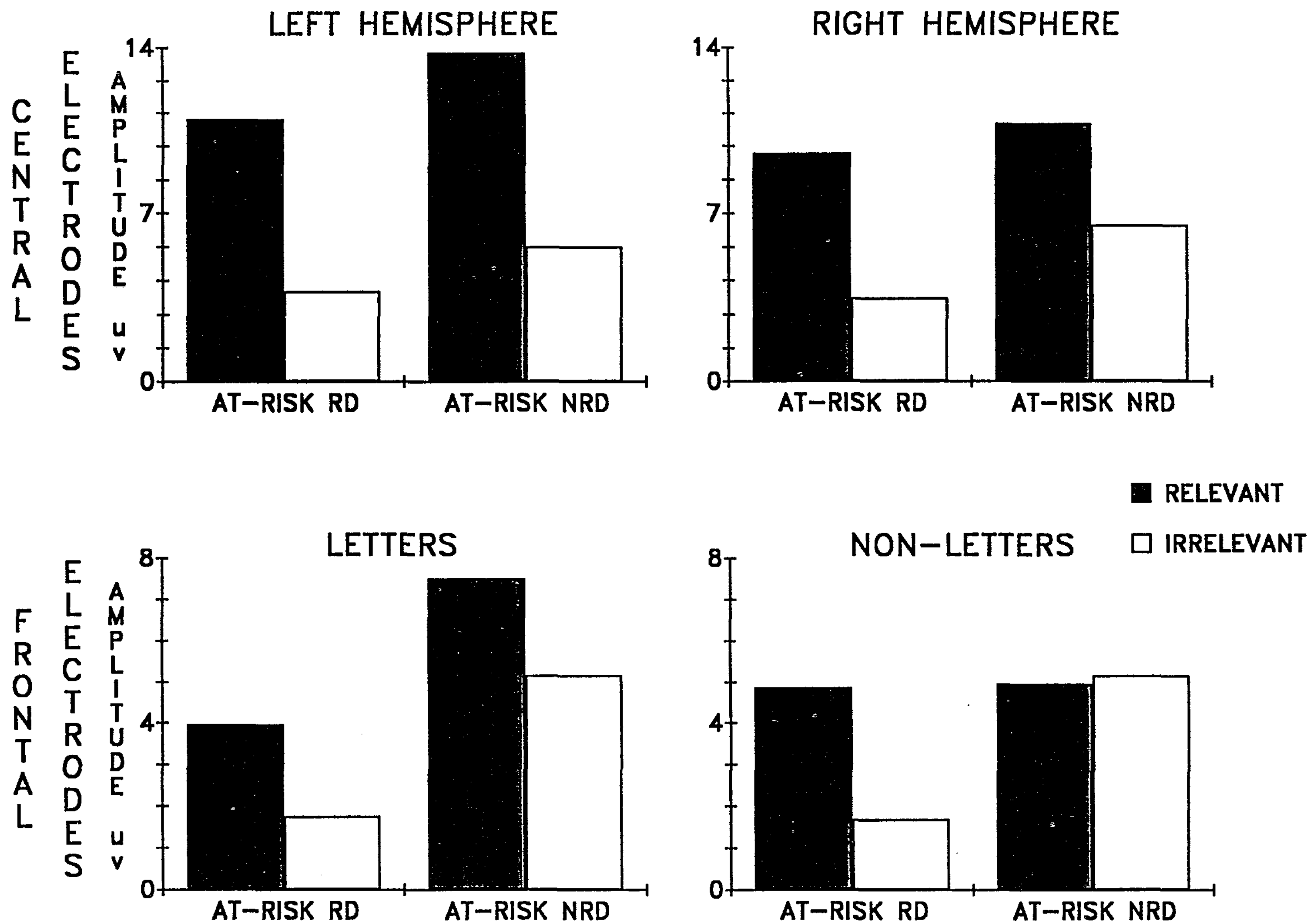


FIGURE 22: P550 AMPLITUDE

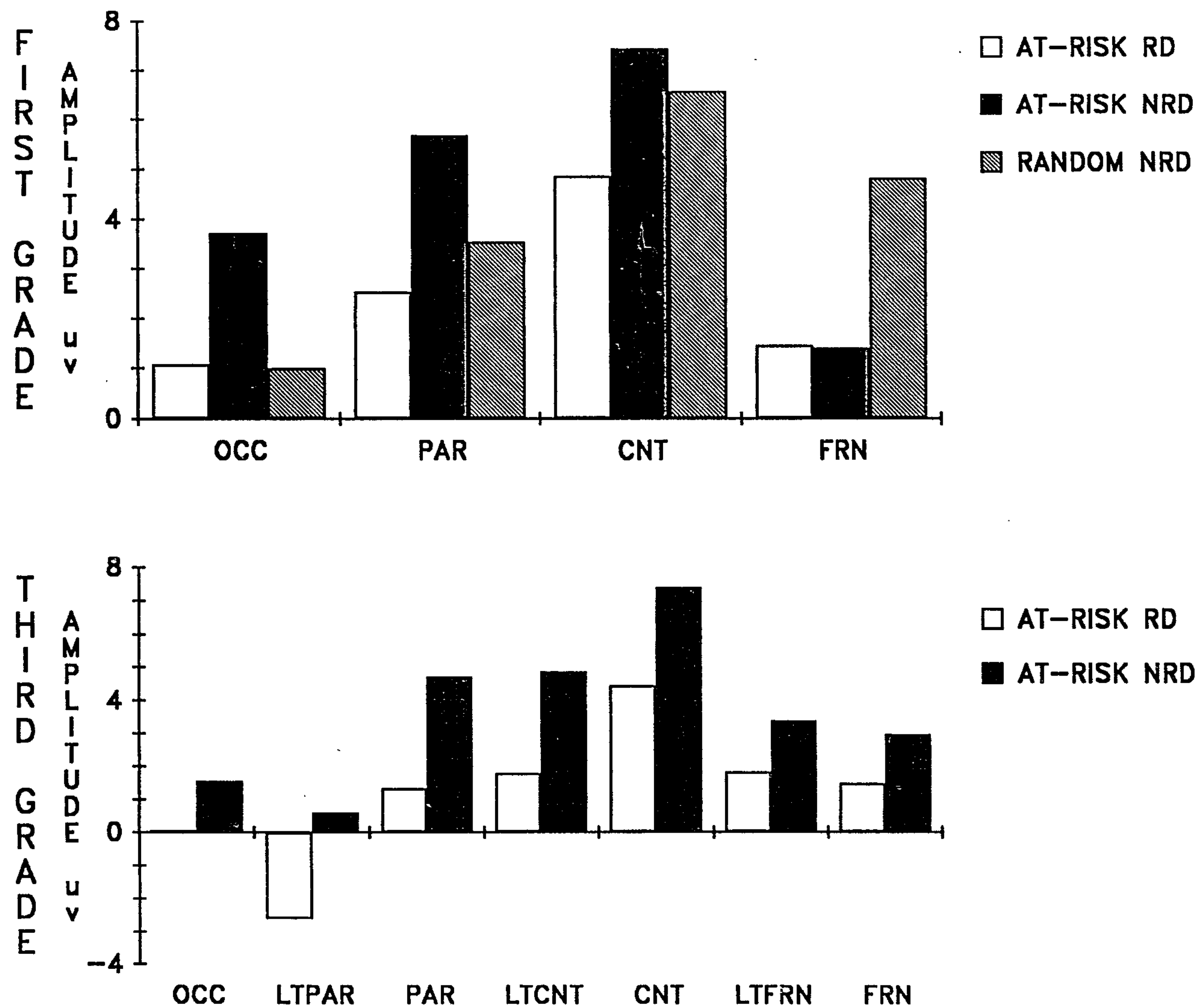


FIGURE 23: P550 AMPLITUDE

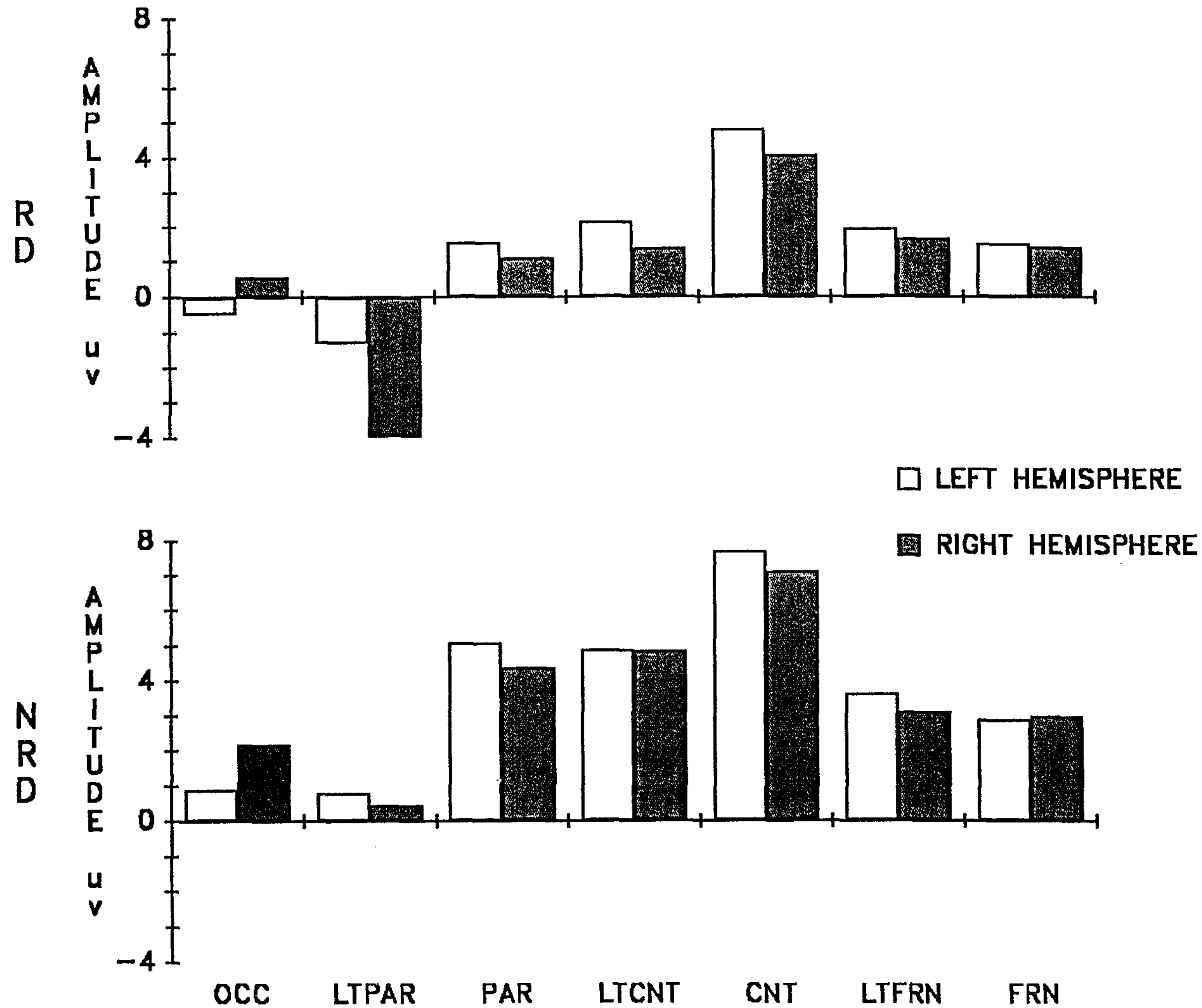


FIGURE 24: P550 AMPLITUDE

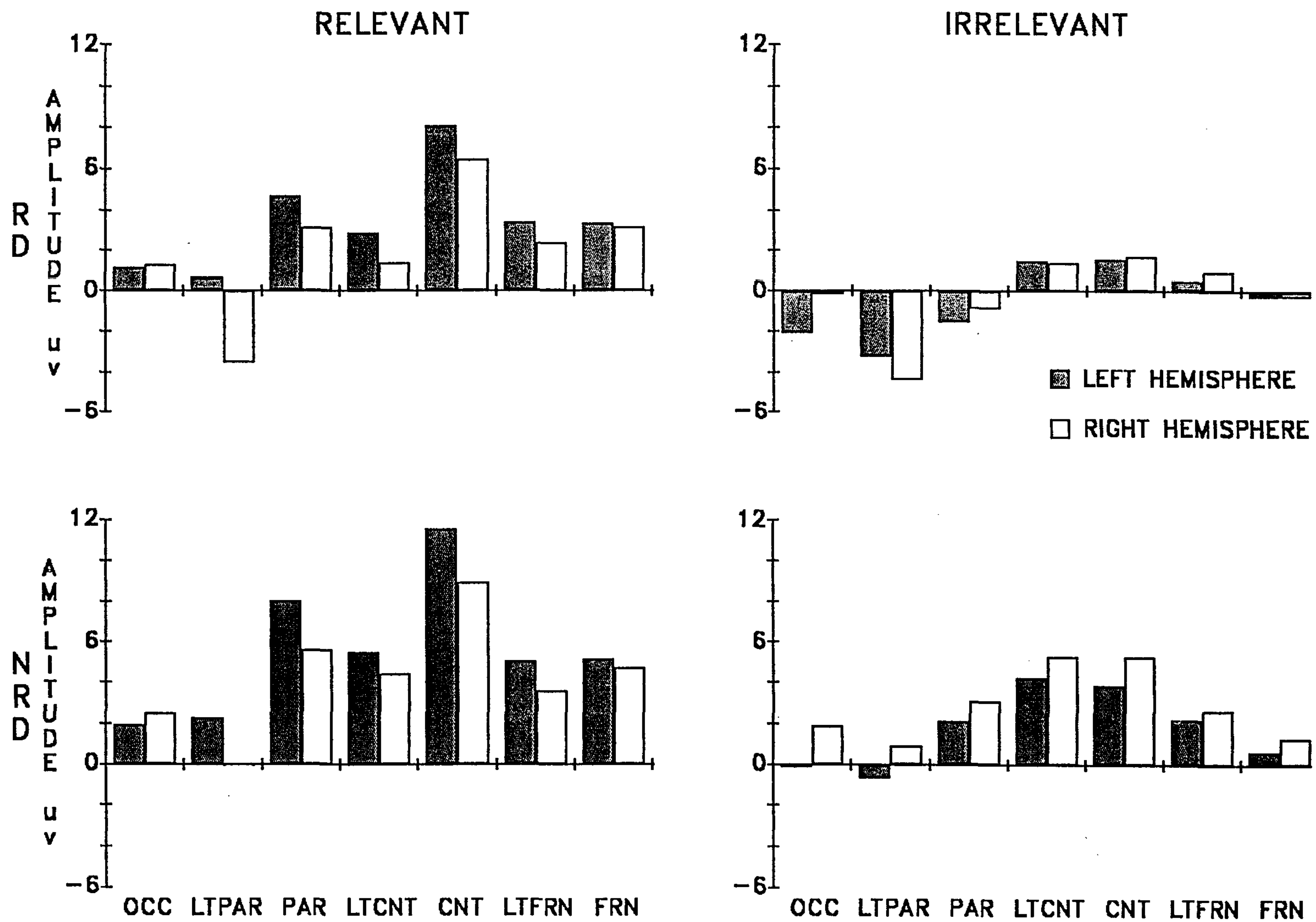
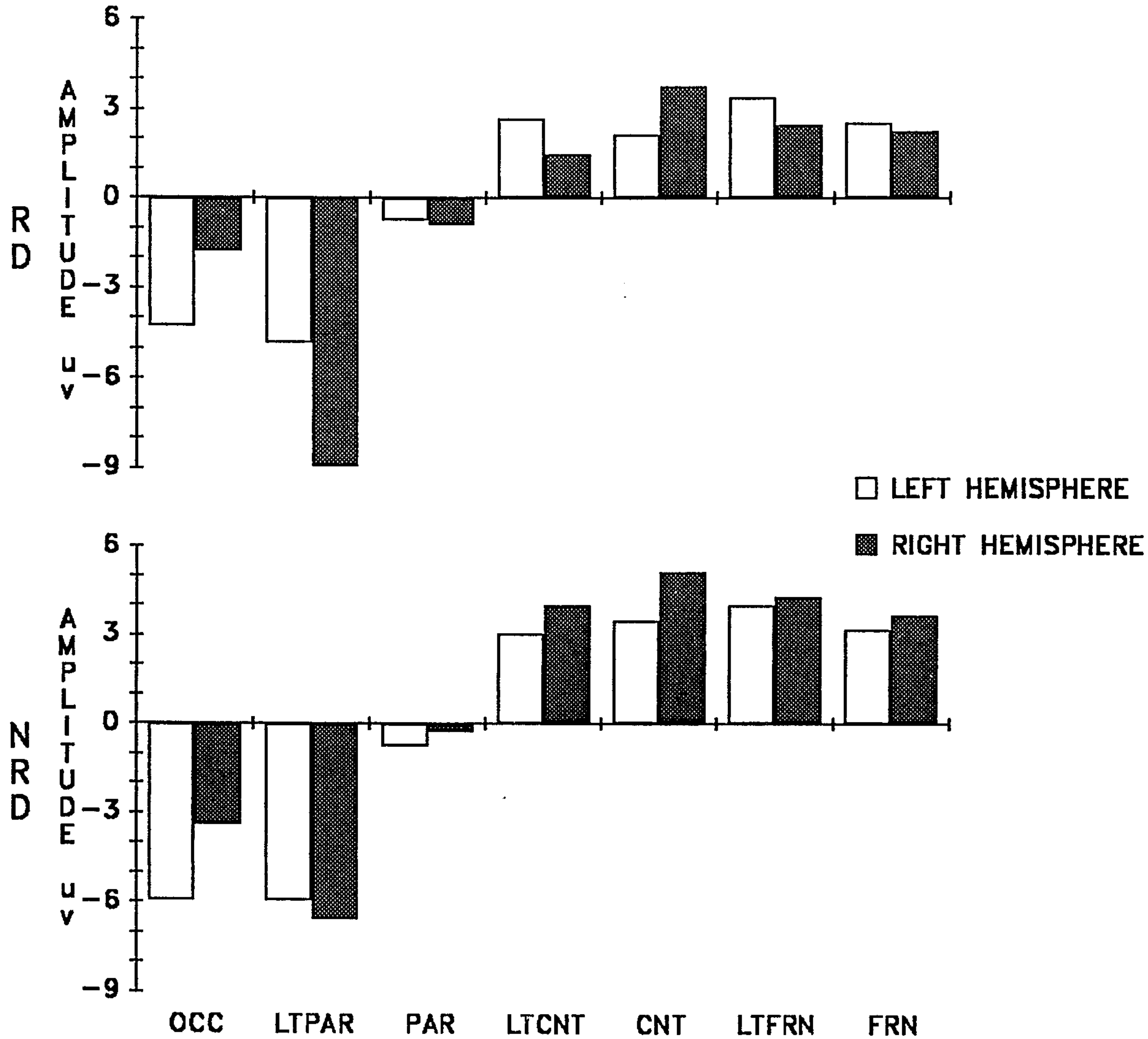


