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The relationship between latent factors of the WISC-R and behavioral functioning as measured by the Child Behavior Checklist

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THE RELATIONSHIP BETWEEN LATENT FACTORS OF THE WISC-R AND BEHAVIORAL FUNCTIONING AS MEASURED BY THE CHILD BEHAVIOR CHECKLIST

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CHAPTER I

INTRODUCTION

The relationship between cognitive constructs and behavioral functioning has been debated extensively by psychologists, educators, and medical personnel. Each discipline offers a myriad of theoretical orientations to explain differences when examining this relationship. Until recently, few investigators examined the relationship between cognitive functioning and behavior problems (BD) in groups of children with learning disorders (LD). Most investigators have consistently utilized a posteriori cluster or factor analytic techniques to establish subgroups of this heterogeneous population, while others have examined the LD population as a homogeneous group. This study of a clinic-referred sample of children with learning and behavior disorders represents a preliminary attempt to develop an empirically and theoretically-driven model of the interrelationships of cognitive constructs and behavioral functioning.

The LD individual, assumed to have average overall ability, is an individual who has variable abilities in behavioral and cognitive domains. Although behavior problems are evident in a proportion of the LD population, it has not been determined whether their cognitive deficits contribute to their behavior problems. In clinical practice, this issue is often addressed by taking a neuropsychological approach, comparing patterns of cognitive functioning with patterns of behavior. Many of the neuropsychological approaches to understanding brain-behavior relationships generalize their findings to the LD population based on clinical samples of individuals who have suffered impairment due to trauma or some other neurological condition. However, many pediatric neuropsychologists have suggested caution in interpreting LD children's deficits based on brain lesion studies (Dean, 1985; Rourke, Fisk, & Strang, 1986) because of the developmental differences between children and adults.

It is probably fair to say that the ability to analyze an individual's performance on standardized psychological and neuropsychological instruments based on the current knowledge of brain-behavior relationships has been proven to be effective, but relatively limited with respect to generalizability to the LD population. If a theoretically-based, actuarial approach to understanding the brain-behavior relationship could be established, then the assessment of specific cognitive constructs may yield information that could be used to predict learning and behavioral functioning. This knowledge would be beneficial in that professionals and parents could be proactive with respect to their intervention efforts to lesson the impact of cognitive and behavioral deficits LD children experience. Although hierarchical models of increasing cognitive complexity related to behavioral functioning have been posited and noted in clinical practice, it is difficult to measure and differentiate between subgroups of LD children. This difficulty has left most empirical investigators reluctant to postulate a priori relationships, as this may result in the reduced homogeneity of each subgroup and subsequent insignificant findings.

The goal of this research project was to develop a heuristic model representative of the relationship between cognition and behavior. Given that the model is designed to delineate specific cognitive constructs related to behavior patterns in LD children, the model is based on the popular and highly respected theories of Luria (1973) and Goldberg and Costa (1981). The hypothesized functional system of interrelated cognitive constructs is presented in Table 1. It should be noted that the constructs presented in the table are often used in clinical assessment to predict an individual's performance on the Wechsler Intelligence Scale for Children - Revised (Sattler, 1988; Kaufman, 1979). It should be noted that one of the difficulties with developing a model of such complexity is the multicollinearity among the constructs. Since each of these constructs share a great deal of variance with one another, determining the unique contributions of each to the overall heuristic model is difficult and requires a priori clustering of abilities before data analysis can begin. To examine the cognitive correlates of behavioral functioning

Table 1

Underlying cognitive abilities of the WISC-R purportedly measured by the hypothetical model

Higher Order Factors	Processing Factors	
Fluid CF	Fluid Expression	Fluid Reception
.Nonverbal Reasoning	.Perceptual Reproduction	.Perception of Abstract Stimuli
.Nonverbal Social Judgement	.Psychomotor Speed	.Discriminate Essential from Nonessent. Detail
.Anticipation of Consequences	.Graphomotor Skill	.Field Independence
.Holistic Processing	.Synthesis of Parts into Wholes	.Analysis of Wholes into Parts
Cortical Tone	Memory	Sensory Motor Integration
.Attention	.Auditory Memory	.Spatial Perception
.Concentration	.Visual Memory	.Perceptual Organization
.Freedom from Distraction	.Short-Term	.Long Verbal Questions
.Timed Test Taking	.Long-Term	.Perceptual Planning
.Temporal Relations		.Much Expressive Language
.Integrated Brain Fxn		.Perceptual Planning
.Time Sequencing		.Visual-Motor Coordin.
		.Sensory Motor Feedback

Note. Table Continues.