FIGURE 25: N700 AMPLITUDE



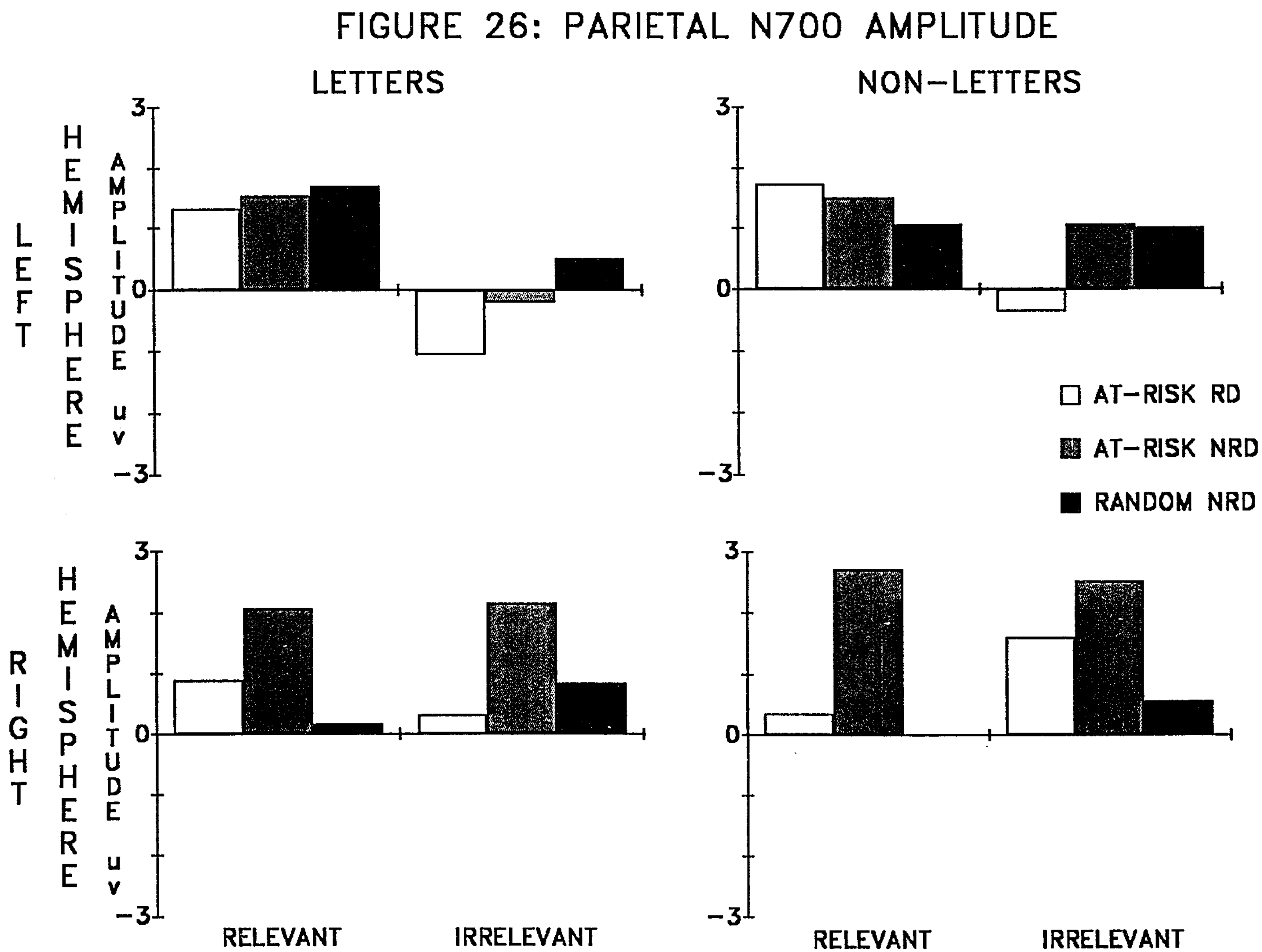
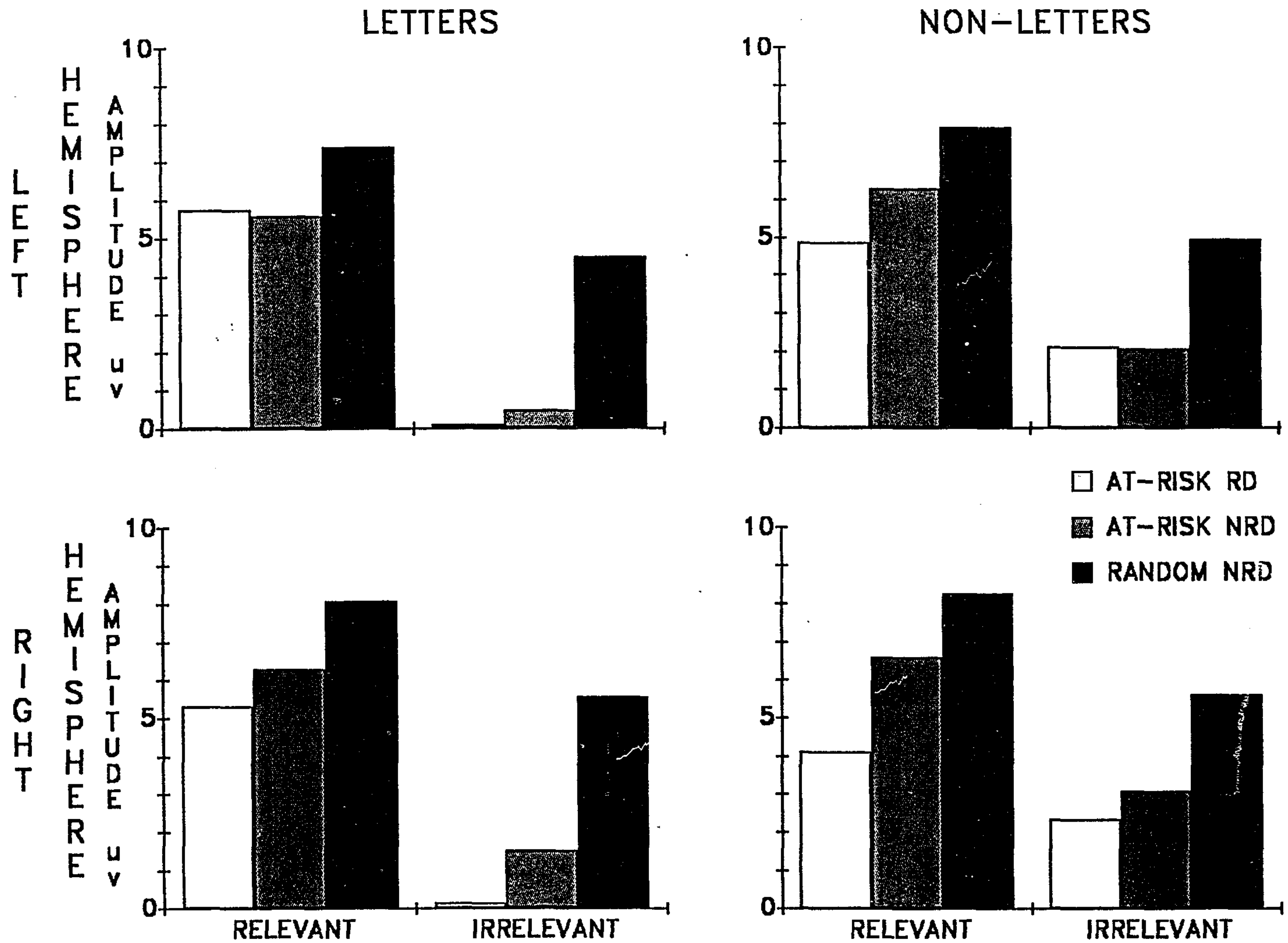


FIGURE 26: PARIETAL N700 AMPLITUDE
LETTERS
NON-LETTERS
LEFT HEMISPHERE
RIGHT HEMISPHERE
AMPLITUDE uv
3
0
-3
AT-RISK RD
AT-RISK NRD
RANDOM NRD
RELEVANT
IRRELEVANT

FIGURE 27: FRONTAL N700 AMPLITUDE



APPENDIX C

NEUROPSYCHOLOGICAL RESEARCH BATTERY FOR THE "AT RISK" SAMPLE SELECTION IN KINDERGARTEN

SCREENING MEASURES FOR "AT RISK" SAMPLE (Not Used In Determining Final At-Risk Status)

Otis-Lennon Mental Ability Test- Primary 1, Level 2 (Otis & Lennon, 1968).

Metropolitan Readiness Test- Level II, Form P (Nurss and McGuran, 1976). An orally administered group readiness test requiring the subject to mark responses in a test booklet. The composite scores comprising the Prereading Skills Composite were used (1) Auditory discrimination of initial sounds and sound symbol correspondence; (2) Visual discriminations among visual symbols and separating of visual patterns from context and (3) Language cognitive concepts, grammatical structures of standard English and listening skills.

RESEARCH MEASURES FOR "AT RISK" SAMPLE

Measures of Phonological Awareness

Phonological awareness tests (Stanovich et al., 1984)

Initial Consonant Not Same - The child listens to four words spoken by the examiner and selects the word not beginning with the same sound as the first word in the list. Number correct is recorded (10 items).

Final Consonant Different- follows the same presentation as above however the child selects the word with the different ending sound from the others. Number correct is recorded (10 items).

Rhyme production- The child orally produces as many words as they can which rhyme with the word spoken by the examiner. Number correct is recorded (10 items).

Lindamood Auditory Conceptualization Test (Lindamood & Lindamood, 1979). The child manipulates different colored blocks to indicate conceptualization of the speech sound patterns presented by the examiner. A converted total score for 28 items is recorded.

Syllable Counting Test (Mann & Lieberman, 1982). In an abbreviated version the examiner produces 1, 2 or 3 syllable words and the child uses a wooden dowel to tap out the number of syllables heard. Total error score for 22 items is recorded.Measures of Phonological Recoding in Lexical Access

Boston Naming Test (Kaplan, Goodglass & Weintraub, 1982). The child is asked to rapidly identify line drawings. Total number of correct responses is recorded (60 items).

Rapid "Automatized" Naming (RAN) Test (Denckla & Rudel, 1976). The child is asked to rapidly name items (objects, letters, numbers or digits) presented visually on a chart. Latency to name 50 randomly ordered stimuli from each set of five stimuli within a stimulus class is the dependent measure.

Measures of Phonetic Recoding in Working Memory

Word String Memory Test (Mann & Lieberman, 1982). An abbreviated version were the examiner reads a string of 4 words, after which the child is to repeat the string in the order presented. Four strings are composed of rhyming and four non-rhyming words. Errors for rhyming, non-rhyming and total errors are recorded.

Additional Research Measures

Alphabet Recitation Test- The child is asked to say the alphabet, dependent measure is the number of correctly named letters regardless of order.

Finger Localization Test- (Satz & Friel, 1973). An adaptation of a sensorimotor task where the child must identify which finger under a cover was touched by the examiner by indicating on a drawing. Fingers are touched one at a time in random order. Number correct for ten trials is the dependent measure.

Reading Achievement Measures

Woodcock Reading Mastery Test-Form A (Woodcock, 1973).

(1) Word Identification Subtest- Requires the untimed reading of a list of sight words graded in difficulty.

(2) Word Attack Subtest- Requires the untimed reading of a list of mono- and polysyllabic pseudowords which are phonetically predictable or non-predictable.

APPENDIX D

FIRST AND THIRD GRADE RESEARCH MEASURES

Reading Achievement Measure (WJRSSA)

Woodcock-Johnson Psychoeducational Battery - Reading Cluster (Woodcock & Johnson, 1977).

The reading cluster of the (WJR) measures three reading skills (subtests) which can be converted to an age corrected standard score (WJRSSA). The composite subtests consist of a Word Identification, Word Attack and Passage Comprehension Subtests. These subtests assess sight word vocabulary, mono and polysyllabic pseudowords reading and passage comprehension. All subtests are untimed and are graded for increasing levels of difficulty.

Continuous Rapid Naming Ability (RAN)

Rapid "Automatized" Naming (RAN) Test (Denckla & Rudel, 1976).

The child is asked to rapidly name items (objects "RANO", letters "RANL", numbers "RANN" or colors "RANC") presented visually on a chart. Latency to name the 50 randomly ordered stimuli within a stimulus class is the dependent measure.

Verbal Intellectual Ability (PPVT)

Peabody Picture Vocabulary Test-Revised (PPVT)(Dunn & Dunn, 1981).

Consists of a non-verbal multiple choice test of receptive vocabulary. The tests consists of the examiner saying a word and providing an illustration plate with four pictures on it. The examinee indicates which picture best illustrates the word. The test consists of 175 plates arranged in an increasing order of difficulty.

General Intellectual Ability (WISCR)

Wechsler Intelligence Scale For Children-Revised (WISCR) (Wechsler, 1974).

An intellectual assessment test consisting of eleven composite subtests presented in a battery format. Six of the eleven subtests (Information, Comprehension, Arithmetic, Similarities, Digit Span, Vocabulary) constitute a Verbal Intellectual Scaled Score for age (VIQ). The five remaining (Digit Symbol, Picture Completion, Block Design, Picture Arrangement, Object Assembly) are used to assess a Performance Intellectual Scaled Score for Age (PIQ). A calculated sum of the VIQ and PIQ provides a full scaled intellectual functioning score with age correction (FIQ).

Attention Deficit Disorder Rating Checklist (DICA)

The attention deficit disorder portion of the Diagnostic Interview for Children and Adolescents (DICA) by Herjanic (1983) was administered to a parent or guardian of each subject. This interview consists of a series of questions regarding the frequency of occurrence of several behaviors which are typical of children with attention deficit disorder.

APPENDIX E

DATA ANALYSIS: INDEPENDENT AND DEPENDENT MEASURES

INDEPENDENT VARIABLES

Time of Evaluation (1st and 3rd grade)

DEPENDENT VARIABLES

Woodcock-Johnson Reading- Age Corrected Standard Score (WJSSA)

RAN Latency Measures for Colors, Letters, Objects, and Numbers (RANC, RANL, RANO, RANN, respectively)

Reaction Time (Letters "RT-L" and Non-letter patterns "RT-P")

Task Accuracy (HITS% & FA% for Letters and Non-letter patterns)

Event-Related Potentials (Variables are Nested n=96)

- ERP components (P120, N220, P470 and P550)
- Stimulus Type (Letters and Non-letter Patterns)
- Stimulus Color (Black and White)
- Electrodes (Occipital, Parietal, Central, Frontal)
- Hemispheres (Left and Right)

DEPENDENT MEASURES TO BE USED AS CO-VARIATES

Age in First Grade

Intellectual Performance (PPVT)

ADD Checklist Score (DICA)

APPENDIX F

ANOVA TABLES FOR ELECTROPHYSIOLOGICAL DATA-RANDOM DAMPLE (n=74)

P120 MEASURE

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	32687.83961	1,73	32687.83961	256.54	0.00
Hemispheric Activity (H)	0.63574	1,73	0.63574	0.03	0.86
Stimulus Type (S)	11.19250	1,73	11.19250	0.51	0.48
Task Relevance (R)	24.24331	1,73	24.24331	1.35	0.25
HS	27.93575	1,73	27.93575	7.75	0.01
HR	6.87574	1,73	6.87574	1.27	0.26
SR	61.36548	1,73	61.36548	2.74	0.10
HSR	2.26277	1,73	2.26277	0.66	0.42

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	935.02703	1,73	935.02703	21.99	0.00
H	22.57324	1,73	22.57324	4.07	0.05
S	18.13000	1,73	18.13000	0.70	0.41
R	139.91358	1,73	139.91358	5.82	0.02
HS	22.41730	1,73	22.41730	4.88	0.03
HR	2.16493	1,73	2.16493	0.41	0.52
SR	1.12439	1,73	1.12439	0.05	0.82
HSR	1.05574	1,73	1.05574	0.24	0.63

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	4164.21285	1,73	4164.21285	109.05	0.00
H	7.42515	1,73	7.42515	1.07	0.30
S	46.71569	1,73	46.71569	1.84	0.18
R	153.34745	1,73	153.34745	5.67	0.02
HS	12.23312	1,73	12.23312	2.04	0.16
HR	10.94637	1,73	10.94637	2.40	0.13
SR	22.76894	1,73	22.76894	1.00	0.32
HSR	8.34812	1,73	8.34812	1.75	0.19

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	7926.38923	1,73	7926.38923	156.16	0.00
H	0.00061	1,73	0.00061	0.00	0.99
S	104.56324	1,73	104.56324	4.32	0.04
R	80.71953	1,73	80.71953	3.34	0.07
HS	6.08108	1,73	6.08108	1.77	0.19
HR	3.48169	1,73	3.48169	1.17	0.28
SR	235.77189	1,73	235.77189	10.26	0.00
HSR	0.06919	1,73	0.06919	0.02	0.90

N220 MEASURE

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	93608.30014	1,73	93608.30014	227.88	0.00
H	62.52999	1,73	62.52999	1.10	0.30
S	105.74330	1,73	105.74330	4.75	0.03
R	66.75920	1,73	66.75920	2.10	0.15
HS	8.08892	1,73	8.08892	1.60	0.21
HR	5.18439	1,73	5.18439	0.73	0.40
SR	91.54703	1,73	91.54703	4.15	0.05
HSR	0.13682	1,73	0.13682	0.02	0.88

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	37739.34619	1,73	37739.34619	236.84	0.00
H	324.50487	1,73	324.50487	23.54	0.00
S	117.46231	1,73	117.46231	4.74	0.03
R	564.13582	1,73	564.13582	18.35	0.00
HS	3.16704	1,73	3.16704	0.70	0.41
HR	7.74204	1,73	7.74204	1.35	0.25
SR	18.80110	1,73	18.80110	1.10	0.30
HSR	12.87380	1,73	12.87380	3.00	0.09

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	77846.43592	1,73	77846.43592	442.69	0.00
H	478.08108	1,73	478.08108	33.51	0.00
S	274.06731	1,73	274.06731	12.53	0.00
R	669.16278	1,73	669.16278	28.82	0.00
HS	4.53250	1,73	4.53250	0.75	0.39
HR	2.81189	1,73	2.81189	0.53	0.47
SR	5.60432	1,73	5.60432	0.26	0.61
HSR	21.26494	1,73	21.26494	3.78	0.06

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	86895.07962	1,73	86895.07962	647.68	0.00
H	44.38583	1,73	44.38583	5.57	0.02
S	334.95288	1,73	334.95288	15.12	0.00
R	1039.59498	1,73	1039.59498	47.54	0.00
HS	3.07988	1,73	3.07988	0.66	0.42
HR	1.76231	1,73	1.76231	0.39	0.54
SR	36.35285	1,73	36.35285	1.93	0.17
HSR	0.69610	1,73	0.69610	0.17	0.68

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P310 MEASURE

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	48763.60550	1,73	48763.60550	247.63	0.00
H	231.87542	1,73	231.87542	12.01	0.00
S	136.33921	1,73	136.33921	9.34	0.00
R	1696.96840	1,73	1696.96840	34.96	0.00
HS	0.88583	1,73	0.88583	0.29	0.59
HR	2.47785	1,73	2.47785	0.58	0.45
SR	2.55610	1,73	2.55610	0.12	0.73
HSR	9.37542	1,73	9.37542	3.48	0.07

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	45941.33115	1,73	45941.33115	419.59	0.00
H	82.27786	1,73	82.27786	4.80	0.03
S	210.60746	1,73	210.60746	13.08	0.00
R	1227.05288	1,73	1227.05288	36.14	0.00
HS	0.19340	1,73	0.19340	0.05	0.83
HR	1.06421	1,73	1.06421	0.25	0.62
SR	20.10610	1,73	20.10610	1.12	0.29
HSR	6.68313	1,73	6.68313	2.84	0.10

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2073.00816	1,73	2073.00816	23.29	0.00
H	496.22297	1,73	496.22297	49.24	0.00
S	59.57574	1,73	59.57574	3.40	0.07
R	667.88757	1,73	667.88757	14.61	0.00
HS	0.04568	1,73	0.04568	0.02	0.90
HR	6.36818	1,73	6.36818	0.97	0.33
SR	6.24433	1,73	6.24433	0.43	0.51
HSR	0.06493	1,73	0.06493	0.02	0.89

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	19413.47642	1,73	19413.47642	120.76	0.00
H	46.04394	1,73	46.04394	2.81	0.10
S	10.09340	1,73	10.09340	0.47	0.49
R	58.00016	1,73	58.00016	2.13	0.15
HS	1.45015	1,73	1.45015	0.81	0.37
HR	6.59840	1,73	6.59840	1.26	0.26
SR	1.78421	1,73	1.78421	0.09	0.76
HSR	0.31704	1,73	0.31704	0.10	0.76

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	23669.41717	1,73	23669.41717	189.75	0.00
H	21.76056	1,73	21.76056	1.54	0.22
S	149.10204	1,73	149.10204	8.67	0.00
R	11323.37641	1,73	11323.37641	221.13	0.00
HS	13.47042	1,73	13.47042	5.83	0.02
HR	166.65341	1,73	166.65341	39.25	0.00
SR	8.39569	1,73	8.39569	0.56	0.46
HSR	2.17705	1,73	2.17705	1.25	0.27

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	27838.43268	1,73	27838.43268	192.13	0.00
H	24.08169	1,73	24.08169	0.98	0.33
S	49.04757	1,73	49.04757	2.93	0.09
R	11148.24497	1,73	11148.24497	242.99	0.00
HS	16.68980	1,73	16.68980	5.27	0.02
HR	44.55027	1,73	44.55027	8.37	0.01
SR	30.96818	1,73	30.96818	1.85	0.18
HSR	0.75919	1,73	0.75919	0.23	0.63

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	35270.82818	1,73	35270.82818	218.43	0.00
H	129.14231	1,73	129.14231	6.99	0.01
S	115.51055	1,73	115.51055	6.86	0.01
R	7134.18251	1,73	7134.18251	183.96	0.00
HS	1.18623	1,73	1.18623	0.37	0.55
HR	86.04813	1,73	86.04813	11.23	0.00
SR	94.32043	1,73	94.32043	4.61	0.04
HSR	1.55083	1,73	1.55083	0.44	0.51

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	8063.09305	1,73	8063.09305	51.67	0.00
H	63.18169	1,73	63.18169	4.57	0.04
S	154.67358	1,73	154.67358	7.69	0.01
R	496.95567	1,73	496.95567	13.49	0.00
HS	1.21324	1,73	1.21324	0.49	0.49
HR	7.40277	1,73	7.40277	1.46	0.23
SR	124.42223	1,73	124.42223	7.41	0.01
HSR	2.38811	1,73	2.38811	0.81	0.37

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	455.17704	1,73	455.17704	4.32	0.04
H	174.16420	1,73	174.16420	8.55	0.00
S	40.21704	1,73	40.21704	2.93	0.09
R	3019.09054	1,73	3019.09054	100.83	0.00
HS	13.47042	1,73	13.47042	11.79	0.00
HR	76.13394	1,73	76.13394	21.41	0.00
SR	67.23015	1,73	67.23015	7.79	0.01
HSR	0.35515	1,73	0.35515	0.45	0.50

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	8412.98124	1,73	8412.98124	71.18	0.00
H	5.86015	1,73	5.86015	0.22	0.64
S	29.20988	1,73	29.20988	2.10	0.15
R	5893.66624	1,73	5893.66624	180.33	0.00
HS	10.19812	1,73	10.19812	8.14	0.01
HR	85.43920	1,73	85.43920	19.29	0.00
SR	0.62921	1,73	0.62921	0.08	0.78
HSR	0.40583	1,73	0.40583	0.30	0.58

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	28911.48022	1,73	28911.48022	239.75	0.00
H	11.60880	1,73	11.60880	0.78	0.38
S	28.85556	1,73	28.85556	2.35	0.13
R	5490.62228	1,73	5490.62228	163.60	0.00
HS	0.57812	1,73	0.57812	0.44	0.51
HR	96.56893	1,73	96.56893	20.01	0.00
SR	30.01502	1,73	30.01502	3.60	0.06
HSR	0.36502	1,73	0.36502	0.22	0.64

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	6609.59392	1,73	6609.59392	47.92	0.00
H	60.40339	1,73	60.40339	6.99	0.01
S	41.90245	1,73	41.90245	3.69	0.06
R	1024.27987	1,73	1024.27987	34.37	0.00
HS	0.28110	1,73	0.28110	0.20	0.65
HR	0.84002	1,73	0.84002	0.29	0.59
SR	21.83731	1,73	21.83731	2.17	0.15
HSR	0.02313	1,73	0.02313	0.02	0.90

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	9654.47038	1,73	9654.47038	68.28	0.00
H	405.07785	1,73	405.07785	14.99	0.00
S	8.49123	1,73	8.49123	0.61	0.44
R	379.36015	1,73	379.36015	9.83	0.00
HS	7.38042	1,73	7.38042	4.21	0.04
HR	6.38893	1,73	6.38893	2.97	0.09
SR	51.20069	1,73	51.20069	4.61	0.04
HSR	4.48015	1,73	4.48015	4.15	0.05

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	140.30278	1,73	140.30278	1.13	0.29
H	8.61142	1,73	8.61142	0.25	0.62
S	27.76223	1,73	27.76223	2.84	0.10
R	0.78811	1,73	0.78811	0.02	0.89
HS	0.38007	1,73	0.38007	0.26	0.61
HR	49.04757	1,73	49.04757	12.87	0.00
SR	2.54297	1,73	2.54297	0.21	0.65
HSR	3.15243	1,73	3.15243	2.91	0.09

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	20386.27703	1,73	20386.27703	181.37	0.00
H	83.40007	1,73	83.40007	4.54	0.04
S	37.00000	1,73	37.00000	3.48	0.07
R	821.09432	1,73	821.09432	19.77	0.00
HS	0.53520	1,73	0.53520	0.40	0.53
HR	56.07575	1,73	56.07575	13.54	0.00
SR	5.68243	1,73	5.68243	0.51	0.48
HSR	3.42061	1,73	3.42061	2.98	0.09

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	16955.22164	1,73	16955.22164	107.82	0.00
H	24.40547	1,73	24.40547	2.61	0.11
S	69.88439	1,73	69.88439	6.24	0.01
R	648.06818	1,73	648.06818	26.48	0.00
HS	3.12331	1,73	3.12331	2.90	0.09
HR	0.18980	1,73	0.18980	0.07	0.79
SR	6.78980	1,73	6.78980	0.57	0.45
HSR	5.33520	1,73	5.33520	4.29	0.04

APPENDIX G

ANOVA TABLES FOR FIRST GRADE ELECTROPHYSIOLOGICAL DATA
READING GROUP COMPARISONS (RD, NRD, & RND) (n=45)

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	18472.80405	1,42	18472.80405	152.49	0.00
Reading Group (POP)	140.81517	2,42	70.40758	0.58	0.56
H	0.00178	1,42	0.00178	0.00	0.99
(H) X (P: POP)	6.65006	2,42	3.32503	0.24	0.79
S	40.13345	1,42	40.13345	2.57	0.12
(S) X (P: POP)	53.25873	2,42	26.62936	1.71	0.19
R	3.64011	1,42	3.64011	0.18	0.68
(R) X (P: POP)	59.28072	2,42	29.64036	1.45	0.25
HS	6.34678	1,42	6.34678	2.25	0.14
(HS) X (P: POP)	8.68539	2,42	4.34270	1.54	0.23
HR	5.62500	1,42	5.62500	1.09	0.30
(HR) X (P: POP)	2.38650	2,42	1.19325	0.23	0.79
SR	4.35600	1,42	4.35600	0.20	0.65
(SR) X (P: POP)	149.02317	2,42	74.51159	3.47	0.04
HSR	7.62711	1,42	7.62711	2.48	0.12
(HSR) X (P: POP)	0.33539	2,42	0.16769	0.05	0.95

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	674.86224	1,42	674.86224	11.75	0.00
P: POP	11.34117	2,42	5.67058	0.10	0.91
H	14.68136	1,42	14.68136	1.54	0.22
(H) X (P: POP)	18.17039	2,42	9.08519	0.96	0.39
S	30.10225	1,42	30.10225	2.03	0.16
(S) X (P: POP)	3.26717	2,42	1.63358	0.11	0.90
R	19.64669	1,42	19.64669	1.12	0.30
(R) X (P: POP)	3.12206	2,42	1.56103	0.09	0.92
HS	0.00136	1,42	0.00136	0.00	0.99
(HS) X (P: POP)	0.67706	2,42	0.33853	0.06	0.94
HR	12.58136	1,42	12.58136	3.21	0.08
(HR) X (P: POP)	17.12039	2,42	8.56019	2.18	0.13
SR	8.31136	1,42	8.31136	0.46	0.50
(SR) X (P: POP)	8.71939	2,42	4.35969	0.24	0.79
HSR	0.47669	1,42	0.47669	0.11	0.74
(HSR) X (P: POP)	1.58906	2,42	0.79453	0.19	0.83

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2336.31226	1,42	2336.31226	48.04	0.00
P: POP	40.93717	2,42	20.46858	0.42	0.66
H	10.10025	1,42	10.10025	1.65	0.21
(H) X (P: POP)	23.37917	2,42	11.68958	1.91	0.16
S	14.84336	1,42	14.84336	1.10	0.30
(S) X (P: POP)	17.32372	2,42	8.66186	0.64	0.53
R	0.42025	1,42	0.42025	0.03	0.87
(R) X (P: POP)	12.87317	2,42	6.43658	0.43	0.65
HS	4.60136	1,42	4.60136	0.88	0.35
(HS) X (P: POP)	0.70506	2,42	0.35253	0.07	0.93
HR	14.60070	1,42	14.60070	5.07	0.03
(HR) X (P: POP)	0.74206	2,42	0.37103	0.13	0.88
SR	0.40669	1,42	0.40669	0.03	0.87
(SR) X (P: POP)	21.12905	2,42	10.56453	0.67	0.52
HSR	0.09669	1,42	0.09669	0.02	0.88
(HSR) X (P: POP)	5.09372	2,42	2.54686	0.65	0.53

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	4729.90003	1,42	4729.90003	100.64	0.00
P: POP	252.30955	2,42	126.15478	2.68	0.08
H	0.93025	1,42	0.93025	0.23	0.63
(H) X (P: POP)	28.72800	2,42	14.36400	3.53	0.04
S	37.96003	1,42	37.96003	1.87	0.18
(S) X (P: POP)	12.46956	2,42	6.23478	0.31	0.74
R	8.74225	1,42	8.74225	0.64	0.43
(R) X (P: POP)	149.97266	2,42	74.98633	5.46	0.01
HS	0.23003	1,42	0.23003	0.06	0.81
(HS) X (P: POP)	8.17756	2,42	4.08878	1.01	0.37
HR	4.83025	1,42	4.83025	1.42	0.24
(HR) X (P: POP)	0.34067	2,42	0.17033	0.05	0.95
SR	28.28003	1,42	28.28003	1.47	0.23
(SR) X (P: POP)	55.08356	2,42	27.54178	1.43	0.25
HSR	18.27003	1,42	18.27003	6.37	0.02
(HSR) X (P: POP)	10.50689	2,42	5.25344	1.83	0.17

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	63022.42825	1,42	63022.42825	130.04	0.00
P: POP	28.20622	2,42	14.10311	0.03	0.97
H	17.24844	1,42	17.24844	0.34	0.56
(H) X (P: POP)	82.60356	2,42	41.30178	0.82	0.45
S	17.24845	1,42	17.24845	0.60	0.44
(S) X (P: POP)	66.58488	2,42	33.29244	1.16	0.32
R	6.18844	1,42	6.18844	0.17	0.68
(R) X (P: POP)	150.40356	2,42	75.20178	2.10	0.14
HS	6.61511	1,42	6.61511	1.49	0.23
(HS) X (P: POP)	4.25689	2,42	2.12844	0.48	0.62
HR	2.84444	1,42	2.84444	0.40	0.53
(HR) X (P: POP)	11.97156	2,42	5.98578	0.85	0.43
SR	17.42400	1,42	17.42400	1.25	0.27
(SR) X (P: POP)	31.41067	2,42	15.70533	1.12	0.34
HSR	17.77778	1,42	17.77778	3.76	0.06
(HSR) X (P: POP)	1.29422	2,42	0.64711	0.14	0.87

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	20049.49882	1,42	20049.49882	89.36	0.00
P: POP	135.56172	2,42	67.78086	0.30	0.74
H	100.70044	1,42	100.70044	6.14	0.02
(H) X (P: POP)	1.51339	2,42	0.75669	0.05	0.95
S	32.64044	1,42	32.64044	1.26	0.27
(S) X (P: POP)	20.49572	2,42	10.24786	0.40	0.68
R	177.52177	1,42	177.52177	7.44	0.01
(R) X (P: POP)	9.26606	2,42	4.63303	0.19	0.82
HS	0.96100	1,42	0.96100	0.23	0.63
(HS) X (P: POP)	2.16450	2,42	1.08225	0.26	0.77
HR	1.32011	1,42	1.32011	0.40	0.53
(HR) X (P: POP)	25.98772	2,42	12.99386	3.93	0.03
SR	86.63211	1,42	86.63211	4.74	0.04
(SR) X (P: POP)	42.83606	2,42	21.41803	1.17	0.32
HSR	4.62400	1,42	4.62400	1.24	0.27
(HSR) X (P: POP)	3.28817	2,42	1.64408	0.44	0.65

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	38918.88229	1,42	38918.88229	212.66	0.00
P: POP	114.68151	2,42	57.34076	0.31	0.73
H	153.27225	1,42	153.27225	15.15	0.00
(H) X (P: POP)	18.50717	2,42	9.25358	0.91	0.41
S	68.03402	1,42	68.03402	2.76	0.10
(S) X (P: POP)	9.17605	2,42	4.58803	0.19	0.83
R	250.83403	1,42	250.83403	11.08	0.00
(R) X (P: POP)	6.76905	2,42	3.38453	0.15	0.86
HS	0.42025	1,42	0.42025	0.08	0.78
(HS) X (P: POP)	15.27217	2,42	7.63608	1.38	0.26
HR	3.46136	1,42	3.46136	0.67	0.42
(HR) X (P: POP)	0.66606	2,42	0.33303	0.06	0.94
SR	28.73025	1,42	28.73025	1.55	0.22
(SR) X (P: POP)	5.31717	2,42	2.65858	0.14	0.87
HSR	14.44003	1,42	14.44003	4.08	0.05
(HSR) X (P: POP)	3.53706	2,42	1.76853	0.50	0.61

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	49212.56355	1,42	49212.56355	376.36	0.00
P: POP	35.48873	2,42	17.74437	0.14	0.87
H	10.57470	1,42	10.57470	1.49	0.23
(H) X (P: POP)	8.50272	2,42	4.25136	0.60	0.55
S	430.99226	1,42	430.99226	28.94	0.00
(S) X (P: POP)	15.64516	2,42	7.82258	0.53	0.60
R	632.29004	1,42	632.29004	25.26	0.00
(R) X (P: POP)	87.89006	2,42	43.94503	1.76	0.19
HS	1.26025	1,42	1.26025	0.41	0.52
(HS) X (P: POP)	2.40517	2,42	1.20258	0.39	0.68
HR	12.80669	1,42	12.80669	4.81	0.03
(HR) X (P: POP)	0.44939	2,42	0.22469	0.08	0.92
SR	0.97136	1,42	0.97136	0.05	0.83
(SR) X (P: POP)	3.70872	2,42	1.85436	0.09	0.92
HSR	5.11225	1,42	5.11225	1.63	0.21
(HSR) X (P: POP)	15.27050	2,42	7.63525	2.43	0.10

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	21156.93343	1,42	21156.93343	177.37	0.00
P: POP	231.73006	2,42	115.86503	0.97	0.39
H	100.91211	1,42	100.91211	4.35	0.04
(H) X (P: POP)	10.76072	2,42	5.38036	0.23	0.79
S	130.56177	1,42	130.56177	7.01	0.01
(S) X (P: POP)	14.69939	2,42	7.34969	0.39	0.68
R	612.04544	1,42	612.04544	18.91	0.00
(R) X (P: POP)	264.46906	2,42	132.23453	4.09	0.02
HS	1.39378	1,42	1.39378	0.43	0.51
(HS) X (P: POP)	0.69406	2,42	0.34703	0.11	0.90
HR	0.49878	1,42	0.49878	0.12	0.73
(HR) X (P: POP)	19.51439	2,42	9.75720	2.36	0.11
SR	22.50000	1,42	22.50000	1.28	0.26
(SR) X (P: POP)	35.11950	2,42	17.55975	1.00	0.38
HSR	0.42711	1,42	0.42711	0.23	0.64
(HSR) X (P: POP)	9.94039	2,42	4.97019	2.65	0.08

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	21000.83369	1,42	21000.83369	246.54	0.00
P: POP	214.49705	2,42	107.24853	1.26	0.29
H	0.44100	1,42	0.44100	0.04	0.84
(H) X (P: POP)	40.43150	2,42	20.21575	1.89	0.16
S	212.21378	1,42	212.21378	7.99	0.01
(S) X (P: POP)	0.42172	2,42	0.21086	0.01	0.99
R	365.62178	1,42	365.62178	17.91	0.00
(R) X (P: POP)	39.06672	2,42	19.53336	0.96	0.39
HS	1.27211	1,42	1.27211	0.37	0.55
(HS) X (P: POP)	0.72039	2,42	0.36019	0.10	0.90
HR	11.30678	1,42	11.30678	4.13	0.05
(HR) X (P: POP)	7.55006	2,42	3.77503	1.38	0.26
SR	27.11511	1,42	27.11511	1.91	0.17
(SR) X (P: POP)	56.35072	2,42	28.17536	1.98	0.15
HSR	0.01344	1,42	0.01344	0.01	0.94
(HSR) X (P: POP)	2.34539	2,42	1.17269	0.54	0.59

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2064.49001	1,42	2064.49001	17.99	0.00
P: POP	72.44839	2,42	36.22419	0.32	0.73
H	223.25625	1,42	223.25625	19.92	0.00
(H) X (P: POP)	5.39817	2,42	2.69908	0.24	0.79
S	181.61803	1,42	181.61803	7.59	0.01
(S) X (P: POP)	65.75872	2,42	32.87936	1.37	0.26
R	92.72025	1,42	92.72025	2.37	0.13
(R) X (P: POP)	64.74516	2,42	32.37258	0.83	0.44
HS	5.65003	1,42	5.65003	1.91	0.17
(HS) X (P: POP)	12.46272	2,42	6.23136	2.11	0.13
HR	2.35225	1,42	2.35225	0.56	0.46
(HR) X (P: POP)	3.56517	2,42	1.78258	0.42	0.66
SR	31.27003	1,42	31.27003	2.15	0.15
(SR) X (P: POP)	64.67105	2,42	32.33553	2.22	0.12
HSR	5.30470	1,42	5.30470	2.07	0.16
(HSR) X (P: POP)	1.16039	2,42	0.58019	0.23	0.80

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	13023.67812	1,42	13023.67812	108.51	0.00
P: POP	265.97007	2,42	132.98503	1.11	0.34
H	17.64470	1,42	17.64470	1.35	0.25
(H) X (P: POP)	30.67439	2,42	15.33720	1.17	0.32
S	27.50069	1,42	27.50069	1.19	0.28
(S) X (P: POP)	134.90505	2,42	67.45253	2.93	0.06
R	12.73136	1,42	12.73136	0.48	0.49
(R) X (P: POP)	11.54172	2,42	5.77086	0.22	0.80
HS	3.42225	1,42	3.42225	1.64	0.21
(HS) X (P: POP)	0.47517	2,42	0.23758	0.11	0.89
HR	0.46225	1,42	0.46225	0.10	0.75
(HR) X (P: POP)	6.96517	2,42	3.48258	0.77	0.47
SR	4.73803	1,42	4.73803	0.26	0.61
(SR) X (P: POP)	43.62740	2,42	21.81370	1.19	0.31
HSR	0.00469	1,42	0.00469	0.00	0.96
(HSR) X (P: POP)	3.57572	2,42	1.78786	0.84	0.44

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	21169.20119	1,42	21169.20119	294.57	0.00
P: POP	590.04616	2,42	295.02308	4.11	0.02
H	0.51378	1,42	0.51378	0.05	0.82
(H) X (P: POP)	3.17406	2,42	1.58703	0.15	0.86
S	16.12900	1,42	16.12900	0.72	0.40
(S) X (P: POP)	58.76216	2,42	29.38108	1.30	0.28
R	5322.24911	1,42	5322.24911	134.40	0.00
(R) X (P: POP)	246.45951	2,42	123.22976	3.11	0.05
HS	2.30400	1,42	2.30400	0.87	0.36
(HS) X (P: POP)	0.10717	2,42	0.05358	0.02	0.98
HR	73.62178	1,42	73.62178	17.58	0.00
(HR) X (P: POP)	2.76806	2,42	1.38403	0.33	0.72
SR	67.08100	1,42	67.08100	3.82	0.06
(SR) X (P: POP)	18.80150	2,42	9.40075	0.54	0.59
HSR	10.81600	1,42	10.81600	3.07	0.09
(HSR) X (P: POP)	4.61117	2,42	2.30558	0.65	0.53

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	20591.93135	1,42	20591.93135	413.94	0.00
P: POP	666.84207	2,42	333.42103	6.70	0.00
H	1.83470	1,42	1.83470	0.18	0.67
(H) X (P: POP)	60.28739	2,42	30.14370	2.93	0.06
S	4.55625	1,42	4.55625	0.26	0.61
(S) X (P: POP)	7.15017	2,42	3.57508	0.21	0.81
R	5264.73027	1,42	5264.73027	131.98	0.00
(R) X (P: POP)	210.19017	2,42	105.09509	2.63	0.08
HS	26.08225	1,42	26.08225	8.17	0.01
(HS) X (P: POP)	1.56817	2,42	0.78408	0.25	0.78
HR	46.01025	1,42	46.01025	14.02	0.00
(HR) X (P: POP)	4.73617	2,42	2.36808	0.72	0.49
SR	30.80025	1,42	30.80025	1.48	0.23
(SR) X (P: POP)	75.26850	2,42	37.63425	1.81	0.18
HSR	1.07803	1,42	1.07803	0.37	0.55
(HSR) X (P: POP)	8.62005	2,42	4.31003	1.49	0.24