Higher Order Factors	Processing Factors	
Crystal CF	Crystal Expression	Crystal Reception
.Acquired Knowledge	.Expressive Language	.Perception of Meaningful Info
.Computation		.Short Verbal Questions
.Verbal Social Judgement		.Word Knowledge
.Verbal Concept Formation		.Discrimination Essential from Noness. Details
.Verbal Reasoning		
.Abstract Thinking		
.Language Development		
.Cause-Effect Relationships		

Note. CF = Concept Formation; Fxn = Function.

based on an a priori classification of cognitive constructs, a nonrecursive structural equation model (Joreskog and Sorbom, 1989) was employed. This statistical technique allows for a comparison of specific abilities as measured by the WISC-R and different cognitive construct models. An analysis of the original model was undertaken and previous factor analytic studies were explored in an attempt to reduce the number of factors and estimated parameters. The final model utilized the exploratory factor analysis of the WISC-R standardization data (Wechsler, 1974) undertaken by Kaufman (1975). Once statistical stability was established, the final constructs were saved and utilized for multiple regression analysis with the narrow and broad band factor scores of the Child Behavior Checklist (CBCL; Achenbach & Edelbrock, 1983) to examine their relationship to behavioral functioning.

CHAPTER II

LITERATURE REVIEW

Overview

The development of a cognitive model based on the knowledge base of neuropsychological functioning requires a synthesis of both theoretical orientations and the results of empirical studies. Ever since David Wechsler first developed the Wechsler-Bellevue Intelligence Scale researchers and theoreticians have explored the relationships between the various subscales and subtests he derived. There have been numerous attempts to address the factorial complexity of the WISC-R subtests; yet much of the controversy surrounding these attempts are centered around the concept of Spearman's g or general mental energy (Spearman, 1927).

The difference between subtests that purportedly measure g is the degree to which complex mental effort is required for a given task (Sattler, 1988). Tasks that are less complex mentally, requiring less mental effort, are considered to be less important to the concept of g. For example, those tasks requiring sensory and motor abilities generally have low loadings for g, whereas those requiring inductive or deductive reasoning skills would be considered to have higher loadings for g. Although a detailed examination of g is beyond the scope of this dissertation, its relation to the theoretical basis of intelligence, and subsequent assumptions made by researchers examining the intellectual functioning of normal and learning disordered populations will be addressed in this review.

The literature on the relationship between LD and BD is largely theoretical; although recent developments in statistical and actuarial methods have resulted in a number of empirical studies. One of the difficulties with obtaining replicable empirical results across studies is the lack of consensus among professionals with respect to the criteria for differentiating LD from BD (Mercer, 1987; Rourke, 1982, Thompson 1989). Most of the studies that have examined the LD population as a unified group have been designed to examine the social competence and behavioral problems of the LD population in schools (Brian, 1978; Brian, Pearl, & Fallon, 1989; Thompson, 1989). Others have examined the relationship of LD and BD through studies of juvenile delinquents (Berman & Seigal, 1976; Broder, Peters, & Zimmerman, 1978; Compton, 1974; Jacobson, 1974; Moffitt & Silva, 1988; Ponitus & Ruttinger, 1976; Robbins, et.al, 1983; Sobol, 1979). Finally, many neuropsychologists have begun to explore the LD-BD link in clinical and psychiatric settings, with several recent studies revealing a relationship between cognitive subtypes and behavioral problems (Berger & Reid, 1989; Bulkhuisen, 1987; Glossner & Koppell, 1987; Nolan, Hammeke, & Barkley, 1983; Nussbaum & Bigler, 1986; Rourke & Fuerst, 1991; Semrud-Clikeman & Hynd, 1990).

LD and WISC-R Studies

Many studies exploring the relationships of the subtests developed by Wechsler for the adult and children's scales have been undertaken. Probably the one study that best describes the factor analytic findings most consistently found for the WISC-R is the three factor solution found by Kaufman (1975) on the Wechsler standardization data. Kaufman (1975) reported that the results of his principal components analysis using a varimax, rather than an oblique rotation, best fits the data for all of the age groups in the standardization sample.