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	23749.37779	1,42	23749.37779	249.51	0.00
P: POP	452.27222	2,42	226.13611	2.38	0.11
H	106.71111	1,42	106.71111	12.36	0.00
(H) X (P: POP)	26.54489	2,42	13.27245	1.54	0.23
S	57.28044	1,42	57.28044	2.72	0.11
(S) X (P: POP)	1.47622	2,42	0.73811	0.04	0.97
R	4348.61511	1,42	4348.61511	124.34	0.00
(R) X (P: POP)	132.53356	2,42	66.26678	1.89	0.16
HS	12.69378	1,42	12.69378	4.31	0.04
(HS) X (P: POP)	0.18956	2,42	0.09478	0.03	0.97
HR	144.90711	1,42	144.90711	30.08	0.00
(HR) X (P: POP)	7.36355	2,42	3.68178	0.76	0.47
SR	15.87600	1,42	15.87600	0.81	0.37
(SR) X (P: POP)	141.81667	2,42	70.90833	3.64	0.03
HSR	0.34844	1,42	0.34844	0.10	0.76
(HSR) X (P: POP)	13.57622	2,42	6.78811	1.86	0.17

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	5503.71600	1,42	5503.71600	33.61	0.00
P: POP	732.16868	2,42	366.08434	2.24	0.12
H	10.88544	1,42	10.88544	1.08	0.30
(H) X (P: POP)	46.93356	2,42	23.46678	2.33	0.11
S	148.73878	1,42	148.73878	10.45	0.00
(S) X (P: POP)	31.93089	2,42	15.96544	1.12	0.34
R	360.00000	1,42	360.00000	10.34	0.00
(R) X (P: POP)	125.59400	2,42	62.79700	1.80	0.18
HS	0.98178	1,42	0.98178	0.28	0.60
(HS) X (P: POP)	6.97356	2,42	3.48678	0.99	0.38
HR	1.27211	1,42	1.27211	0.34	0.56
(HR) X (P: POP)	11.96355	2,42	5.98178	1.59	0.22
SR	19.13611	1,42	19.13611	1.00	0.32
(SR) X (P: POP)	34.35489	2,42	17.17744	0.90	0.42
HSR	0.03600	1,42	0.03600	0.01	0.91
(HSR) X (P: POP)	2.48267	2,42	1.24133	0.45	0.64

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	1345.59999	1,42	1345.59999	11.85	0.00
P: POP	571.79717	2,42	285.89858	2.52	0.09
H	92.01111	1,42	92.01111	5.27	0.03
(H) X (P: POP)	7.85406	2,42	3.92703	0.22	0.80
S	0.00711	1,42	0.00711	0.00	0.98
(S) X (P: POP)	21.57339	2,42	10.78669	1.20	0.31
R	2346.00277	1,42	2346.00277	76.22	0.00
(R) X (P: POP)	30.46439	2,42	15.23219	0.49	0.61
HS	11.52045	1,42	11.52045	15.34	0.00
(HS) X (P: POP)	0.16006	2,42	0.08003	0.11	0.90
HR	46.22500	1,42	46.22500	13.84	0.00
(HR) X (P: POP)	2.90017	2,42	1.45008	0.43	0.65
SR	0.36100	1,42	0.36100	0.03	0.87
(SR) X (P: POP)	10.74017	2,42	5.37008	0.43	0.65
HSR	4.66944	1,42	4.66944	7.25	0.01
(HSR) X (P: POP)	0.10039	2,42	0.05019	0.08	0.93

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	5527.20101	1,42	5527.20101	81.00	0.00
P: POP	627.25401	2,42	313.62701	4.60	0.02
H	3.68045	1,42	3.68045	0.27	0.60
(H) X (P: POP)	17.27355	2,42	8.63678	0.64	0.53
S	0.10678	1,42	0.10678	0.01	0.92
(S) X (P: POP)	22.40289	2,42	11.20144	1.13	0.33
R	3793.40545	1,42	3793.40545	159.16	0.00
(R) X (P: POP)	43.71356	2,42	21.85678	0.92	0.41
HS	7.74400	1,42	7.74400	6.00	0.02
(HS) X (P: POP)	2.03467	2,42	1.01733	0.79	0.46
HR	60.84444	1,42	60.84444	21.58	0.00
(HR) X (P: POP)	8.68689	2,42	4.34344	1.54	0.23
SR	3.64011	1,42	3.64011	0.30	0.58
(SR) X (P: POP)	14.52955	2,42	7.26478	0.61	0.55
HSR	3.13600	1,42	3.13600	2.56	0.12
(HSR) X (P: POP)	0.77600	2,42	0.38800	0.32	0.73

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	14282.10066	1,42	14282.10066	176.15	0.00
P: POP	415.10157	2,42	207.55078	2.56	0.09
H	61.75226	1,42	61.75226	6.57	0.01
(H) X (P: POP)	28.69400	2,42	14.34700	1.53	0.23
S	0.63336	1,42	0.63336	0.07	0.80
(S) X (P: POP)	25.28355	2,42	12.64178	1.36	0.27
R	4072.99670	1,42	4072.99670	197.20	0.00
(R) X (P: POP)	47.29089	2,42	23.64544	1.14	0.33
HS	3.19225	1,42	3.19225	1.86	0.18
(HS) X (P: POP)	0.84267	2,42	0.42133	0.25	0.78
HR	156.42025	1,42	156.42025	45.46	0.00
(HR) X (P: POP)	5.77400	2,42	2.88700	0.84	0.44
SR	2.58403	1,42	2.58403	0.24	0.63
(SR) X (P: POP)	19.11356	2,42	9.55678	0.89	0.42
HSR	1.89225	1,42	1.89225	0.99	0.33
(HSR) X (P: POP)	2.18867	2,42	1.09433	0.57	0.57

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2371.59999	1,42	2371.59999	20.72	0.00
P: POP	922.87817	2,42	461.43908	4.03	0.03
H	26.67778	1,42	26.67778	3.35	0.07
(H) X (P: POP)	42.09006	2,42	21.04503	2.65	0.08
S	12.84444	1,42	12.84444	1.21	0.28
(S) X (P: POP)	25.71039	2,42	12.85519	1.21	0.31
R	1221.02498	1,42	1221.02498	44.02	0.00
(R) X (P: POP)	113.49649	2,42	56.74825	2.05	0.14
HS	1.65378	1,42	1.65378	1.41	0.24
(HS) X (P: POP)	0.41806	2,42	0.20903	0.18	0.84
HR	2.66944	1,42	2.66944	1.12	0.30
(HR) X (P: POP)	3.52839	2,42	1.76419	0.74	0.48
SR	0.88011	1,42	0.88011	0.08	0.78
(SR) X (P: POP)	12.71206	2,42	6.35603	0.59	0.56
HSR	0.03211	1,42	0.03211	0.02	0.89
(HSR) X (P: POP)	1.06906	2,42	0.53453	0.35	0.71

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	3555.11023	1,42	3555.11023	28.69	0.00
P: POP	79.21017	2,42	39.60508	0.32	0.73
H	271.96225	1,42	271.96225	6.61	0.01
(H) X (P: POP)	122.38850	2,42	61.19425	1.49	0.24
S	0.04669	1,42	0.04669	0.00	0.95
(S) X (P: POP)	12.32039	2,42	6.16019	0.58	0.56
R	154.58003	1,42	154.58003	5.76	0.02
(R) X (P: POP)	48.50406	2,42	24.25203	0.90	0.41
HS	4.11736	1,42	4.11736	3.39	0.07
(HS) X (P: POP)	2.49206	2,42	1.24603	1.03	0.37
HR	7.31025	1,42	7.31025	3.26	0.08
(HR) X (P: POP)	2.88817	2,42	1.44408	0.64	0.53
SR	25.01669	1,42	25.01669	1.95	0.17
(SR) X (P: POP)	2.24539	2,42	1.12269	0.09	0.92
HSR	1.86336	1,42	1.86336	2.21	0.14
(HSR) X (P: POP)	4.73572	2,42	2.36786	2.81	0.07

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	363.60900	1,42	363.60900	3.07	0.09
P: POP	80.64066	2,42	40.32033	0.34	0.71
H	12.54400	1,42	12.54400	0.54	0.47
(H) X (P: POP)	64.29800	2,42	32.14900	1.38	0.26
S	7.68544	1,42	7.68544	0.77	0.38
(S) X (P: POP)	8.95022	2,42	4.47511	0.45	0.64
R	23.71600	1,42	23.71600	0.74	0.39
(R) X (P: POP)	13.94867	2,42	6.97433	0.22	0.80
HS	0.54444	1,42	0.54444	0.38	0.54
(HS) X (P: POP)	0.02489	2,42	0.01244	0.01	0.99
HR	59.37345	1,42	59.37345	19.58	0.00
(HR) X (P: POP)	10.57622	2,42	5.28811	1.74	0.19
SR	10.95511	1,42	10.95511	1.61	0.21
(SR) X (P: POP)	1.42222	2,42	0.71111	0.10	0.90
HSR	1.04544	1,42	1.04544	0.96	0.33
(HSR) X (P: POP)	10.69155	2,42	5.34578	4.89	0.01

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	9338.11727	1,42	9338.11727	81.13	0.00
P: POP	188.75539	2,42	94.37770	0.82	0.45
H	5.50069	1,42	5.50069	0.33	0.57
(H) X (P: POP)	12.99705	2,42	6.49853	0.39	0.68
S	33.91736	1,42	33.91736	2.85	0.10
(S) X (P: POP)	8.15439	2,42	4.07719	0.34	0.71
R	822.34668	1,42	822.34668	24.47	0.00
(R) X (P: POP)	44.36872	2,42	22.18436	0.66	0.52
HS	0.15625	1,42	0.15625	0.11	0.74
(HS) X (P: POP)	0.10117	2,42	0.05058	0.04	0.96
HR	112.56025	1,42	112.56025	23.12	0.00
(HR) X (P: POP)	3.60950	2,42	1.80475	0.37	0.69
SR	18.72336	1,42	18.72336	3.04	0.09
(SR) X (P: POP)	14.77439	2,42	7.38720	1.20	0.31
HSR	1.83470	1,42	1.83470	1.39	0.25
(HSR) X (P: POP)	6.52072	2,42	3.26036	2.46	0.10

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	7410.19134	1,42	7410.19134	55.03	0.00
P: POP	774.37504	2,42	387.18752	2.88	0.07
H	17.20470	1,42	17.20470	1.92	0.17
(H) X (P: POP)	15.54205	2,42	7.77103	0.87	0.43
S	37.44225	1,42	37.44225	3.24	0.08
(S) X (P: POP)	7.89817	2,42	3.94908	0.34	0.71
R	1226.55625	1,42	1226.55625	39.14	0.00
(R) X (P: POP)	41.47850	2,42	20.73925	0.66	0.52
HS	1.61336	1,42	1.61336	1.37	0.25
(HS) X (P: POP)	0.09672	2,42	0.04836	0.04	0.96
HR	7.65625	1,42	7.65625	3.79	0.06
(HR) X (P: POP)	1.19817	2,42	0.59908	0.30	0.74
SR	45.44003	1,42	45.44003	6.76	0.01
(SR) X (P: POP)	44.78672	2,42	22.39336	3.33	0.05
HSR	0.14803	1,42	0.14803	0.10	0.75
(HSR) X (P: POP)	0.12239	2,42	0.06119	0.04	0.96

APPENDIX H

ANOVA TABLES FOR THIRD GRADE ELECTROPHYSIOLOGICAL DATA
READING GROUP COMPARISON RD vs. NRD (n=30)

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	14004.12032	1,28	14004.12032	154.49	0.00
P: POP	4.29338	1,28	4.29338	0.05	0.83
H	117.18038	1,28	117.18038	4.86	0.04
(H) X (P: POP)	7.81204	1,28	7.81204	0.32	0.57
S	0.87604	1,28	0.87604	0.06	0.81
(S) X (P: POP)	17.65837	1,28	17.65837	1.21	0.28
R	0.78204	1,28	0.78204	0.04	0.84
(R) X (P: POP)	8.47504	1,28	8.47504	0.45	0.51
HS	0.00337	1,28	0.00337	0.00	0.96
(HS) X (P: POP)	0.03038	1,28	0.03038	0.02	0.89
HR	0.42504	1,28	0.42504	0.19	0.66
(HR) X (P: POP)	1.08004	1,28	1.08004	0.49	0.49
SR	2.75204	1,28	2.75204	0.13	0.72
(SR) X (P: POP)	1.75104	1,28	1.75104	0.08	0.78
HSR	13.68038	1,28	13.68038	7.67	0.01
(HSR) X (P: POP)	0.00204	1,28	0.00204	0.00	0.97

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	4019.65350	1,28	4019.65350	123.69	0.00
P: POP	73.04067	1,28	73.04067	2.25	0.15
H	52.64067	1,28	52.64067	9.75	0.00
(H) X (P: POP)	7.42017	1,28	7.42017	1.37	0.25
S	2.94817	1,28	2.94817	0.22	0.65
(S) X (P: POP)	20.65067	1,28	20.65067	1.51	0.23
R	23.81400	1,28	23.81400	1.47	0.24
(R) X (P: POP)	6.73350	1,28	6.73350	0.42	0.52
HS	0.32267	1,28	0.32267	0.16	0.69
(HS) X (P: POP)	3.40817	1,28	3.40817	1.73	0.20
HR	0.43350	1,28	0.43350	0.13	0.72
(HR) X (P: POP)	1.41067	1,28	1.41067	0.41	0.53
SR	15.60600	1,28	15.60600	0.68	0.41
(SR) X (P: POP)	39.52817	1,28	39.52817	1.73	0.20
HSR	1.56817	1,28	1.56817	0.46	0.50
(HSR) X (P: POP)	0.45067	1,28	0.45067	0.13	0.72

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	1627.08337	1,28	1627.08337	67.33	0.00
P: POP	16.38037	1,28	16.38037	0.68	0.42
H	28.91204	1,28	28.91204	4.58	0.04
(H) X (P: POP)	18.20504	1,28	18.20504	2.88	0.10
S	7.52604	1,28	7.52604	0.65	0.43
(S) X (P: POP)	0.02604	1,28	0.02604	0.00	0.96
R	35.49704	1,28	35.49704	2.15	0.15
(R) X (P: POP)	16.48504	1,28	16.48504	1.00	0.33
HS	0.67204	1,28	0.67204	0.28	0.60
(HS) X (P: POP)	0.00937	1,28	0.00937	0.00	0.95
HR	0.16537	1,28	0.16537	0.07	0.80
(HR) X (P: POP)	13.02004	1,28	13.02004	5.26	0.03
SR	5.61204	1,28	5.61204	0.28	0.60
(SR) X (P: POP)	9.16504	1,28	9.16504	0.45	0.51
HSR	1.33504	1,28	1.33504	0.35	0.56
(HSR) X (P: POP)	6.11204	1,28	6.11204	1.60	0.22

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2236.87204	1,28	2236.87204	103.30	0.00
P: POP	13.58504	1,28	13.58504	0.63	0.43
H	13.68038	1,28	13.68038	3.18	0.09
(H) X (P: POP)	0.82838	1,28	0.82838	0.19	0.66
S	14.25938	1,28	14.25938	1.99	0.17
(S) X (P: POP)	0.45938	1,28	0.45938	0.06	0.80
R	26.60004	1,28	26.60004	1.33	0.26
(R) X (P: POP)	43.43504	1,28	43.43504	2.18	0.15
HS	0.97537	1,28	0.97537	0.73	0.40
(HS) X (P: POP)	5.55104	1,28	5.55104	4.17	0.05
HR	1.13437	1,28	1.13437	0.44	0.51
(HR) X (P: POP)	0.05104	1,28	0.05104	0.02	0.89
SR	3.06004	1,28	3.06004	0.16	0.69
(SR) X (P: POP)	0.00204	1,28	0.00204	0.00	0.99
HSR	1.42604	1,28	1.42604	0.40	0.53
(HSR) X (P: POP)	17.33438	1,28	17.33438	4.82	0.04

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	8450.25331	1,28	8450.25331	194.29	0.00
P: POP	134.55036	1,28	134.55036	3.09	0.09
H	455.12604	1,28	455.12604	30.76	0.00
(H) X (P: POP)	138.77604	1,28	138.77604	9.38	0.00
S	6.43537	1,28	6.43537	0.87	0.36
(S) X (P: POP)	12.19504	1,28	12.19504	1.66	0.21
R	0.15504	1,28	0.15504	0.01	0.91
(R) X (P: POP)	4.95938	1,28	4.95938	0.38	0.54
HS	2.97038	1,28	2.97038	0.91	0.35
(HS) X (P: POP)	0.57037	1,28	0.57037	0.17	0.68
HR	9.32204	1,28	9.32204	1.35	0.26
(HR) X (P: POP)	0.02204	1,28	0.02204	0.00	0.96
SR	37.52504	1,28	37.52504	3.23	0.08
(SR) X (P: POP)	0.16537	1,28	0.16537	0.01	0.91
HSR	6.50104	1,28	6.50104	1.31	0.26
(HSR) X (P: POP)	7.10704	1,28	7.10704	1.43	0.24

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	1425.93749	1,28	1425.93749	81.05	0.00
P: POP	16.12017	1,28	16.12017	0.92	0.35
H	51.70817	1,28	51.70817	6.45	0.02
(H) X (P: POP)	22.69350	1,28	22.69350	2.83	0.10
S	0.05400	1,28	0.05400	0.01	0.91
(S) X (P: POP)	7.07267	1,28	7.07267	1.84	0.19
R	0.70417	1,28	0.70417	0.10	0.76
(R) X (P: POP)	16.74817	1,28	16.74817	2.31	0.14
HS	6.14400	1,28	6.14400	1.63	0.21
(HS) X (P: POP)	0.96267	1,28	0.96267	0.26	0.62
HR	3.40817	1,28	3.40817	0.57	0.45
(HR) X (P: POP)	2.28150	1,28	2.28150	0.38	0.54
SR	0.19267	1,28	0.19267	0.02	0.89
(SR) X (P: POP)	3.95267	1,28	3.95267	0.37	0.55
HSR	0.91267	1,28	0.91267	0.13	0.72
(HSR) X (P: POP)	22.32600	1,28	22.32600	3.28	0.08

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2450.56504	1,28	2450.56504	152.23	0.00
P: POP	6.90204	1,28	6.90204	0.43	0.52
H	33.07837	1,28	33.07837	4.85	0.04
(H) X (P: POP)	8.10338	1,28	8.10338	1.19	0.29
S	6.17604	1,28	6.17604	0.97	0.33
(S) X (P: POP)	5.73504	1,28	5.73504	0.90	0.35
R	3.48004	1,28	3.48004	0.34	0.57
(R) X (P: POP)	8.93204	1,28	8.93204	0.86	0.36
HS	0.10004	1,28	0.10004	0.04	0.85
(HS) X (P: POP)	2.30104	1,28	2.30104	0.84	0.37
HR	1.36504	1,28	1.36504	0.26	0.62
(HR) X (P: POP)	7.31504	1,28	7.31504	1.37	0.25
SR	0.06337	1,28	0.06337	0.01	0.94
(SR) X (P: POP)	6.43538	1,28	6.43538	0.53	0.47
HSR	0.49504	1,28	0.49504	0.13	0.72
(HSR) X (P: POP)	0.24704	1,28	0.24704	0.07	0.80

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	50779.50427	1,28	50779.50427	158.76	0.00
P: POP	155.52600	1,28	155.52600	0.49	0.49
H	1.17600	1,28	1.17600	0.04	0.85
(H) X (P: POP)	1.32017	1,28	1.32017	0.04	0.84
S	116.20417	1,28	116.20417	7.31	0.01
(S) X (P: POP)	29.96266	1,28	29.96266	1.88	0.18
R	2.60417	1,28	2.60417	0.15	0.70
(R) X (P: POP)	32.26667	1,28	32.26667	1.92	0.18
HS	0.11267	1,28	0.11267	0.02	0.88
(HS) X (P: POP)	1.32017	1,28	1.32017	0.28	0.60
HR	0.01667	1,28	0.01667	0.00	0.95
(HR) X (P: POP)	1.98017	1,28	1.98017	0.48	0.49
SR	0.46817	1,28	0.46817	0.02	0.88
(SR) X (P: POP)	9.60000	1,28	9.60000	0.45	0.51
HSR	6.53400	1,28	6.53400	2.41	0.13
(HSR) X (P: POP)	0.84017	1,28	0.84017	0.31	0.58

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	9753.75003	1,28	9753.75003	102.69	0.00
P: POP	17.71267	1,28	17.71267	0.19	0.67
H	407.68266	1,28	407.68266	32.06	0.00
(H) X (P: POP)	12.15000	1,28	12.15000	0.96	0.34
S	10.16817	1,28	10.16817	0.69	0.41
(S) X (P: POP)	27.60817	1,28	27.60817	1.88	0.18
R	509.83351	1,28	509.83351	34.05	0.00
(R) X (P: POP)	0.66150	1,28	0.66150	0.04	0.84
HS	13.53750	1,28	13.53750	2.95	0.10
(HS) X (P: POP)	3.90150	1,28	3.90150	0.85	0.36
HR	1.32017	1,28	1.32017	0.29	0.60
(HR) X (P: POP)	0.00417	1,28	0.00417	0.00	0.98
SR	5.28066	1,28	5.28066	0.29	0.60
(SR) X (P: POP)	17.06667	1,28	17.06667	0.93	0.34
HSR	0.29400	1,28	0.29400	0.06	0.82
(HSR) X (P: POP)	1.73400	1,28	1.73400	0.33	0.57

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	24064.04253	1,28	24064.04253	323.79	0.00
P: POP	1.87267	1,28	1.87267	0.03	0.88
H	185.85599	1,28	185.85599	16.28	0.00
(H) X (P: POP)	0.38400	1,28	0.38400	0.03	0.86
S	3.55267	1,28	3.55267	0.23	0.64
(S) X (P: POP)	11.44067	1,28	11.44067	0.73	0.40
R	550.85399	1,28	550.85399	47.80	0.00
(R) X (P: POP)	0.91267	1,28	0.91267	0.08	0.78
HS	4.81667	1,28	4.81667	0.78	0.38
(HS) X (P: POP)	13.82400	1,28	13.82400	2.25	0.15
HR	7.77600	1,28	7.77600	1.72	0.20
(HR) X (P: POP)	27.47267	1,28	27.47267	6.08	0.02
SR	29.68066	1,28	29.68066	1.49	0.23
(SR) X (P: POP)	5.89067	1,28	5.89067	0.30	0.59
HSR	0.00267	1,28	0.00267	0.00	0.98
(HSR) X (P: POP)	1.94400	1,28	1.94400	0.50	0.48

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	29090.62197	1,28	29090.62197	363.84	0.00
P: POP	0.39204	1,28	0.39204	0.00	0.94
H	15.05004	1,28	15.05004	2.80	0.11
(H) X (P: POP)	0.01204	1,28	0.01204	0.00	0.96
S	15.25104	1,28	15.25104	0.61	0.44
(S) X (P: POP)	1.27604	1,28	1.27604	0.05	0.82
R	355.51005	1,28	355.51005	17.03	0.00
(R) X (P: POP)	6.37004	1,28	6.37004	0.31	0.59
HS	7.81204	1,28	7.81204	2.30	0.14
(HS) X (P: POP)	3.72504	1,28	3.72504	1.10	0.30
HR	9.48038	1,28	9.48038	2.52	0.12
(HR) X (P: POP)	0.18704	1,28	0.18704	0.05	0.83
SR	17.12004	1,28	17.12004	0.97	0.33
(SR) X (P: POP)	2.34037	1,28	2.34037	0.13	0.72
HSR	7.52604	1,28	7.52604	2.58	0.12
(HSR) X (P: POP)	4.56504	1,28	4.56504	1.57	0.22

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	35753.32713	1,28	35753.32713	202.68	0.00
P: POP	11.22338	1,28	11.22338	0.06	0.80
H	2975.80844	1,28	2975.80844	48.91	0.00
(H) X (P: POP)	88.93838	1,28	88.93838	1.46	0.24
S	105.73538	1,28	105.73538	5.85	0.02
(S) X (P: POP)	9.40104	1,28	9.40104	0.52	0.48
R	94.37603	1,28	94.37603	6.83	0.01
(R) X (P: POP)	3.38438	1,28	3.38438	0.24	0.62
HS	7.59704	1,28	7.59704	1.16	0.29
(HS) X (P: POP)	1.13437	1,28	1.13437	0.17	0.68
HR	4.73204	1,28	4.73204	0.41	0.53
(HR) X (P: POP)	5.85938	1,28	5.85938	0.50	0.48
SR	0.17604	1,28	0.17604	0.02	0.90
(SR) X (P: POP)	0.00704	1,28	0.00704	0.00	0.98
HSR	0.80504	1,28	0.80504	0.10	0.76
(HSR) X (P: POP)	15.96504	1,28	15.96504	1.91	0.18

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	8157.33605	1,28	8157.33605	215.32	0.00
P: POP	13.34817	1,28	13.34817	0.35	0.56
H	129.36017	1,28	129.36017	12.27	0.00
(H) X (P: POP)	11.09400	1,28	11.09400	1.05	0.31
S	19.72267	1,28	19.72267	3.21	0.08
(S) X (P: POP)	0.46817	1,28	0.46817	0.08	0.78
R	158.43750	1,28	158.43750	17.06	0.00
(R) X (P: POP)	1.53600	1,28	1.53600	0.17	0.69
HS	16.32817	1,28	16.32817	2.97	0.10
(HS) X (P: POP)	0.41667	1,28	0.41667	0.08	0.79
HR	9.12600	1,28	9.12600	1.86	0.18
(HR) X (P: POP)	10.16817	1,28	10.16817	2.07	0.16
SR	0.02017	1,28	0.02017	0.00	0.96
(SR) X (P: POP)	3.95267	1,28	3.95267	0.57	0.46
HSR	0.77067	1,28	0.77067	0.12	0.74
(HSR) X (P: POP)	1.83750	1,28	1.83750	0.28	0.60

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	19598.72264	1,28	19598.72264	305.69	0.00
P: POP	8.81667	1,28	8.81667	0.14	0.71
H	167.00017	1,28	167.00017	15.27	0.00
(H) X (P: POP)	7.84817	1,28	7.84817	0.72	0.40
S	32.70817	1,28	32.70817	2.48	0.13
(S) X (P: POP)	0.50417	1,28	0.50417	0.04	0.85
R	176.47350	1,28	176.47350	15.96	0.00
(R) X (P: POP)	10.83750	1,28	10.83750	0.98	0.33
HS	5.28066	1,28	5.28066	0.70	0.41
(HS) X (P: POP)	0.08067	1,28	0.08067	0.01	0.92
HR	0.26667	1,28	0.26667	0.06	0.81
(HR) X (P: POP)	25.61067	1,28	25.61067	5.56	0.03
SR	1.12067	1,28	1.12067	0.09	0.76
(SR) X (P: POP)	0.52267	1,28	0.52267	0.04	0.84
HSR	14.11350	1,28	14.11350	3.51	0.07
(HSR) X (P: POP)	0.01350	1,28	0.01350	0.00	0.95

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	11108.48264	1,28	11108.48264	57.95	0.00
P: POP	1.73400	1,28	1.73400	0.01	0.92
H	203.50416	1,28	203.50416	10.02	0.00
(H) X (P: POP)	19.15350	1,28	19.15350	0.94	0.34
S	77.74816	1,28	77.74816	6.02	0.02
(S) X (P: POP)	1.26150	1,28	1.26150	0.10	0.76
R	615.68066	1,28	615.68066	41.04	0.00
(R) X (P: POP)	2.01667	1,28	2.01667	0.13	0.72
HS	2.99267	1,28	2.99267	1.17	0.29
(HS) X (P: POP)	0.01067	1,28	0.01067	0.00	0.95
HR	8.89350	1,28	8.89350	6.02	0.02
(HR) X (P: POP)	2.44017	1,28	2.44017	1.65	0.21
SR	4.98817	1,28	4.98817	0.62	0.44
(SR) X (P: POP)	3.12817	1,28	3.12817	0.39	0.54
HSR	0.24067	1,28	0.24067	0.12	0.73
(HSR) X (P: POP)	0.03267	1,28	0.03267	0.02	0.90

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	10374.03505	1,28	10374.03505	167.79	0.00
P: POP	57.91837	1,28	57.91837	0.94	0.34
H	36.27037	1,28	36.27037	3.51	0.07
(H) X (P: POP)	0.24704	1,28	0.24704	0.02	0.88
S	124.56004	1,28	124.56004	7.62	0.01
(S) X (P: POP)	10.79504	1,28	10.79504	0.66	0.42
R	1206.46504	1,28	1206.46504	90.23	0.00
(R) X (P: POP)	9.96338	1,28	9.96338	0.75	0.40
HS	0.40838	1,28	0.40838	0.16	0.69
(HS) X (P: POP)	0.01204	1,28	0.01204	0.00	0.94
HR	0.90037	1,28	0.90037	0.29	0.59
(HR) X (P: POP)	0.02204	1,28	0.02204	0.01	0.93
SR	10.20937	1,28	10.20937	0.75	0.39
(SR) X (P: POP)	10.88004	1,28	10.88004	0.80	0.38
HSR	2.97037	1,28	2.97037	0.83	0.37
(HSR) X (P: POP)	1.21837	1,28	1.21837	0.34	0.56

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2277.96815	1,28	2277.96815	21.62	0.00
P: POP	55.48817	1,28	55.48817	0.53	0.47
H	206.83266	1,28	206.83266	31.53	0.00
(H) X (P: POP)	8.66400	1,28	8.66400	1.32	0.26
S	72.60000	1,28	72.60000	5.67	0.02
(S) X (P: POP)	9.76067	1,28	9.76067	0.76	0.39
R	902.48816	1,28	902.48816	36.41	0.00
(R) X (P: POP)	18.48150	1,28	18.48150	0.75	0.40
HS	7.42017	1,28	7.42017	2.57	0.12
(HS) X (P: POP)	2.20417	1,28	2.20417	0.76	0.39
HR	0.01667	1,28	0.01667	0.00	0.95
(HR) X (P: POP)	4.48267	1,28	4.48267	1.17	0.29
SR	26.66667	1,28	26.66667	2.58	0.12
(SR) X (P: POP)	22.32600	1,28	22.32600	2.16	0.15
HSR	10.66817	1,28	10.66817	3.72	0.06
(HSR) X (P: POP)	0.00417	1,28	0.00417	0.00	0.97

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	11726.42400	1,28	11726.42400	124.67	0.00
P: POP	56.06666	1,28	56.06666	0.60	0.45
H	15.81067	1,28	15.81067	1.64	0.21
(H) X (P: POP)	11.61600	1,28	11.61600	1.21	0.28
S	63.44816	1,28	63.44816	3.28	0.08
(S) X (P: POP)	16.53750	1,28	16.53750	0.85	0.36
R	86.16017	1,28	86.16017	2.63	0.12
(R) X (P: POP)	0.16017	1,28	0.16017	0.00	0.94
HS	0.58017	1,28	0.58017	0.26	0.62
(HS) X (P: POP)	1.83750	1,28	1.83750	0.81	0.37
HR	0.10417	1,28	0.10417	0.05	0.83
(HR) X (P: POP)	0.70417	1,28	0.70417	0.32	0.58
SR	0.96267	1,28	0.96267	0.05	0.83
(SR) X (P: POP)	39.36600	1,28	39.36600	1.91	0.18
HSR	0.17067	1,28	0.17067	0.07	0.79
(HSR) X (P: POP)	1.35000	1,28	1.35000	0.59	0.45

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	15604.16261	1,28	15604.16261	196.63	0.00
P: POP	38.08067	1,28	38.08067	0.48	0.49
H	42.00067	1,28	42.00067	1.33	0.26
(H) X (P: POP)	9.12600	1,28	9.12600	0.29	0.59
S	144.15000	1,28	144.15000	12.21	0.00
(S) X (P: POP)	8.36267	1,28	8.36267	0.71	0.41
R	572.88599	1,28	572.88599	57.88	0.00
(R) X (P: POP)	0.35267	1,28	0.35267	0.04	0.85
HS	0.68267	1,28	0.68267	0.23	0.63
(HS) X (P: POP)	3.65067	1,28	3.65067	1.25	0.27
HR	1.17600	1,28	1.17600	0.35	0.56
(HR) X (P: POP)	0.72600	1,28	0.72600	0.21	0.65
SR	3.95267	1,28	3.95267	0.43	0.52
(SR) X (P: POP)	0.00600	1,28	0.00600	0.00	0.98
HSR	0.68267	1,28	0.68267	0.12	0.73
(HSR) X (P: POP)	2.16600	1,28	2.16600	0.38	0.54

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	3787.38148	1,28	3787.38148	128.53	0.00
P: POP	9.12600	1,28	9.12600	0.31	0.58
H	61.40817	1,28	61.40817	10.59	0.00
(H) X (P: POP)	15.81067	1,28	15.81067	2.73	0.11
S	55.10416	1,28	55.10416	6.79	0.01
(S) X (P: POP)	5.04600	1,28	5.04600	0.62	0.44
R	232.85400	1,28	232.85400	22.84	0.00
(R) X (P: POP)	0.00417	1,28	0.00417	0.00	0.98
HS	11.70417	1,28	11.70417	3.03	0.09
(HS) X (P: POP)	11.97067	1,28	11.97067	3.10	0.09
HR	0.38400	1,28	0.38400	0.08	0.77
(HR) X (P: POP)	0.10417	1,28	0.10417	0.02	0.88
SR	8.97067	1,28	8.97067	1.33	0.26
(SR) X (P: POP)	0.16017	1,28	0.16017	0.02	0.88
HSR	16.85400	1,28	16.85400	5.51	0.03
(HSR) X (P: POP)	0.84017	1,28	0.84017	0.27	0.60

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	10263.87605	1,28	10263.87605	155.43	0.00
P: POP	30.03337	1,28	30.03337	0.45	0.51
H	47.61504	1,28	47.61504	4.10	0.05
(H) X (P: POP)	35.49704	1,28	35.49704	3.05	0.09
S	52.36004	1,28	52.36004	3.72	0.06
(S) X (P: POP)	14.65204	1,28	14.65204	1.04	0.32
R	41.25104	1,28	41.25104	2.25	0.15
(R) X (P: POP)	0.00338	1,28	0.00338	0.00	0.99
HS	13.11338	1,28	13.11338	5.29	0.03
(HS) X (P: POP)	0.21004	1,28	0.21004	0.08	0.77
HR	0.12604	1,28	0.12604	0.03	0.87
(HR) X (P: POP)	4.84504	1,28	4.84504	1.08	0.31
SR	0.05104	1,28	0.05104	0.00	0.95
(SR) X (P: POP)	13.39537	1,28	13.39537	0.85	0.36
HSR	0.01504	1,28	0.01504	0.01	0.94
(HSR) X (P: POP)	0.06338	1,28	0.06338	0.02	0.89

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	8869.50422	1,28	8869.50422	158.32	0.00
P: POP	298.82017	1,28	298.82017	5.33	0.03
H	0.06667	1,28	0.06667	0.01	0.91
(H) X (P: POP)	19.04067	1,28	19.04067	3.86	0.06
S	16.32817	1,28	16.32817	1.28	0.27
(S) X (P: POP)	10.50017	1,28	10.50017	0.82	0.37
R	1849.26018	1,28	1849.26018	58.05	0.00
(R) X (P: POP)	22.44817	1,28	22.44817	0.70	0.41
HS	4.93067	1,28	4.93067	3.82	0.06
(HS) X (P: POP)	1.47267	1,28	1.47267	1.14	0.29
HR	54.15000	1,28	54.15000	18.52	0.00
(HR) X (P: POP)	1.12067	1,28	1.12067	0.38	0.54
SR	11.70417	1,28	11.70417	1.60	0.22
(SR) X (P: POP)	0.16017	1,28	0.16017	0.02	0.88
HSR	0.68267	1,28	0.68267	0.49	0.49
(HSR) X (P: POP)	0.09600	1,28	0.09600	0.07	0.80

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	10733.43751	1,28	10733.43751	215.69	0.00
P: POP	483.36819	1,28	483.36819	9.71	0.00
H	13.44267	1,28	13.44267	2.53	0.12
(H) X (P: POP)	3.95267	1,28	3.95267	0.74	0.40
S	7.84817	1,28	7.84817	0.42	0.52
(S) X (P: POP)	0.74817	1,28	0.74817	0.04	0.84
R	3414.11264	1,28	3414.11264	98.79	0.00
(R) X (P: POP)	42.33600	1,28	42.33600	1.22	0.28
HS	5.16267	1,28	5.16267	2.31	0.14
(HS) X (P: POP)	10.75267	1,28	10.75267	4.80	0.04
HR	103.22817	1,28	103.22817	28.40	0.00
(HR) X (P: POP)	8.74017	1,28	8.74017	2.40	0.13
SR	1.06667	1,28	1.06667	0.14	0.71
(SR) X (P: POP)	0.64067	1,28	0.64067	0.08	0.77
HSR	1.98017	1,28	1.98017	0.77	0.39
(HSR) X (P: POP)	0.98817	1,28	0.98817	0.38	0.54

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	15621.90703	1,28	15621.90703	154.04	0.00
P: POP	301.28003	1,28	301.28003	2.97	0.10
H	54.62604	1,28	54.62604	6.20	0.02
(H) X (P: POP)	0.59004	1,28	0.59004	0.07	0.80
S	26.20204	1,28	26.20204	1.77	0.19
(S) X (P: POP)	57.13504	1,28	57.13504	3.86	0.06
R	2469.77507	1,28	2469.77507	92.59	0.00
(R) X (P: POP)	2.14704	1,28	2.14704	0.08	0.78
HS	6.24038	1,28	6.24038	2.26	0.14
(HS) X (P: POP)	1.10704	1,28	1.10704	0.40	0.53
HR	97.41003	1,28	97.41003	26.13	0.00
(HR) X (P: POP)	29.05105	1,28	29.05105	7.79	0.01
SR	10.45837	1,28	10.45837	1.47	0.24
(SR) X (P: POP)	24.76838	1,28	24.76838	3.48	0.07
HSR	0.10004	1,28	0.10004	0.03	0.87
(HSR) X (P: POP)	5.73504	1,28	5.73504	1.53	0.23

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	4627.06017	1,28	4627.06017	39.13	0.00
P: POP	417.64816	1,28	417.64816	3.53	0.07
H	0.72600	1,28	0.72600	0.21	0.65
(H) X (P: POP)	3.17400	1,28	3.17400	0.92	0.35
S	10.83750	1,28	10.83750	0.87	0.36
(S) X (P: POP)	43.18017	1,28	43.18017	3.47	0.07
R	212.44017	1,28	212.44017	7.70	0.01
(R) X (P: POP)	40.18017	1,28	40.18017	1.46	0.24
HS	0.19267	1,28	0.19267	0.10	0.76
(HS) X (P: POP)	0.72600	1,28	0.72600	0.36	0.55
HR	0.13067	1,28	0.13067	0.06	0.80
(HR) X (P: POP)	0.00067	1,28	0.00067	0.00	0.99
SR	9.20417	1,28	9.20417	0.82	0.37
(SR) X (P: POP)	46.99350	1,28	46.99350	4.20	0.05
HSR	2.09067	1,28	2.09067	0.74	0.40
(HSR) X (P: POP)	1.23267	1,28	1.23267	0.44	0.51

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	8282.57501	1,28	8282.57501	150.15	0.00
P: POP	300.38438	1,28	300.38438	5.45	0.03
H	2.88204	1,28	2.88204	0.12	0.73
(H) X (P: POP)	7.88437	1,28	7.88437	0.33	0.57
S	3.52837	1,28	3.52837	0.26	0.61
(S) X (P: POP)	0.01504	1,28	0.01504	0.00	0.97
R	1396.35503	1,28	1396.35503	57.91	0.00
(R) X (P: POP)	0.78204	1,28	0.78204	0.03	0.86
HS	43.43504	1,28	43.43504	10.50	0.00
(HS) X (P: POP)	9.24338	1,28	9.24338	2.23	0.15
HR	60.90338	1,28	60.90338	8.58	0.01
(HR) X (P: POP)	1.92604	1,28	1.92604	0.27	0.61
SR	7.95704	1,28	7.95704	1.30	0.26
(SR) X (P: POP)	0.06337	1,28	0.06337	0.01	0.92
HSR	18.09504	1,28	18.09504	6.98	0.01
(HSR) X (P: POP)	0.18704	1,28	0.18704	0.07	0.79