The Kaufman (1975) results yielded the factors named Verbal Comprehension (Information, Similarities, Vocabulary, Comprehension), Perceptual Organization (Picture Completion, Picture Arrangement, Block Design, Object Assembly, Mazes), and Freedom from Distractibility (Arithmetic, Digit Span, Coding). Based on a second-order factor analysis revealing one factor (g), Kaufman (1975) found that Vocabulary (.80), Information (.76), Similarities (.76), Block Design (.73), and Comprehension (.72) are good measures of g; Arithmetic (.65), Object Assembly (.62), Picture Completion (.61), and Picture Arrangement (.60) are fair measures of g; and Digit Span (.49), Mazes (.45) and Coding (.41) are poor measures of g. Note how all of the "good" measures of g are highly dependent on verbal ability and knowledge (except Block Design). Given the apparent highly verbal nature of *g*, several investigators have questioned its construct validity, and as a result many studies have attempted to distinguish "true" intelligence from achievement related abilities.

Prior to this study researchers had developed alternative ways to examine the Wechsler scales. For instance, Witkin, Dyk, Faterson, Goodenough, & Karp, (1962) described a similar pattern to the Kaufman analysis for the WISC. They labeled their factors Verbal Comprehension (Information, Vocabulary, Comprehension), Analytic Field Approach (Picture Completion, Block Design, Object Assembly), and Attention/Concentration (Arithmetic, Digit Span, and Coding). Vernon (1950) developed a structural paradigm for the WISC that was hierarchical in nature. Considered to have *g* at the apex, Vernon's model has two broad factors subordinate to *g*, Verbal-Educational ability (*v:ed*) and Spatial-Mechanical-Practical ability (*k:m*), which were then subdivided into specific abilities.

Despite some findings for two factor solutions of WISC-R instead of three, the three factor solution appears to best represent the data for both normal and learning disabled populations (Sutter & Bishop, 1986). However, due to the instability of the Freedom for Distractibility subtests and their loadings some have argued that in addition to examining the factors, it is important to examine the specific and shared variances of each of the subtests during psychoeducational evaluation (Groff & Hubble, 1984). In an early confirmatory factor analysis comparing a two and a three factor solution, Silverstein (1982) found modest support for the three factor solution; but did not report statistical support for the contention that the slightly better fit should be weighed against the clinical utility of the more parsimonious two factor solution.

Bannatyne (1974) proposed a recategorization of the WISC subtests to aid in diagnosing learning disabled children. The Bannatyne factors consist of Spatial (Picture Completion, Block Design, Object Assembly), Conceptual (Comprehension, Similarities, Vocabulary), Sequential (Arithmetic, Digit Span, Coding), and Acquired Knowledge (Information, Arithmetic, Vocabulary) factors. Bannatyne (1974) reported that the pattern thought to be common for learning disabled children was that their Spatial abilities were greater than their lower Sequential abilities, with Conceptual abilities in between the two factors. Developed as a theoretical model designed to facilitate clinical analysis of the data, there has been little empirical support of the construct validity of the Bannatyne model.

Sattler (1982) examined 30 WISC-R studies for reading disabled children, and rank ordered the tests based on their increasing difficulty for this population. The rank order from least to most difficult is Picture Completion, Picture Arrangement, Block Design, Object Assembly, Similarities, Comprehension, Vocabulary, Coding, Digit Span, Arithmetic, and

Information. The last four tests have been referred to as the ACID tests. The ACID profile, like that of Bannatyne's factor structure, is an attempt to examine the interrelationships of subtests and look for similarities to aid in clinical interpretation of profiles.

In a review of the factor analytic findings, Blaha & Vance (1979) reported that the factor patterns in general were less consistent for learning disabled children and varied significantly from the normal population as a function of the severity of the learning disabled group utilized. Like Vernon (1950) the authors called for hierarchical models to represent general and specific factors of intelligence. In a review of 13 hierarchical studies of the WISC-R, Blaha and Wallbrown (1984) found support for the Vernon model, yet indicated that more factors are needed at the first level to account for atypical sample solutions. Departing from previous first order solutions, they found that the Verbal Comprehension factor consisted of Verbal Knowledge (Information, Vocabulary, Comprehension), Verbal Abstraction (Similarities), and Freedom from Distractibility (Arithmetic, Digit Span). Their Spatial/Mechanical/Practical factor consisted of Spatial (Object Assembly, Block Design, Mazes, and Picture Completion) and Quasi-specific (Picture Arrangement, Coding) factors.

In an attempt to distinguish between cognitive ability and achievement, Kaufman and Kaufman (1983) designed the Kaufman Assessment Battery for Children (K-ABC). Reviewing the previous findings for g on the WISC-R and other measures, Kaufman thought that g, as conceived by traditional intelligence theorists, was more a measure of achievement and acquired knowledge than it was of cognitive abilities. Thought to represent "true" abilities of the left and right hemispheres, Kaufman's K-ABC Mental Processing Composite consists of the Sequential (left hemisphere) and Simultaneous (right hemisphere) subscales. A separate Achievement subscale was designed to assess those abilities acquired through experience and education. Designed to eliminate the literate bias in psychoeducational assessment, the K-ABC has received much critical acclaim, as well as a great deal of criticism.

Factor analytic studies of the K-ABC and WISC-R have generally supported Kaufman's assumptions; although the conclusions drawn from those results have varied depending on the theoretical orientations of the researchers. In a joint factor analysis of the WISC-R and K-ABC, Kaufman and McLean (1987) found that a three factor solution best described both scales. The authors found support for Kaufman's assumptions, in that the Verbal Comprehension factor of the WISC-R loaded on the same factor as the K-ABC Achievement subscale, the FFD factor and Sequential subscale loaded on the same factor, and the Perceptual Organization factor and Simultaneous subscale loaded on a third factor.

Using hierarchical confirmatory factor analysis, Keith and Novak (1987) found similar results, yet interpreted them differently. Arguing that the Achievement subscale, since it was a good measure of g in relation to the WISC-R, should actually be included in the Mental Processing Composite score. They indicated that their findings did not support Kaufman's assumptions and as a result, they warned against the use of the Mental Processing Composite and Achievement subscales for ability-achievement discrepancy determination. Another confirmatory factor analysis of the K-ABC and WISC-R (Good & Lane, 1990) found that for at-risk children a four factor model best fit the data. Instead of Kaufman's equating the WISC-R Verbal Comprehension and K-ABC Achievement factors, they found that Verbal Comprehension could be divided into a processing factor of similar name, and a Reading Achievement factor.

In a study designed to address the right hemisphere-left hemisphere debate for the K-ABC and WISC-R, Morris and Bigler (1987) found some support for the K-ABC model. Using neuropsychological instruments, the K-ABC, and the WISC-R, Morris and Bigler (1987) found that the Simultaneous subscale (.66) correlated higher with right hemisphere tasks than did the Performance subscale (.48). However, the reverse was found to be true for the Verbal (.57) and Sequential (.44) subscale correlations with left hemisphere functioning. The authors pointed out that Luria (1980) had equated sequential abilities with fronto-temporal functioning and simultaneous abilities with parietal-occipital functioning, rather than the left-right hemisphere distinction posited by Kaufman.

The Differential Abilities Scale (DAS) is another instrument designed to address the factorial complexity found in the studies of other intellectual instruments (Elliot, 1990). The three main factors of the DAS are Verbal, Nonverbal Reasoning, and Spatial factors, each having acceptable loadings on g; whereas the low g loading subtests are called the Diagnostic subtests, in that they are considered to measure relatively independent abilities. Attempts to relate sequential(successive)-simultaneous processes to the WISC-R according to the DAS model (Naglierri, Kamphaus, & Kaufman, 1983) have indicated that Picture Completion, Picture Arrangement, Block Design, Object Assembly, and Mazes are simultaneous processing tests and Digit Span and Coding are successive processing subtests.

Of the studies using this perspective, Naglieri, Das, and Jarman (1990) have reported that evidence is mounting for interpreting standardized intelligence tests from a neuropsychological perspective. The authors suggest that the limitations of traditional analyses of these measures can be overcome by examining four factors based on Luria's model (1973). They offer the PASS (Planning, Attention/Arousal, Simultaneous, and Successive) model for examining test results using a theoretically sound framework. In a summary of their validity studies, Naglieri, Das, and Jarman (1990) have found that reading disabled subjects were deficient in Planning and had lower Attention/Arousal scores; delinquents were deficient in Attention/Arousal; and ADHD subjects were deficient in Planning, Attention/Arousal; and Successive Processing.