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	6955.26670	1,28	6955.26670	221.72	0.00
P: POP	482.80067	1,28	482.80067	15.39	0.00
H	1.20417	1,28	1.20417	0.11	0.74
(H) X (P: POP)	0.08817	1,28	0.08817	0.01	0.93
S	50.96817	1,28	50.96817	6.35	0.02
(S) X (P: POP)	55.48817	1,28	55.48817	6.91	0.01
R	91.26667	1,28	91.26667	9.67	0.00
(R) X (P: POP)	3.65067	1,28	3.65067	0.39	0.54
HS	4.59267	1,28	4.59267	2.51	0.12
(HS) X (P: POP)	0.13067	1,28	0.13067	0.07	0.79
HR	31.24816	1,28	31.24816	7.39	0.01
(HR) X (P: POP)	2.20417	1,28	2.20417	0.52	0.48
SR	36.97350	1,28	36.97350	6.85	0.01
(SR) X (P: POP)	18.48150	1,28	18.48150	3.43	0.07
HSR	0.15000	1,28	0.15000	0.04	0.84
(HSR) X (P: POP)	1.12067	1,28	1.12067	0.32	0.57

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	4317.16837	1,28	4317.16837	111.87	0.00
P: POP	249.49204	1,28	249.49204	6.47	0.02
H	10.12704	1,28	10.12704	1.12	0.30
(H) X (P: POP)	29.47004	1,28	29.47004	3.27	0.08
S	28.63504	1,28	28.63504	2.64	0.12
(S) X (P: POP)	6.70004	1,28	6.70004	0.62	0.44
R	119.70938	1,28	119.70938	5.67	0.02
(R) X (P: POP)	31.46504	1,28	31.46504	1.49	0.23
HS	1.27604	1,28	1.27604	0.60	0.45
(HS) X (P: POP)	1.48838	1,28	1.48838	0.70	0.41
HR	12.37604	1,28	12.37604	2.01	0.17
(HR) X (P: POP)	0.71504	1,28	0.71504	0.12	0.74
SR	23.87704	1,28	23.87704	2.44	0.13
(SR) X (P: POP)	24.13004	1,28	24.13004	2.47	0.13
HSR	0.02204	1,28	0.02204	0.01	0.94
(HSR) X (P: POP)	1.13438	1,28	1.13438	0.27	0.61

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UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	154.56150	1,28	154.56150	2.16	0.15
P: POP	136.50416	1,28	136.50416	1.91	0.18
H	85.44267	1,28	85.44267	7.29	0.01
(H) X (P: POP)	0.91267	1,28	0.91267	0.08	0.78
S	0.06017	1,28	0.06017	0.00	0.95
(S) X (P: POP)	35.72816	1,28	35.72816	2.45	0.13
R	211.68816	1,28	211.68816	8.04	0.01
(R) X (P: POP)	14.70150	1,28	14.70150	0.56	0.46
HS	0.35267	1,28	0.35267	0.54	0.47
(HS) X (P: POP)	0.81667	1,28	0.81667	1.25	0.27
HR	40.01667	1,28	40.01667	24.13	0.00
(HR) X (P: POP)	0.35267	1,28	0.35267	0.21	0.65
SR	2.86017	1,28	2.86017	0.54	0.47
(SR) X (P: POP)	1.50417	1,28	1.50417	0.28	0.60
HSR	0.00000	1,28	0.00000	0.00	1.00
(HSR) X (P: POP)	0.00067	1,28	0.00067	0.00	0.97

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2210.08707	1,28	2210.08707	31.19	0.00
P: POP	689.86505	1,28	689.86505	9.74	0.00
H	20.01038	1,28	20.01038	2.02	0.17
(H) X (P: POP)	1.27604	1,28	1.27604	0.13	0.72
S	0.26004	1,28	0.26004	0.02	0.88
(S) X (P: POP)	1.55204	1,28	1.55204	0.15	0.71
R	1327.75105	1,28	1327.75105	41.01	0.00
(R) X (P: POP)	14.06504	1,28	14.06504	0.43	0.52
HS	2.70937	1,28	2.70937	2.97	0.10
(HS) X (P: POP)	0.49504	1,28	0.49504	0.54	0.47
HR	116.34338	1,28	116.34338	29.81	0.00
(HR) X (P: POP)	4.84504	1,28	4.84504	1.24	0.27
SR	8.25104	1,28	8.25104	1.50	0.23
(SR) X (P: POP)	0.11704	1,28	0.11704	0.02	0.89
HSR	2.26204	1,28	2.26204	1.99	0.17
(HSR) X (P: POP)	0.08437	1,28	0.08437	0.07	0.79

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	8460.93749	1,28	8460.93749	97.09	0.00
P: POP	523.33067	1,28	523.33067	6.01	0.02
H	26.53350	1,28	26.53350	2.79	0.11
(H) X (P: POP)	0.32267	1,28	0.32267	0.03	0.86
S	0.60000	1,28	0.60000	0.07	0.79
(S) X (P: POP)	16.32817	1,28	16.32817	2.03	0.17
R	1917.61067	1,28	1917.61067	91.97	0.00
(R) X (P: POP)	0.04817	1,28	0.04817	0.00	0.96
HS	5.52067	1,28	5.52067	4.00	0.06
(HS) X (P: POP)	0.04817	1,28	0.04817	0.03	0.85
HR	128.48066	1,28	128.48066	37.02	0.00
(HR) X (P: POP)	19.83750	1,28	19.83750	5.72	0.02
SR	0.98817	1,28	0.98817	0.16	0.69
(SR) X (P: POP)	4.05600	1,28	4.05600	0.66	0.42
HSR	0.93750	1,28	0.93750	0.47	0.50
(HSR) X (P: POP)	0.60000	1,28	0.60000	0.30	0.59

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	1182.37204	1,28	1182.37204	14.49	0.00
P: POP	130.68504	1,28	130.68504	1.60	0.22
H	0.00938	1,28	0.00938	0.00	0.96
(H) X (P: POP)	0.47704	1,28	0.47704	0.11	0.75
S	9.24338	1,28	9.24338	1.02	0.32
(S) X (P: POP)	26.07004	1,28	26.07004	2.88	0.10
R	846.37704	1,28	846.37704	24.11	0.00
(R) X (P: POP)	2.62504	1,28	2.62504	0.07	0.79
HS	2.26204	1,28	2.26204	2.04	0.16
(HS) X (P: POP)	0.00204	1,28	0.00204	0.00	0.97
HR	6.56704	1,28	6.56704	3.52	0.07
(HR) X (P: POP)	3.38438	1,28	3.38438	1.81	0.19
SR	6.37004	1,28	6.37004	0.69	0.41
(SR) X (P: POP)	22.26504	1,28	22.26504	2.42	0.13
HSR	3.29004	1,28	3.29004	2.47	0.13
(HSR) X (P: POP)	1.00104	1,28	1.00104	0.75	0.39

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	241.40204	1,28	241.40204	4.09	0.05
P: POP	631.47705	1,28	631.47705	10.70	0.00
H	140.60704	1,28	140.60704	10.42	0.00
(H) X (P: POP)	80.62004	1,28	80.62004	5.97	0.02
S	2.50104	1,28	2.50104	0.24	0.63
(S) X (P: POP)	14.85038	1,28	14.85038	1.45	0.24
R	171.19704	1,28	171.19704	12.69	0.00
(R) X (P: POP)	30.88838	1,28	30.88838	2.29	0.14
HS	10.54204	1,28	10.54204	8.05	0.01
(HS) X (P: POP)	2.22337	1,28	2.22337	1.70	0.20
HR	185.68004	1,28	185.68004	38.95	0.00
(HR) X (P: POP)	4.03004	1,28	4.03004	0.85	0.37
SR	10.37504	1,28	10.37504	2.63	0.12
(SR) X (P: POP)	0.21004	1,28	0.21004	0.05	0.82
HSR	0.53204	1,28	0.53204	0.28	0.60
(HSR) X (P: POP)	0.03038	1,28	0.03038	0.02	0.90

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2668.66702	1,28	2668.66702	107.62	0.00
P: POP	567.64504	1,28	567.64504	22.89	0.00
H	9.16504	1,28	9.16504	0.72	0.40
(H) X (P: POP)	8.77838	1,28	8.77838	0.69	0.41
S	14.65204	1,28	14.65204	2.83	0.10
(S) X (P: POP)	10.45837	1,28	10.45837	2.02	0.17
R	12.01538	1,28	12.01538	2.47	0.13
(R) X (P: POP)	3.72504	1,28	3.72504	0.76	0.39
HS	18.76004	1,28	18.76004	13.38	0.00
(HS) X (P: POP)	0.03037	1,28	0.03037	0.02	0.88
HR	46.02504	1,28	46.02504	16.37	0.00
(HR) X (P: POP)	1.39538	1,28	1.39538	0.50	0.49
SR	13.02004	1,28	13.02004	3.12	0.09
(SR) X (P: POP)	1.92604	1,28	1.92604	0.46	0.50
HSR	0.15504	1,28	0.15504	0.07	0.80
(HSR) X (P: POP)	0.03037	1,28	0.03037	0.01	0.91

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	1637.51506	1,28	1637.51506	42.46	0.00
P: POP	145.23704	1,28	145.23704	3.77	0.06
H	9.72038	1,28	9.72038	1.17	0.29
(H) X (P: POP)	0.73704	1,28	0.73704	0.09	0.77
S	3.19704	1,28	3.19704	0.45	0.51
(S) X (P: POP)	14.16204	1,28	14.16204	1.99	0.17
R	243.00937	1,28	243.00937	13.31	0.00
(R) X (P: POP)	1.52004	1,28	1.52004	0.08	0.78
HS	4.03004	1,28	4.03004	3.21	0.08
(HS) X (P: POP)	0.01837	1,28	0.01837	0.01	0.90
HR	40.42604	1,28	40.42604	10.62	0.00
(HR) X (P: POP)	0.85204	1,28	0.85204	0.22	0.64
SR	1.71704	1,28	1.71704	0.29	0.59
(SR) X (P: POP)	6.43538	1,28	6.43538	1.10	0.30
HSR	1.30537	1,28	1.30537	0.56	0.46
(HSR) X (P: POP)	0.07704	1,28	0.07704	0.03	0.86

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N700 MEASURE

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE OCCIPITAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	3562.02148	1,28	3562.02148	25.65	0.00
P: POP	167.33399	1,28	167.33399	1.20	0.28
H	377.00266	1,28	377.00266	13.62	0.00
(H) X (P: POP)	0.03750	1,28	0.03750	0.00	0.97
S	1.98017	1,28	1.98017	0.18	0.68
(S) X (P: POP)	13.82400	1,28	13.82400	1.25	0.27
R	257.50817	1,28	257.50817	13.07	0.00
(R) X (P: POP)	8.06667	1,28	8.06667	0.41	0.53
HS	0.19267	1,28	0.19267	0.29	0.59
(HS) X (P: POP)	0.22817	1,28	0.22817	0.35	0.56
HR	6.80067	1,28	6.80067	3.21	0.08
(HR) X (P: POP)	1.38017	1,28	1.38017	0.65	0.43
SR	0.25350	1,28	0.25350	0.02	0.88
(SR) X (P: POP)	0.77067	1,28	0.77067	0.07	0.79
HSR	1.60067	1,28	1.60067	3.74	0.06
(HSR) X (P: POP)	0.93750	1,28	0.93750	2.19	0.15

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	106.80005	1,28	106.80005	1.08	0.31
P: POP	4.73204	1,28	4.73204	0.05	0.83
H	1.68338	1,28	1.68338	0.11	0.74
(H) X (P: POP)	5.49037	1,28	5.49037	0.36	0.56
S	14.65204	1,28	14.65204	1.43	0.24
(S) X (P: POP)	21.78037	1,28	21.78037	2.13	0.16
R	8.55037	1,28	8.55037	0.23	0.64
(R) X (P: POP)	0.02604	1,28	0.02604	0.00	0.98
HS	0.87604	1,28	0.87604	1.00	0.32
(HS) X (P: POP)	0.12604	1,28	0.12604	0.14	0.71
HR	66.88704	1,28	66.88704	15.93	0.00
(HR) X (P: POP)	0.01838	1,28	0.01838	0.00	0.95
SR	5.73504	1,28	5.73504	0.50	0.48
(SR) X (P: POP)	0.03037	1,28	0.03037	0.00	0.96
HSR	3.01504	1,28	3.01504	4.40	0.05
(HSR) X (P: POP)	0.22204	1,28	0.22204	0.32	0.57

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	3177.72038	1,28	3177.72038	33.36	0.00
P: POP	112.20338	1,28	112.20338	1.18	0.29
H	152.16338	1,28	152.16338	17.57	0.00
(H) X (P: POP)	0.00937	1,28	0.00937	0.00	0.97
S	55.39204	1,28	55.39204	8.96	0.01
(S) X (P: POP)	1.08004	1,28	1.08004	0.17	0.68
R	278.85704	1,28	278.85704	9.71	0.00
(R) X (P: POP)	27.13538	1,28	27.13538	0.95	0.34
HS	0.82838	1,28	0.82838	0.59	0.45
(HS) X (P: POP)	0.33004	1,28	0.33004	0.24	0.63
HR	62.73037	1,28	62.73037	9.03	0.01
(HR) X (P: POP)	0.40838	1,28	0.40838	0.06	0.81
SR	30.31704	1,28	30.31704	2.78	0.11
(SR) X (P: POP)	3.15104	1,28	3.15104	0.29	0.60
HSR	6.76704	1,28	6.76704	6.96	0.01
(HSR) X (P: POP)	1.42604	1,28	1.42604	1.47	0.24

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	2068.00103	1,28	2068.00103	27.96	0.00
P: POP	65.00004	1,28	65.00004	0.88	0.36
H	0.55104	1,28	0.55104	0.07	0.79
(H) X (P: POP)	9.24337	1,28	9.24337	1.19	0.28
S	94.62704	1,28	94.62704	16.98	0.00
(S) X (P: POP)	0.82837	1,28	0.82837	0.15	0.70
R	432.28505	1,28	432.28505	15.26	0.00
(R) X (P: POP)	21.42037	1,28	21.42037	0.76	0.39
HS	1.92604	1,28	1.92604	1.93	0.18
(HS) X (P: POP)	0.26004	1,28	0.26004	0.26	0.61
HR	12.01537	1,28	12.01537	6.60	0.02
(HR) X (P: POP)	3.67537	1,28	3.67537	2.02	0.17
SR	10.62604	1,28	10.62604	1.35	0.25
(SR) X (P: POP)	2.18504	1,28	2.18504	0.28	0.60
HSR	0.31537	1,28	0.31537	0.35	0.56
(HSR) X (P: POP)	0.73704	1,28	0.73704	0.81	0.38

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL PARIETAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	10383.24153	1,28	10383.24153	108.40	0.00
P: POP	24.19350	1,28	24.19350	0.25	0.62
H	337.48815	1,28	337.48815	11.09	0.00
(H) X (P: POP)	182.00416	1,28	182.00416	5.98	0.02
S	2.48067	1,28	2.48067	0.44	0.51
(S) X (P: POP)	18.37067	1,28	18.37067	3.25	0.08
R	182.00416	1,28	182.00416	8.94	0.01
(R) X (P: POP)	3.60150	1,28	3.60150	0.18	0.68
HS	1.66667	1,28	1.66667	0.88	0.36
(HS) X (P: POP)	0.77067	1,28	0.77067	0.41	0.53
HR	104.80817	1,28	104.80817	18.95	0.00
(HR) X (P: POP)	0.40017	1,28	0.40017	0.07	0.79
SR	1.53600	1,28	1.53600	0.20	0.66
(SR) X (P: POP)	0.05400	1,28	0.05400	0.01	0.93
HSR	0.06667	1,28	0.06667	0.06	0.81
(HSR) X (P: POP)	0.26667	1,28	0.26667	0.23	0.64

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL CENTRAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	1904.06667	1,28	1904.06667	63.90	0.00
P: POP	120.98400	1,28	120.98400	4.06	0.05
H	0.86400	1,28	0.86400	0.05	0.82
(H) X (P: POP)	67.84066	1,28	67.84066	4.27	0.05
S	23.06400	1,28	23.06400	9.77	0.00
(S) X (P: POP)	0.24067	1,28	0.24067	0.10	0.75
R	5.46017	1,28	5.46017	1.04	0.32
(R) X (P: POP)	1.56817	1,28	1.56817	0.30	0.59
HS	0.77067	1,28	0.77067	0.43	0.52
(HS) X (P: POP)	0.86400	1,28	0.86400	0.48	0.50
HR	47.34817	1,28	47.34817	8.68	0.01
(HR) X (P: POP)	2.28150	1,28	2.28150	0.42	0.52
SR	18.04017	1,28	18.04017	3.71	0.06
(SR) X (P: POP)	0.02817	1,28	0.02817	0.01	0.94
HSR	3.12817	1,28	3.12817	1.83	0.19
(HSR) X (P: POP)	1.09350	1,28	1.09350	0.64	0.43

UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE TEMPORAL FRONTAL

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	TAIL PROB.
OVALL: GRAND MEAN	3032.41504	1,28	3032.41504	81.69	0.00
P: POP	87.24204	1,28	87.24204	2.35	0.14
H	5.73504	1,28	5.73504	0.53	0.47
(H) X (P: POP)	21.66004	1,28	21.66004	2.02	0.17
S	46.72838	1,28	46.72838	13.91	0.00
(S) X (P: POP)	0.18704	1,28	0.18704	0.06	0.82
R	255.23437	1,28	255.23437	15.13	0.00
(R) X (P: POP)	7.81204	1,28	7.81204	0.46	0.50
HS	4.67604	1,28	4.67604	2.79	0.11
(HS) X (P: POP)	1.52004	1,28	1.52004	0.91	0.35
HR	25.02604	1,28	25.02604	5.09	0.03
(HR) X (P: POP)	0.40838	1,28	0.40838	0.08	0.78
SR	0.69338	1,28	0.69338	0.09	0.77
(SR) X (P: POP)	0.17604	1,28	0.17604	0.02	0.88
HSR	1.92604	1,28	1.92604	1.64	0.21
(HSR) X (P: POP)	0.97537	1,28	0.97537	0.83	0.37

APPENDIX I

SPEARMAN RANK CORRELATION COEFFICIENTS FOR THE RANDOM SAMPLE (n=74)

P120 AMPLITUDE

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.0745	0.0595	0.1109	-0.0159	-0.0178	0.0014
O2	-0.2022	0.1005	0.1151	-0.0873	-0.0585	0.0067
P3	0.0211	-0.0717	-0.1371	0.1665	-0.2307	0.1197
P4	-0.0533	-0.0152	-0.0652	0.0869	-0.2545	0.0612
C3	0.0011	-0.0452	-0.1637	0.1641	-0.2448	-0.0016
C4	0.0411	-0.0501	-0.1106	0.0280	-0.3124	-0.0196
F3	0.0547	-0.1105	-0.2140	-0.0083	-0.1586	-0.0657
F4	0.0259	-0.1020	-0.2009	-0.1228	-0.1340	-0.0508

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.2182	-0.2172	-0.0445	0.0341	-0.3118	-0.2366	0.0883
O2	-0.2628	-0.3030	-0.1014	-0.0886	-0.3585	-0.3678	-0.0314
P3	-0.0924	-0.1060	0.1499	0.0452	0.0530	-0.0162	0.1475
P4	-0.2432	-0.2587	0.0421	0.0419	-0.0206	-0.1376	0.0438
C3	-0.0063	-0.0061	0.1106	-0.0337	0.1558	0.0756	0.0831
C4	-0.1540	-0.1501	0.0708	0.0095	0.0698	-0.0261	-0.0399
F3	0.0106	-0.0642	0.1512	-0.0189	0.1363	0.0903	0.0234
F4	-0.0195	-0.0436	0.0383	-0.0182	0.1002	0.0761	-0.0255