A joint confirmatory factor analysis of the DAS and the WISC-R revealed that a five factor solution best fits the data set (Stone, 1992). For the WISC-R subtests, the five factors yielded: Information, Similarities, Vocabulary, and Comprehension loadings for the Verbal Ability factor; no loadings for the Nonverbal Reasoning factor (only the DAS Matrices subtest loaded on this factor); Picture Completion, Block Design, Object Assembly major, and Picture Arrangement and Mazes minor, loadings on the Spatial Ability factor; Arithmetic and Digit Span loadings on the Numerical Ability factor; and the Coding subtest loading on the Processing Speed factor. Stone (1992) noted that the WISC-III factor analysis also distinguished between these last two factors traditionally forming the single Freedom from Distractibility factor. On the WISC-III (Wechsler, 1991), with the addition of the Symbol Search subtest, the two factors are now labeled Freedom from Distractibility (Arithmetic and Digit Span) and Processing Speed (Coding and Symbol Search).

In an attempt to explore the interaction of neuropsychological functioning and performance on the WISC-R, several studies have been employed to address this question. In their review of the instability of the Freedom from Distractibility factor, Ownby and Mathews (1988) argued that a variety of complex abilities were related to this factor. Although they did agree that the Arithmetic, Digit Span, and Coding subtests were sensitive measures of executive function following their factor analytic study, they argued that Factor 3 was a better descriptor than Freedom from Distractibility. They noted that a comparison of these subtests and neuropsychological measures yielded several related but disparate abilities in this factor. Not only was sustained attention important for performing well on this factor, but also visuo-spatial organization and rapid shifting of mental operations on symbolic material abilities were important as well.

In an examination of the interrelationship between the WISC-R and the Halstead-Reitan Neuropsychological Test Battery (HRTNB) for older children, D'Amato, Gray, and Dean (1988a) employed canonical correlation and factor analytic techniques to determine six factors for a large sample of 1,181 children referred for learning problems. Only one significant canonical correlation, accounting for 10% of the variance, emerged between the two measures, which they labeled General Cognitive Reasoning. Subsequent to this result, a factor analysis of the measures revealed a six factor solution, with fairly little overlap between the WISC-R and HRNTB found. Factor one consisted of major loadings for the typical Verbal Comprehension WISC-R subtests, with a medium loading for Arithmetic (.47). Factor three consisted of the typical

Perceptual Organization WISC-R subtests. Factor four demonstrated some overlap between the instruments, with the Freedom from Distractibility WISC-R subtests loading with the HRNTB subtests of Speech Sounds, Seashore Rhythm, Trails A and B. Picture Arrangement also loaded with Trails A and B on Factor five, which also included the Tactile Performance Test, Dominant and Nondominant Hand loadings.

Seidenberg, Giordani, Berent, and Boll (1983) designed a study of children with different WISC-R IQ scores in an attempt to determine the influence of intelligence on the typical methods of clinical analysis of the HRNTB, primarily level of performance, pattern of performance, and left/right differences (leaving out pathognomonic signs). They divided their subjects into four groups based on IQ scores of nine point intervals ranging from 70 to 100+ and then used multivariate analysis of covariance (with SES as a covariate) to examine the difference between the groups. They found that five of the 14 HRNTB subtests distinguished the groups, with the better the score most often being indicative of higher IQ for the four groups. The HRNTB Category, Speech Sounds, Seashore Rhythm, Trails B, and Aphasia Screening subtests were the tests found to discriminate between the groups. The authors concluded that tests of problem solving, language, and auditory perceptual analysis were most impacted by IQ, whereas simple sensory and motor functions, as well as left/right differences were not impacted by IQ level.

However, they analyzed only Full Scale scores in their study.

A number of investigators have examined the relationships of specific aspects of the WISC-R, HRNTB, and other instruments. Francis, Fletcher, and Rourke (1988) compared several sensorimotor subtests and used the WISC-R Information, Similarities, Vocabulary, Block Design, and Object Assembly subtests to add to the discriminant validity of the sensorimotor instruments utilizing a nested hierarchical confirmatory factor analytic design. They found little support for right/left differences in their comparison, but did find discriminating power for simple versus complex sensorimotor tasks. The most complex interaction model (right/left, simple/complex, sensory/motor) did fit the data better, however their discriminate analysis revealed significant support for the more parsimonious simple/complex dichotomy.

A comparison of the HRNTB Speech Sounds and Seashore Rhythm subtests and the WISC-R was undertaken utilizing canonical correlation to determine the underlying constructs shared between the two measures (Strom, Mason, Williams, Dean, & Fischer, 1988). The results indicated that on the first canonical root, Information, Arithmetic, Digit Span, and Block Design were related to the auditory discrimination measures Speech Sounds and Seashore Rhythm, and on the second canonical root Information and Similarities were related to these measures. The authors felt that their results did confirm that verbal auditory discrimination abilities were assessed by Speech Sounds and the nonverbal auditory discrimination abilities were measured by Seashore Rhythm. They reported that memory and attention, as well as verbal and nonverbal measures of an ability to form concepts (Similarities and Block Design) were necessary prerequisites to perform well on these HRNTB subtests. Although not readily apparent, the authors postulated that the ability to distinguish "same" versus "different" on the HRNTB subtests would account for the need of the concept formation abilities thought to be shared with Block Design and Similarities performance.

As the Peabody Picture Vocabulary Test (PPVT) has been argued to be an general index of verbal comprehension and achievement (Dean, 1980), investigators have examined its construct validity by comparing it to the WISC-R, HRNTB, and other instruments. One unique study compared oral versus written presentation of the stimulus words to examine if the WISC-R and HRNTB tests were related to performance on the PPVT (Stone, Gray, Dean, & Strom, 1989). The authors found support for a neuropsychological difference between the two modes of presentation. For both presentations, Information and Vocabulary were positively correlated and Coding was negatively related to the PPVT. For the traditional oral presentation the HRNTB Category, Speech Sounds, and Seashore Rhythm subtests were significantly related to PPVT performance. For the written presentation, Picture

Completion, Picture Arrangement, and Finger Oscillation were related to PPVT performance. The authors reported that these similarities and differences have implications for hearing impaired and learning disabled test format presentations. In another study of the PPVT, WISC-R, and HRNTB, factor analysis of the data revealed that the PPVT was most related to their Verbal Comprehension factor, sharing loadings with verbal subtests of the WISC-R (except Digit Span) and Picture Completion (D'Amato, Gray, and Dean, 1988b). They offered that this test was indeed more a measure of intellectual functioning rather than achievement, as the PPVT failed to load on their Verbal Achievement factor defined primarily by the Wide Range Achievement Test subtests of Reading, Spelling, and Arithmetic.

Finally, one area of considerable controversy surrounding the differential intellectual processes thought to result in learning disorders is the inability of the hemispheres to interact effectively and efficiently when processing information. In a review of the hypotheses surrounding this issue, Kershner (1983) stated that the main difficulty experienced by learning disabled children is that interhemispheric communication is limited by the resources available at any one time for a given hemisphere. For LD children, the result is an inconsistent utilization of the different hemispheres for different tasks based on this dual processor, limited capacity model (Kershner, 1983). Previous research has shown a developmental trend for these abilities, with cross-modal integration abilities increasing with age (Flannery & Balling, 1979). In an investigation designed to examine the cross-modal integration abilities of learning disabled children and normal children, Snow, Barnett, Cunningham, and Ernst (1988) revealed support for this assumption. Comparing the two groups on cross modal discrimination and memory tasks, they found an age effect for the former and group effect for the latter, with learning disabled children showing lower levels of memory performance. The authors felt that in both instances a developmental lag in the learning disabled sample best described the differences found in the study, with cross modal memory abilities lagging further behind the age-dependent discrimination abilities.

As reported above there have been a number of studies and theories designed to address the complexity of intellectual and neuropsychological constructs observed in clinical practice. Although research findings have revealed certain important similarities and differences in models of cognitive functioning, most of these studies have utilized exploratory factor analytic techniques. Confirmatory and structural equation modelling studies have been limited to verifying or refuting previously held positions. Other studies have explored specific aspects of cognitive functioning from a theoretical model; however, most often researchers limit the exploration of their hypothetical model by comparing and contrasting only one specific aspect or construct of what is naturally a more global model of neuropsychological functioning and information processing.

Problems with Differentiating LD from BD

According to the U.S. Department of Health, Education and Welfare (Kolb & Whishaw, 1985), many common characteristics of learning disabled and behavioral disordered individuals can be identified. These characteristics include: hyperactivity, perceptual-motor impairment, emotional lability, general coordination deficits, disorders of attention (short attention span, distractibility, perseveration), impulsivity, disorders of memory and cognition, specific learning disabilities, disorders of speech and hearing, and neurological signs/irregular EEG.