N220 AMPLITUDE

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	0.0751	-0.0155	-0.0215	-0.0181	-0.0290	-0.0799
O2	0.1254	-0.0923	-0.0766	-0.0346	-0.0009	-0.0112
P3	-0.1101	0.0870	-0.0014	-0.0318	-0.0108	-0.0385
P4	-0.1169	-0.0239	-0.1071	0.0330	-0.1253	-0.0785
C3	-0.1161	0.1022	0.0122	-0.0663	-0.1041	-0.0630
C4	-0.1169	-0.0239	-0.1071	0.0330	-0.1253	-0.0785
F3	-0.1711	0.0430	0.0036	0.0244	-0.0203	0.0610
F4	-0.1036	-0.0127	-0.0538	-0.0271	-0.1088	-0.1132
P3-P4	0.0097	0.2397	0.2527	-0.1079	0.1869	-0.0324
C3-C4	-0.0700	0.2603	0.2347	-0.1600	0.0736	-0.0330

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	0.0977	0.0653	-0.0214	-0.0445	0.1364	0.0581	-0.0689
O2	0.1654	0.1066	0.0222	0.1132	0.2291	0.2206	0.0358
P3	-0.0203	-0.0476	-0.1683	-0.1276	-0.0407	-0.1559	-0.1290
P4	0.0312	-0.0325	-0.0812	-0.1689	-0.1006	-0.2353	-0.0647
C3	-0.1641	-0.2274	-0.1183	-0.1353	-0.1550	-0.2810	-0.0848
C4	0.0312	-0.0325	-0.0812	-0.1689	-0.1006	-0.2353	-0.0647
F3	0.0127	-0.0241	-0.0131	-0.1156	-0.1459	-0.3023	-0.0397
F4	-0.0530	-0.0953	-0.0341	-0.2530	-0.2348	-0.3478	-0.1096
P3-P4	-0.1601	-0.0934	-0.2294	0.1162	-0.0057	0.1043	-0.1549
C3-C4	-0.3147	-0.2946	-0.0911	0.1387	-0.1009	-0.0127	-0.0610

P310 AMPLITUDE

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.1313	0.0521	0.0843	-0.1838	0.1686	0.0339
O2	-0.1580	0.0065	0.0228	-0.1362	0.0503	0.0898
P3	-0.1571	-0.0223	-0.1323	-0.0549	-0.0783	0.1139
P4	-0.0861	-0.1077	-0.2768	0.0554	-0.1794	0.1745
C3	0.1295	-0.2234	-0.2630	0.0453	-0.1321	0.1662
C4	0.2336	-0.3470	-0.4017	-0.0140	-0.2811	0.1494
F3	0.1599	-0.2305	-0.2024	0.1047	-0.0612	0.1355
F4	0.1460	-0.3052	-0.2097	-0.0232	-0.1344	0.1393

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	0.0049	-0.1214	-0.0789	-0.1595	-0.0919	-0.1075	-0.0024
O2	0.0844	-0.0724	-0.0734	-0.1480	-0.0441	-0.0883	-0.0767
P3	-0.0224	-0.0548	-0.0918	-0.1476	0.0557	-0.0974	-0.0418
P4	0.1516	0.0303	0.0998	-0.0516	0.1442	0.0439	0.0717
C3	0.1276	0.1397	0.1153	-0.0598	0.2854	0.1278	0.1713
C4	0.2233	0.1659	0.1113	-0.0605	0.3544	0.1834	0.1080
F3	0.1705	0.1366	0.0277	-0.1154	0.2483	0.0434	0.0459
F4	0.1724	0.0660	0.0263	-0.0744	0.1334	-0.0188	-0.0047

P470 AMPLITUDE

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.0773	-0.0681	-0.1174	0.0505	0.0182	0.2639
O2	-0.0819	-0.1030	-0.1337	0.0142	0.1552	0.2650
P3	-0.0379	0.1009	0.0911	0.0456	0.0422	0.0301
P4	-0.0463	-0.0043	-0.0037	0.0051	0.1130	0.1223
C3	0.0147	0.1244	0.0833	0.0162	0.0412	-0.0787
C4	-0.0133	0.0648	0.0360	-0.0029	0.0824	0.0377
F3	-0.0827	0.0657	-0.0009	0.1083	0.0597	-0.0364
F4	-0.1557	-0.0117	-0.0632	0.1868	0.1685	0.0868
P3-P4	-0.0981	0.2379	0.1542	0.0505	0.1405	-0.1785
C3-C4	-0.0698	0.1262	0.1246	-0.0090	0.1235	-0.1890

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	0.1633	0.1729	0.2486	0.1581	0.1670	0.0733	0.2317
O2	0.2105	0.1129	0.2131	0.0355	0.0269	-0.0249	0.1810
P3	0.1022	0.0999	-0.0251	0.0191	0.0240	0.0417	0.0498
P4	0.2467	0.0987	0.0747	0.0130	-0.0258	0.0136	0.1219
C3	0.1173	0.0836	-0.1086	-0.0802	-0.0234	-0.0509	-0.1089
C4	0.2048	0.0653	-0.0404	-0.0574	-0.0167	-0.0981	-0.0230
F3	0.1394	0.0588	-0.1020	-0.1948	0.0411	-0.0851	-0.0555
F4	0.2950	0.2182	-0.0002	-0.1069	0.1987	0.0098	0.0147
P3-P4	-0.2496	-0.0661	-0.1938	-0.0377	-0.0114	-0.0405	-0.1333
C3-C4	-0.1706	-0.0073	-0.0798	-0.0208	-0.0450	0.0299	-0.0738

P550 AMPLITUDE

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1 .
O1	0.1067	-0.0938	-0.1790	0.0901	-0.1239	0.1563
O2	0.1610	-0.0693	-0.1031	0.0615	-0.0213	0.0989
P3	-0.0638	0.1672	0.0936	0.0032	0.0671	0.0420
P4	0.0544	0.1177	0.1193	-0.0549	0.1558	0.1083
C3	-0.0992	0.3275	0.2936	-0.1193	0.2037	-0.1130
C4	-0.0609	0.2178	0.2230	-0.1291	0.1849	0.0763
F3	-0.1677	0.2173	0.1913	-0.0279	0.1978	-0.0187
F4	-0.2550	0.1943	0.1795	0.0215	0.2140	0.0351
P3-P4	-0.2084	0.1761	0.0654	0.0736	-0.0402	0.0096
C3-C4	-0.0773	0.1139	0.0712	0.0489	-0.0026	-0.2215

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3 .
O1	0.0807	0.1602	0.2515	0.1891	0.2697	0.1990	0.1501
O2	0.0187	0.0806	0.1427	0.0821	0.1091	0.1408	0.1272
P3	-0.0107	0.0172	-0.0155	0.0602	0.0550	0.0514	0.0217
P4	0.0267	0.0203	-0.0191	0.0505	-0.0380	0.0037	0.0062
C3	-0.1070	-0.0911	-0.1718	-0.0365	-0.1727	-0.1557	-0.1971
C4	0.0413	-0.0085	-0.0987	0.0291	-0.1487	-0.1309	-0.0929
F3	-0.0082	-0.0551	-0.1505	-0.1488	-0.1289	-0.1832	-0.0103
F4	0.1142	0.0562	-0.1063	-0.1004	-0.0390	-0.0965	-0.0267
P3-P4	-0.0828	0.0311	-0.0254	0.0715	0.0878	0.0437	-0.0170
C3-C4	-0.1770	-0.0336	-0.0647	-0.0679	-0.0272	0.0087	-0.1456

N700 AMPLITUDE

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1 .
O1	0.0818	-0.0315	-0.1872	0.0935	-0.2493	-0.0362
O2	0.0151	0.1312	-0.0151	0.0779	-0.0603	-0.1492
P3	-0.1022	0.1090	0.0462	0.0402	-0.0212	-0.0242
P4	-0.0056	0.2606	0.1455	-0.0417	0.1859	-0.0790
C3	-0.0674	0.2692	0.2643	-0.0509	0.1529	-0.1812
C4	-0.0964	0.3118	0.3119	-0.0917	0.2460	-0.1176
F3	-0.1964	0.2384	0.2292	-0.0212	0.1429	-0.1260
F4	-0.3272	0.2912	0.2630	-0.0226	0.1979	-0.1648

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3 .
O1	0.0144	0.0487	0.1407	-0.0454	0.1228	0.0560	-0.0090
O2	-0.0857	0.0037	0.0055	-0.1054	-0.0014	-0.0039	0.0057
P3	-0.0504	-0.0585	-0.0504	-0.0385	0.0025	-0.0418	-0.1021
P4	-0.0883	-0.0391	-0.1378	-0.0836	-0.0682	-0.0600	-0.0927
C3	-0.2266	-0.1779	-0.1385	-0.1404	-0.2826	-0.2072	-0.2395
C4	-0.1392	-0.0926	-0.1510	-0.1100	-0.2744	-0.2020	-0.1853
F3	-0.1328	-0.1618	-0.1685	-0.1875	-0.2969	-0.2823	-0.1544
F4	-0.1052	-0.1152	-0.1872	-0.2694	-0.2269	-0.2725	-0.2128

APPENDIX J

SPEARMAN RANK CORRELATION COEFFICIENTS FOR THE READING GROUP COMPARISONS

P120 AMPLITUDE

"AT-RISK" READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.1008	0.2208	0.0919	0.5327	0.2934	0.0554
O2	0.0306	0.1023	-0.0685	0.6762	0.3381	0.2288
P3	-0.0883	-0.1509	-0.1235	-0.0180	-0.2543	-0.1404
P4	0.0198	-0.3124	-0.1910	-0.0197	-0.3292	-0.0500
C3	-0.1072	-0.2498	0.0577	-0.1185	-0.1522	-0.1986
C4	0.0612	-0.4578	-0.0829	-0.1489	-0.1377	-0.1501
F3	-0.3078	-0.3321	0.2901	-0.4323	0.1538	-0.3557
F4	-0.1530	-0.3698	0.2054	-0.4431	-0.0519	-0.2806

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.1895	-0.3789	-0.5612	-0.2475	0.3011	-0.0519	-0.3250
O2	-0.3628	-0.3199	-0.3557	0.0592	0.3620	0.3903	0.0500
P3	0.4132	0.2129	-0.0796	-0.1490	0.1202	0.0125	0.0983
P4	0.2609	0.0679	0.1394	0.1704	0.3369	0.2901	0.3536
C3	0.3363	0.0394	-0.1646	-0.1338	-0.0143	0.1057	-0.0036
C4	0.2413	0.0876	0.0769	0.1076	0.2903	0.1826	0.2179
F3	0.2073	0.1680	-0.0536	-0.2798	-0.2688	-0.2328	-0.1036
F4	0.1215	0.0107	0.0143	-0.0269	-0.1756	0.0734	0.0714

"AT-RISK" NON-READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.3492	0.2729	-0.1919	0.1523	0.1394	-0.0807
O2	-0.5497	0.2549	-0.4036	0.1613	0.1805	0.0395
P3	-0.2453	0.1275	-0.2224	-0.0161	-0.1483	-0.2099
P4	-0.2016	0.0818	-0.4345	0.0305	-0.1172	-0.2406
C3	-0.5783	0.3178	-0.3587	0.0986	0.0071	0.0448
C4	-0.1156	0.1042	-0.2873	-0.0099	-0.2970	-0.1032
F3	0.0340	-0.1562	-0.3498	-0.2151	-0.0304	-0.0789
F4	0.0519	-0.2334	-0.2816	-0.2151	-0.0143	-0.1309

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.2502	-0.0912	-0.4401	0.2431	0.1706	0.2594	-0.0179
O2	-0.1340	-0.0590	-0.0447	0.2145	0.2119	0.1324	0.3521
P3	-0.2288	-0.2806	-0.2326	0.0536	0.0539	0.0250	0.2395
P4	-0.4544	-0.3435	-0.3295	0.0009	-0.0997	0.0313	-0.0653
C3	-0.1895	-0.2181	0.0519	0.0804	0.2083	0.0286	0.4343
C4	-0.3166	-0.2236	-0.4029	0.0698	-0.1069	0.1012	-0.1127
F3	-0.4147	-0.1752	-0.1324	-0.1394	-0.4058	-0.1216	-0.2020
F4	-0.2895	-0.1197	-0.3184	-0.1412	-0.3788	0.0215	-0.3771

RANDOM NON-READING DISABLED GROUP (N=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1 .
O1	0.2368	-0.2609	-0.0358	-0.0736	0.0000	0.3085
O2	-0.0897	-0.1787	0.1950	-0.1634	0.1714	0.4664
P3	-0.0538	0.0608	0.1038	0.3645	-0.0821	0.1758
P4	-0.3677	0.2967	0.1163	0.2424	0.0750	0.2493
C3	-0.0987	0.2145	-0.1288	0.3932	-0.2786	0.0664
C4	-0.1883	0.5326	0.1807	0.3375	-0.0500	-0.0126
F3	0.0341	0.0483	-0.2916	0.1634	0.0107	0.0054
F4	0.1901	0.2538	-0.0429	0.1741	-0.0321	0.0323

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3 .
O1	0.3614	0.6011	0.3878	0.3932	0.0665	0.6301	0.5776
O2	0.4454	0.4759	0.2645	0.1526	0.1797	0.2862	0.4574
P3	0.2773	0.4955	0.3664	0.2496	0.1204	0.3384	0.6045
P4	0.2093	0.3148	0.0751	0.2083	0.3324	0.1026	0.2924
C3	0.1413	0.2791	0.1877	0.1418	0.2965	0.1206	0.3336
C4	0.0429	0.3041	-0.0018	0.1329	0.2606	0.1602	0.1776
F3	0.0018	-0.1610	0.4772	0.4973	0.2336	0.2412	0.3354
F4	-0.1914	-0.1485	0.3414	0.4991	0.0503	0.2538	0.3695

N220 AMPLITUDE

"AT-RISK" READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1 .
O1	-0.2214	0.3339	0.1387	-0.4484	-0.1377	-0.1305
O2	-0.3222	0.2621	0.1694	-0.5292	-0.3792	-0.1859
P3	-0.3186	0.4022	0.0198	0.1076	0.3023	0.0304
P4	-0.1008	0.2765	0.4144	0.0646	0.5492	-0.2913
C3	-0.1512	0.3645	0.1423	0.3677	0.5170	-0.0769
C4	-0.1008	0.2765	0.4144	0.0646	0.5492	-0.2913
F3	0.1782	0.0808	0.1892	0.5937	0.7227	0.1787
F4	0.1332	0.0898	0.1838	0.5955	0.7120	0.0572
(P3-P4)	-0.0198	-0.0916	-0.3712	0.0592	0.0948	0.2842
(C3-C4)	0.2520	-0.1508	-0.4090	0.2457	0.0948	0.2145

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3 .
O1	-0.0840	0.0340	0.1501	-0.0126	-0.1935	-0.2399	-0.0250
O2	-0.1501	-0.1644	0.1144	0.0646	-0.3047	-0.4458	-0.1821
P3	-0.4969	-0.5004	-0.4254	-0.1722	-0.2724	-0.0322	-0.1893
P4	-0.6291	-0.7006	-0.6309	-0.1525	-0.1720	-0.1021	-0.4429
C3	-0.7185	-0.6613	-0.5505	-0.1991	-0.1541	0.0842	-0.3214
C4	-0.6291	-0.7006	-0.6309	-0.1525	-0.1720	-0.1021	-0.4429
F3	-0.3164	-0.2270	-0.2359	-0.1901	0.2581	0.3187	-0.1500
F4	-0.4879	-0.3735	-0.3021	-0.1489	0.0932	0.2668	-0.2214
(P3-P4)	0.0626	0.2413	0.2717	-0.0323	-0.0645	0.3706	0.4179
(C3-C4)	0.1823	0.4182	0.4969	-0.0682	-0.0143	0.5783	0.5107

"AT-RISK" NON-READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	0.4458	-0.3770	0.1166	-0.1685	-0.1126	-0.0700
O2	0.4816	-0.4058	0.2135	-0.2079	-0.1001	-0.1686
P3	0.5551	-0.0592	0.3283	0.0753	0.0643	0.0179
P4	0.5139	0.1113	0.2009	0.4050	-0.0375	0.0520
C3	0.4781	0.2298	0.4502	0.1613	-0.1001	0.1578
C4	0.5139	0.1113	0.2009	0.4050	-0.0375	0.0520
F3	0.4029	0.2244	0.3372	0.2222	0.0983	0.0700
F4	0.3996	0.2462	0.2729	0.2538	0.0716	-0.1095
(P3-P4)	0.1021	-0.1293	0.3821	-0.5538	0.0876	0.0520
(C3-C4)	0.0913	0.1454	0.5166	-0.4301	-0.4450	0.2027

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	0.0804	-0.0214	0.3596	-0.3628	-0.3501	-0.4776	-0.0786
O2	-0.0715	-0.1340	0.2218	-0.3485	-0.3519	-0.3900	-0.2341
P3	0.1501	0.0947	-0.1878	-0.2234	-0.2639	-0.2737	-0.2985
P4	0.1323	0.0500	-0.3649	-0.2609	-0.2531	-0.2934	-0.3843
C3	0.1466	0.0858	-0.3113	-0.0161	-0.0413	-0.0447	-0.2359
C4	0.1323	0.0500	-0.3649	-0.2609	-0.2531	-0.2934	-0.3843
F3	0.0929	0.0572	-0.4168	-0.0250	-0.0575	-0.0733	-0.1912
F4	-0.1503	-0.2147	-0.4924	-0.1950	-0.1581	-0.2167	-0.3309
(P3-P4)	0.1072	0.1662	0.2987	0.1483	0.0072	0.0340	0.1037
(C3-C4)	0.1984	0.1644	0.0841	0.4754	0.4183	0.5886	0.1591

RANDOM NON-READING DISABLED GROUP (N=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.1453	0.1162	-0.0733	0.0359	-0.0464	-0.3713
O2	-0.1668	-0.0054	-0.1717	0.0413	-0.0571	-0.2744
P3	-0.2619	-0.0912	-0.3631	0.0610	-0.3536	-0.1614
P4	-0.2388	-0.2272	-0.5577	0.2570	-0.4879	-0.2172
C3	-0.3390	0.0232	-0.2021	0.1580	-0.3964	-0.0448
C4	-0.2388	-0.2272	-0.5577	0.2570	-0.4879	-0.2172
F3	-0.4987	-0.4415	-0.2755	-0.1562	-0.2643	0.3480
F4	-0.2493	-0.5273	-0.4419	0.0197	-0.3786	0.0197
(P3-P4)	-0.0915	0.3092	0.1646	-0.1418	0.1179	-0.1740
(C3-C4)	-0.2547	0.4879	0.6494	0.0664	0.1250	0.0538

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.3381	-0.5564	-0.2395	-0.2424	-0.1114	-0.4987	-0.4592
O2	-0.1342	-0.3113	-0.2574	-0.1185	-0.3288	-0.4123	-0.2691
P3	0.0447	-0.1020	-0.5130	-0.2029	-0.0881	-0.2304	-0.3839
P4	0.2748	-0.0340	-0.2683	-0.2642	-0.1484	-0.2505	-0.3097
C3	-0.0072	-0.0465	-0.5666	-0.1293	-0.0665	-0.1242	-0.4126
C4	0.2748	-0.0340	-0.2683	-0.2642	-0.1484	-0.2505	-0.3097
F3	0.4812	0.1306	-0.2234	-0.1203	-0.0791	-0.3474	-0.1830
F4	0.3667	-0.0519	-0.0929	-0.3016	-0.2210	-0.3726	-0.2816
(P3-P4)	-0.4168	-0.1306	-0.5487	0.0880	0.0485	0.0954	-0.2780
(C3-C4)	-0.4884	-0.0018	-0.3360	0.1939	0.1258	0.2952	-0.0933

P310 AMPLITUDE

"AT-RISK" READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.1008	0.2208	0.0919	0.5327	0.2934	0.0554
O2	0.0306	0.1023	-0.0685	0.6762	0.3381	0.2288
P3	-0.0883	-0.1509	-0.1235	-0.0180	-0.2543	-0.1404
P4	0.0198	-0.3124	-0.1910	-0.0197	-0.3292	-0.0500
C3	-0.1072	-0.2498	0.0577	-0.1185	-0.1522	-0.1986
C4	0.0612	-0.4578	-0.0829	-0.1489	-0.1377	-0.1501
F3	-0.3078	-0.3321	0.2901	-0.4323	0.1538	-0.3557
F4	-0.1530	-0.3698	0.2054	-0.4431	-0.0519	-0.2806