Gaddes (1980) found a number of dysfunctional characteristics associated with learning disabilities to include: hard and soft signs of brain dysfunction, abnormal cerebral lateralization, maturational lag, and environmental deprivation, all of which affect behavior. It seems apparent that incorporated in the above characteristics is the definition of behavioral disorders. Mercer (1987) notes that students with learning disabilities frequently have social and emotional problems that would make them eligible for services in the behavior disabilities category if they were not labeled learning disabled. It is possible that the nature of LD student's overt behavior, rather than their cognitive deficits, determines the course of their referral problem and subsequent labelling as LD or BD.

Part of the difficulty in adequately differentiating LD from BD subgroups is the determination of how social competence and behavior patterns are related to, and interact with, higher level cognitive processes. A review of the literature indicates that approximately 50% (Rourke & Fuerst, 1991) of LD children display little or no behavioral dysfunction; however, the remainder present deviant profiles on standardized psychosocial instruments, indicating the presence of behavior disorders. Rourke and several colleagues have been exploring the relationship between neuropsychological constructs related to specific learning disabilities and the interrelationship of these constructs to specific behavioral and emotional profiles for over 15 years. Rourke (1982) indicates that a principle component analysis of social competence reveals that three areas are necessary for successful social interaction (perceptual skills, such as those needed for the perception of verbal or nonverbal content; cognitive abilities, such as those required to establish cause and effect relationships; and motor and language skills, the skills needed to respond in social situations). Rourke reports that LD students may be deficient in one or more of these areas, which can result in a significant pathological behavior pattern.

Many LD students do develop successful mechanisms to cope with their disability, thus the behavioral "normalcy" of many LD children, while others need specific interventions to overcome their deficits. The noticeable behavioral profiles of LD individuals with externalizing conduct disorders, (characterized by overt, disruptive, adversarial behavior) are often judged by others to be dysfunctional and maladaptive, with academic deficiencies often seen as related to the behavior disorder. Those LD individuals with internalizing personality problems are less apparent behaviorally, as their behavior minimizes overt conflict over their noticeable inadequate academic performance. Learning disabled individuals with ADD or ADHD characteristics may or may not display either of the above profiles, possibly depending on the associated academic, cognitive, and behavioral difficulties they display, in addition to the attention deficit. It seems apparent that the LD student's processing strengths or weaknesses could be related to the type of coping pattern and psychosocial pattern they display. The adaptive coping pattern could result in their utilization of specific behavioral repertoires, based on cognitive and psychosocial development, which may or may not produce maladaptive responses to their environment as judged by others.

It is likely that most of the functional brain areas work simultaneously while processing complex social information, affecting social perception and judgement, problem solving skills, and self-perception. Psychosocial development could affect an individual's ability to adapt and compensate for information processing deficits, as they are likely to rely on their intact modalities to interpret social communication. It would seem apparent that individuals with hemispheric deficiencies and concomitant attentional or hyperactivity problems would be less successful in developing compensatory mechanisms as they would be less able to attend to social information and would respond differentially in social situations.

Attempts have been made to determine what variables affect cognitive and behavioral performance in the LD population. Three common factors emerge during analysis of behavior problems in LD children. The first behavior factor exhibited by children with LD is externalizing conduct disorder (CD). Individuals with conduct disorder display overt, undersocialized, aggressive or antisocial behaviors. Hypothesized to be related to dysfunctional social cognition skills, this behavior pattern has been associated with deficient right hemisphere functioning (Bryan, 1977; Glossner & Koppell, 1987; Nussbaum, Bigler, & Koch, 1988; Rourke & Fuerst, 1991). The second factor LD students frequently present is internalizing Personality Problems (PP), with individuals often characterized by avoidant behaviors such as anxiety, depression, and social withdrawal. This pattern has been related to both right and left hemisphere dysfunction (Glossner & Koppell, 1987; Nussbaum, Bigler, & Koch, 1988;

Rourke & Fuerst, 1991; Thompson, 1989).

Learning disordered individuals may display both CD and PP factors, and a third factor as well. The Inadequacy-Immaturity factor (II) describes individuals similar to those considered as having Attention Deficit Disorder (ADD) or ADD with Hyperactivity (ADHD). These LD individuals display behaviors of inattention, impulsivity, distractibility, difficulty with delaying gratification, overarousal, and noncompliance. As these deficiencies are often seen in children with LD, the II factor is seldom considered as a separate category and possibly obfuscates the stability of the other factors, as the ADD behaviors often statistically load on the CD and/or PP factors in factor analytic studies. Several studies have revealed the validity of this third factor, on both cognitive and behavioral measures; however, there is substantial disagreement over the neuropsychological basis of ADD(H). Studies have implicated the midbrain, frontal lobe, and right hemisphere as sources of ADD and ADHD (Kolb & Whishaw, 1985).