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.1895	-0.3789	-0.5612	-0.2475	0.3011	-0.0519	-0.3250
O2	-0.3628	-0.3199	-0.3557	0.0592	0.3620	0.3903	0.0500
P3	0.4132	0.2129	-0.0796	-0.1490	0.1202	0.0125	0.0983
P4	0.2609	0.0679	0.1394	0.1704	0.3369	0.2901	0.3536
C3	0.3363	0.0394	-0.1646	-0.1338	-0.0143	0.1057	-0.0036
C4	0.2413	0.0876	0.0769	0.1076	0.2903	0.1826	0.2179
F3	0.2073	0.1680	-0.0536	-0.2798	-0.2688	-0.2328	-0.1036
F4	0.1215	0.0107	0.0143	-0.0269	-0.1756	0.0734	0.0714

"AT-RISK" NON-READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.3492	0.2729	-0.1919	0.1523	0.1394	-0.0807
O2	-0.5497	0.2549	-0.4036	0.1613	0.1805	0.0395
P3	-0.2453	0.1275	-0.2224	-0.0161	-0.1483	-0.2099
P4	-0.2016	0.0818	-0.4345	0.0305	-0.1172	-0.2406
C3	-0.5783	0.3178	-0.3587	0.0986	0.0071	0.0448
C4	-0.1156	0.1042	-0.2873	-0.0099	-0.2970	-0.1032
F3	0.0340	-0.1562	-0.3498	-0.2151	-0.0304	-0.0789
F4	0.0519	-0.2334	-0.2816	-0.2151	-0.0143	-0.1309

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.2502	-0.0912	-0.4401	0.2431	0.1706	0.2594	-0.0179
O2	-0.1340	-0.0590	-0.0447	0.2145	0.2119	0.1324	0.3521
P3	-0.2288	-0.2806	-0.2326	0.0536	0.0539	0.0250	0.2395
P4	-0.4544	-0.3435	-0.3295	0.0009	-0.0997	0.0313	-0.0653
C3	-0.1895	-0.2181	0.0519	0.0804	0.2083	0.0286	0.4343
C4	-0.3166	-0.2236	-0.4029	0.0698	-0.1069	0.1012	-0.1127
F3	-0.4147	-0.1752	-0.1324	-0.1394	-0.4058	-0.1216	-0.2020
F4	-0.2895	-0.1197	-0.3184	-0.1412	-0.3788	0.0215	-0.3771

RANDOM NON-READING DISABLED GROUP (N=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	0.2368	-0.2609	-0.0358	-0.0736	0.0000	0.3085
O2	-0.0897	-0.1787	0.1950	-0.1634	0.1714	0.4664
P3	-0.0538	0.0608	0.1038	0.3645	-0.0821	0.1758
P4	-0.3677	0.2967	0.1163	0.2424	0.0750	0.2493
C3	-0.0987	0.2145	-0.1288	0.3932	-0.2786	0.0664
C4	-0.1883	0.5326	0.1807	0.3375	-0.0500	-0.0126
F3	0.0341	0.0483	-0.2916	0.1634	0.0107	0.0054
F4	0.1901	0.2538	-0.0429	0.1741	-0.0321	0.0323

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	0.3614	0.6011	0.3878	0.3932	0.0665	0.6301	0.5776
O2	0.4454	0.4759	0.2645	0.1526	0.1797	0.2862	0.4574
P3	0.2773	0.4955	0.3664	0.2496	0.1204	0.3384	0.6045
P4	0.2093	0.3148	0.0751	0.2083	0.3324	0.1026	0.2924
C3	0.1413	0.2791	0.1877	0.1418	0.2965	0.1206	0.3336
C4	0.0429	0.3041	-0.0018	0.1329	0.2606	0.1602	0.1776
F3	0.0018	-0.1610	0.4772	0.4973	0.2336	0.2412	0.3354
F4	-0.1914	-0.1485	0.3414	0.4991	0.0503	0.2538	0.3695

P470 AMPLITUDE

"AT-RISK" READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.1008	0.2208	0.0919	0.5327	0.2934	0.0554
O2	0.0306	0.1023	-0.0685	0.6762	0.3381	0.2288
P3	-0.0883	-0.1509	-0.1235	-0.0180	-0.2543	-0.1404
P4	0.0198	-0.3124	-0.1910	-0.0197	-0.3292	-0.0500
C3	-0.1072	-0.2498	0.0577	-0.1185	-0.1522	-0.1986
C4	0.0612	-0.4578	-0.0829	-0.1489	-0.1377	-0.1501
F3	-0.3078	-0.3321	0.2901	-0.4323	0.1538	-0.3557
F4	-0.1530	-0.3698	0.2054	-0.4431	-0.0519	-0.2806
(P3-P4)	0.0234	0.1562	0.1892	0.1453	0.3470	-0.1877
(C3-C4)	-0.2577	0.2677	0.4202	0.2451	0.2811	-0.1968

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.1895	-0.3789	-0.5612	-0.2475	0.3011	-0.0519	-0.3250
O2	-0.3628	-0.3199	-0.3557	0.0592	0.3620	0.3903	0.0500
P3	0.4132	0.2129	-0.0796	-0.1490	0.1202	0.0125	0.0983
P4	0.2609	0.0679	0.1394	0.1704	0.3369	0.2901	0.3536
P3	0.3363	0.0394	-0.1646	-0.1338	-0.0143	0.1057	-0.0036
C4	0.2413	0.0876	0.0769	0.1076	0.2903	0.1826	0.2179
F3	0.2073	0.1680	-0.0536	-0.2798	-0.2688	-0.2328	-0.1036
F4	0.1215	0.0107	0.0143	-0.0269	-0.1756	0.0734	0.0714
(P3-P4)	0.2538	0.3718	-0.0071	-0.4538	-0.0860	-0.1182	-0.1643
(C3-C4)	0.1869	0.0993	-0.2791	-0.4578	-0.2583	0.0090	-0.2627

"AT-RISK" NON-READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.3492	0.2729	-0.1919	0.1523	0.1394	-0.0807
O2	-0.5497	0.2549	-0.4036	0.1613	0.1805	0.0395
P3	-0.2453	0.1275	-0.2224	-0.0161	-0.1483	-0.2099
P4	-0.2016	0.0818	-0.4345	0.0305	-0.1172	-0.2406
C3	-0.5783	0.3178	-0.3587	0.0986	0.0071	0.0448
C4	-0.1156	0.1042	-0.2873	-0.0099	-0.2970	-0.1032
F3	0.0340	-0.1562	-0.3498	-0.2151	-0.0304	-0.0789
F4	0.0519	-0.2334	-0.2816	-0.2151	-0.0143	-0.1309
(P3-P4)	-0.2990	0.2837	0.4251	-0.1505	0.1126	0.0395
(C3-C4)	-0.4440	0.3896	0.1919	0.0986	0.1752	0.2744

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.2502	-0.0912	-0.4401	0.2431	0.1706	0.2594	-0.0179
O2	-0.1340	-0.0590	-0.0447	0.2145	0.2119	0.1324	0.3521
P3	-0.2288	-0.2806	-0.2326	0.0536	0.0539	0.0250	0.2395
P4	-0.4544	-0.3435	-0.3295	0.0009	-0.0997	0.0313	-0.0653
C3	-0.1895	-0.2181	0.0519	0.0804	0.2083	0.0286	0.4343
C4	-0.3166	-0.2236	-0.4029	0.0698	-0.1069	0.1012	-0.1127
F3	-0.4147	-0.1752	-0.1324	-0.1394	-0.4058	-0.1216	-0.2020
F4	-0.2895	-0.1197	-0.3184	-0.1412	-0.3788	0.0215	-0.3771
(P3-P4)	0.0375	-0.2055	0.0072	0.0340	0.2514	-0.0966	0.4129
(C3-C4)	0.1233	-0.0590	0.2218	0.0357	0.3573	0.0107	0.4021

RANDOM NON-READING DISABLED GROUP (N=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	0.2368	-0.2609	-0.0358	-0.0736	0.0000	0.3085
O2	-0.0897	-0.1787	0.1950	-0.1634	0.1714	0.4664
P3	-0.0538	0.0608	0.1038	0.3645	-0.0821	0.1758
P4	-0.3677	0.2967	0.1163	0.2424	0.0750	0.2493
C3	-0.0987	0.2145	-0.1288	0.3932	-0.2786	0.0664
C4	-0.1883	0.5326	0.1807	0.3375	-0.0500	-0.0126
F3	0.0341	0.0483	-0.2916	0.1634	0.0107	0.0054
F4	0.1901	0.2538	-0.0429	0.1741	-0.0321	0.0323
(P3-P4)	0.4215	-0.3289	-0.0608	0.0539	-0.2571	-0.1022
(C3-C4)	0.2852	-0.6077	-0.3256	-0.1059	-0.1857	0.1058

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	0.3614	0.6011	0.3878	0.3932	0.0665	0.6301	0.5776
O2	0.4454	0.4759	0.2645	0.1526	0.1797	0.2862	0.4574
P3	0.2773	0.4955	0.3664	0.2496	0.1204	0.3384	0.6045
P4	0.2093	0.3148	0.0751	0.2083	0.3324	0.1026	0.2924
C3	0.1413	0.2791	0.1877	0.1418	0.2965	0.1206	0.3336
C4	0.0429	0.3041	-0.0018	0.1329	0.2606	0.1602	0.1776
F3	0.0018	-0.1610	0.4772	0.4973	0.2336	0.2412	0.3354
F4	-0.1914	-0.1485	0.3414	0.4991	0.0503	0.2538	0.3695
(P3-P4)	0.1163	0.2075	0.2752	-0.0664	-0.3253	0.2196	0.2798
(C3-C4)	0.2326	-0.0233	0.4861	0.1185	-0.1671	-0.0324	0.4072

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"AT-RISK" READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.2214	0.3339	0.1387	-0.4484	-0.1377	-0.1305
O2	-0.3222	0.2621	0.1694	-0.5292	-0.3792	-0.1859
P3	-0.3186	0.4022	0.0198	0.1076	0.3023	0.0304
P4	-0.3258	0.6266	0.2036	-0.0126	0.0966	-0.1930
C3	-0.1512	0.3645	0.1423	0.3677	0.5170	-0.0769
C4	-0.1008	0.2765	0.4144	0.0646	0.5492	-0.2913
F3	0.1782	0.0808	0.1892	0.5937	0.7227	0.1787
F4	0.1332	0.0898	0.1838	0.5955	0.7120	0.0572
(C3-C4)	0.2520	-0.1508	-0.4090	0.2457	0.0948	0.2145
(P3-P4)	-0.0306	-0.3591	-0.2901	0.0879	0.1717	0.3164

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.0840	0.0340	0.1501	-0.0126	-0.1935	-0.2399	-0.0250
O2	-0.1501	-0.1644	0.1144	0.0646	-0.3047	-0.4458	-0.1821
P3	-0.4969	-0.5004	-0.4254	-0.1722	-0.2724	-0.0322	-0.1893
P4	-0.6309	-0.8418	-0.7721	-0.1668	-0.4516	-0.3133	-0.6071
C3	-0.7185	-0.6613	-0.5505	-0.1991	-0.1541	0.0842	-0.3214
C4	-0.6291	-0.7006	-0.6309	-0.1525	-0.1720	-0.1021	-0.4429
F3	-0.3164	-0.2270	-0.2359	-0.1901	0.2581	0.3187	-0.1500
F4	-0.4879	-0.3735	-0.3021	-0.1489	0.0932	0.2668	-0.2214
(C3-C4)	0.1823	0.4182	0.4969	-0.0682	-0.0143	0.5783	0.5107
(P3-P4)	0.1233	0.3128	0.3342	0.0574	0.0717	0.4816	0.5500

"AT-RISK" NON-READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	0.4458	-0.3770	0.1166	-0.1685	-0.1126	-0.0700
O2	0.4816	-0.4058	0.2135	-0.2079	-0.1001	-0.1686
P3	0.5551	-0.0592	0.3283	0.0753	0.0643	0.0179
P4	0.3760	0.0090	0.2350	0.2634	0.0107	0.1489
C3	0.4781	0.2298	0.4502	0.1613	-0.1001	0.1578
C4	0.5139	0.1113	0.2009	0.4050	-0.0375	0.0520
F3	0.4029	0.2244	0.3372	0.2222	0.0983	0.0700
F4	0.3996	0.2462	0.2729	0.2538	0.0716	-0.1095
(C3-C4)	0.0913	0.1454	0.5166	-0.4301	-0.4450	0.2027
(P3-P4)	0.2167	0.0934	0.2422	-0.4104	-0.1430	0.1022

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	0.0804	-0.0214	0.3596	-0.3628	-0.3501	-0.4776	-0.0786
O2	-0.0715	-0.1340	0.2218	-0.3485	-0.3519	-0.3900	-0.2341
P3	0.1501	0.0947	-0.1878	-0.2234	-0.2639	-0.2737	-0.2985
P4	0.2413	0.1716	-0.2290	-0.2038	-0.2424	-0.3148	-0.2377
C3	0.1466	0.0858	-0.3113	-0.0161	-0.0413	-0.0447	-0.2359
C4	0.1323	0.0500	-0.3649	-0.2609	-0.2531	-0.2934	-0.3843
F3	0.0929	0.0572	-0.4168	-0.0250	-0.0575	-0.0733	-0.1912
F4	-0.1503	-0.2147	-0.4924	-0.1950	-0.1581	-0.2167	-0.3309
(C3-C4)	0.1984	0.1644	0.0841	0.4754	0.4183	0.5886	0.1591
(P3-P4)	-0.0715	0.0286	0.0626	0.3450	0.2711	0.4973	0.0429

RANDOM NON-READING DISABLED GROUP (N=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1 .
O1	-0.1453	0.1162	-0.0733	0.0359	-0.0464	-0.3713
O2	-0.1668	-0.0054	-0.1717	0.0413	-0.0571	-0.2744
P3	-0.2619	-0.0912	-0.3631	0.0610	-0.3536	-0.1614
P4	-0.2439	-0.2288	-0.5653	0.1023	-0.4036	-0.1973
C3	-0.3390	0.0232	-0.2021	0.1580	-0.3964	-0.0448
C4	-0.2388	-0.2272	-0.5577	0.2570	-0.4879	-0.2172
F3	-0.4987	-0.4415	-0.2755	-0.1562	-0.2643	0.3480
F4	-0.2493	-0.5273	-0.4419	0.0197	-0.3786	0.0197
(C3-C4)	-0.2547	0.4879	0.6494	0.0664	0.1250	0.0538
(P3-P4)	0.0341	0.4969	0.4562	-0.0969	0.2714	-0.1309

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3 .
O1	-0.3381	-0.5564	-0.2395	-0.2424	-0.1114	-0.4987	-0.4592
O2	-0.1342	-0.3113	-0.2574	-0.1185	-0.3288	-0.4123	-0.2691
P3	0.0447	-0.1020	-0.5130	-0.2029	-0.0881	-0.2304	-0.3839
P4	0.3041	0.0859	-0.4147	-0.2621	-0.1707	-0.2322	-0.4000
C3	-0.0072	-0.0465	-0.5666	-0.1293	-0.0665	-0.1242	-0.4126
C4	0.2748	-0.0340	-0.2683	-0.2642	-0.1484	-0.2505	-0.3097
F3	0.4812	0.1306	-0.2234	-0.1203	-0.0791	-0.3474	-0.1830
F4	0.3667	-0.0519	-0.0929	-0.3016	-0.2210	-0.3726	-0.2816
(C3-C4)	-0.4884	-0.0018	-0.3360	0.1939	0.1258	0.2952	-0.0933
(P3-P4)	-0.6261	-0.3828	-0.5022	0.0144	-0.0288	-0.1278	-0.1937

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"AT-RISK" READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1 .
O1	-0.2214	0.3339	0.1387	-0.4484	-0.1377	-0.1305
O2	-0.3222	0.2621	0.1694	-0.5292	-0.3792	-0.1895
P3	-0.3186	0.4022	0.0198	0.1076	0.3023	0.0304
P4	-0.3258	0.6266	0.2036	-0.0126	0.0966	-0.1930
C3	-0.1512	0.3645	0.1423	0.3677	0.5170	-0.0769
C4	-0.1008	0.2765	0.4144	0.0646	0.5492	-0.2913
F3	0.1782	0.0808	0.1892	0.5937	0.7227	0.1787
F4	0.1332	0.0898	0.1838	0.5955	0.7120	0.0572

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3 .
O1	-0.0840	0.0340	0.1501	-0.0126	-0.1935	-0.2399	-0.0250
O2	-0.1501	-0.1644	0.1144	0.0646	-0.3047	-0.4458	-0.1821
P3	-0.4969	-0.5004	-0.4254	-0.1722	-0.2724	-0.0322	-0.1893
P4	-0.6309	-0.8418	-0.7721	-0.1668	-0.4516	-0.3133	-0.6071
C3	-0.7185	-0.6613	-0.5505	-0.1991	-0.1541	0.0842	-0.3214
C4	-0.6291	-0.7006	-0.6309	-0.1525	-0.1720	-0.1021	-0.4429
F3	-0.3164	-0.2270	-0.2359	-0.1901	0.2581	0.3187	-0.1500
F4	-0.4879	-0.3735	-0.3021	-0.1489	0.0932	0.2668	-0.2214

"AT-RISK" NON-READING DISABLED GROUP (n=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	0.4458	-0.3770	0.1166	-0.1685	-0.1126	-0.0700
O2	0.4816	-0.4058	0.2135	-0.2079	-0.1001	-0.1686
P3	0.5551	-0.0592	0.3283	0.0753	0.0643	0.0179
P4	0.3760	0.0090	0.2350	0.2634	0.0107	0.1489
C3	0.4781	0.2298	0.4502	0.1613	-0.1001	0.1587
C4	0.5139	0.1113	0.2009	0.4050	-0.0375	0.0520
F3	0.4029	0.2244	0.3372	0.2222	0.0983	0.0700
F4	0.3996	0.2462	0.2729	0.2538	0.0716	-0.1095

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	0.0804	-0.0214	0.3596	-0.3628	-0.3501	-0.4776	-0.0786
O2	-0.0715	-0.1340	0.2218	-0.3485	-0.3519	-0.3900	-0.2341
P3	0.1501	0.0947	-0.1878	-0.2234	-0.2639	-0.2737	-0.2985
P4	0.2413	0.1716	-0.2290	-0.2038	-0.2424	-0.3148	-0.2377
C3	0.1466	0.0858	-0.3113	-0.0161	-0.0413	-0.0447	-0.2359
C4	0.1323	0.0500	-0.3649	-0.2609	-0.2531	-0.2934	-0.3843
F3	0.0929	0.0572	-0.4168	-0.0250	-0.0575	-0.0733	-0.1912
F4	-0.1503	-0.2147	-0.4924	-0.1950	-0.1581	-0.2167	-0.3309

RANDOM NON-READING DISABLED GROUP (N=15)

	AGE1	WJRA1	WJRA3	ADD1	PPVT1	RNC1
O1	-0.1453	0.1162	-0.0733	0.0359	-0.0464	-0.3713
O2	-0.1668	-0.0054	-0.1717	0.0413	-0.0571	-0.2744
P3	-0.2619	-0.0912	-0.3631	0.0610	-0.3536	-0.1614
P4	-0.2439	-0.2288	-0.5653	0.1023	-0.4036	-0.1973
C3	-0.3390	0.0232	-0.2021	0.1580	-0.3964	-0.0448
C4	-0.2388	-0.2272	-0.5577	0.2570	-0.4879	-0.2172
F3	-0.4987	-0.4415	-0.2755	-0.1562	-0.2643	0.3480
F4	-0.2493	-0.5273	-0.4419	0.0197	-0.3786	0.0197

	RNL1	RNN1	RNO1	RNC3	RNL3	RNN3	RNO3
O1	-0.3381	-0.5564	-0.2395	-0.2424	-0.1114	-0.4987	-0.4592
O2	-0.1342	-0.3113	-0.2574	-0.1185	-0.3288	-0.4123	-0.2691
P3	0.0447	-0.1020	-0.5130	-0.2029	-0.0881	-0.2304	-0.3839
P4	0.3041	0.0859	-0.4147	-0.2621	-0.1707	-0.2322	-0.4000
C3	-0.0072	-0.0465	-0.5666	-0.1293	-0.0665	-0.1242	-0.4126
C4	0.2748	-0.0340	-0.2683	-0.2642	-0.1484	-0.2505	-0.3097
F3	0.4812	0.1306	-0.2234	-0.1203	-0.0791	-0.3474	-0.1830
F4	0.3667	-0.0519	-0.0929	-0.3016	-0.2210	-0.3726	-0.2816