LD Group Studies

Although many studies have been designed to examine the LD population without establishing cognitive subtypes empirically, the authors of these studies have often postulated that different processing strengths and weaknesses can result in subsequent behavior problems. One such area of research has been directed at examining the social competence skills of LD and BD youth. A review of the literature (Brian, Pearl, and Fallon, 1989) revealed that LD youth were often dependent, immature, had poorer social competence, and deficient academic performance. The authors found that LD children were likely to be neglected or rejected by others, and had higher internalizing, externalizing and total behavior problems compared to normal controls. LD children were also more likely to adapt group values over their own, were typically less assertive, and had difficulty with detecting deception in role-taking situations.

Bryan (1977) in an earlier study postulated that social interaction difficulties may reflect deficient visual-spatial skills and difficulties in comprehending non-verbal communication. Bryan found that LD children scored significantly lower on both auditory and visual presentations of social information, which was partially replicated by Stone and La Greca (1984); although in the latter study they found that under incentive motivation conditions the LD subjects performed equally well. Researchers have also postulated that LD children may be deficient in the analysis and production of speech (Bryan, 1982), are unable to utilize effective role taking skills (Bruck & Hebert, 1982), or have inappropriate interpersonal goals or strategies (Carlson, 1987).

Attempts have been made to explore the self concepts, attributions, and locus of control characteristics of LD children. Margalit and Zak (1984) compared LD children and normal controls on measures of anxiety and self concept. The LD subjects were reportedly more anxious about their academic and interpersonal success, but only when they limited control over their success in these situations. In general, studies such as the one undertaken by Hiebert, Wong, and Hunter (1982) have found that LD children have lower academic expectations and self esteem; yet this does not always carry over into other domains such as physical ability (Chovan & Morrison, 1984). Studies of attribution and locus of control tend to indicate that LD children tend to externalize their successes (due to chance or task ease), yet internalize their failures (due to a lack of ability or effort on their part. A comprehensive, longitudinal study examining these factors found that LD children suffered from lower self-esteem and external attribution patterns. An interesting finding of the study was that LD children were not likely to become worse over time, indicating that they persevered in the face of substantial difficulties and failures (Chapman, 1988).

Of the studies that utilize parent behavior rating scales to assess LD behavioral functioning, several indicate that LD and other special education populations score higher (indicating psychopathology) on the Behavior Problem Checklist (BPC) on all three dimensions (CD, PP, II) than the regular population (Greiger & Richards, 1976; Cullinan, Epstein, and Dembinski, 1979; Gajar, 1979; Touliatos & Lindhom, 1980). Most of the studies were unable to differentiate between the subjects based on school placement labels (LD, BD, Mentally Retarded-MR). Cullinan, et al. (1979) found that only the CD factor was significantly greater among BD students. Gajar (1979) found that BD students presented significant discrepancies on the CD and PP problems as compared to LD/EMH students. In contrast, McCarthy & Paraskevopous (1979) indicated that both LD and BD students scored significantly higher on the CD dimension. Touliatos & Lindholm (1980) found that LD children had significantly more problems on the PP, CD and II factors, but not on a socialized delinquency factor. An interesting difference was found in terms of the stability of PP problems. For normal subjects PP scores increased from kindergarten through the third grade and then declined. However, the LD students with PP increased steadily through eighth grade, the ceiling of his study.

Teacher ratings of LD and BD students have tended to report similar profiles for both LD and BD students, yet more significant behavioral problems for the BD group (Harris, King, Reifler, & Rosenberg, 1984). However, several studies have found that the Achievement, Intellectual Screening, and Development Scales of the Personality Inventory for Children were significantly problematic for LD groups (Breen and Barkley, 1984; Dollinger, Goh, & Cody, 1984). Teacher ratings of LD students have revealed that as a group, LD students are rated less favorably than their normal classmates. Garret and Crump (1980) found that teachers rated LD students as significantly less preferred than their normal peers, and Siperstein and Goding (1983) reported that teachers consistently ranked LD students in the lower third of the class for behavior problems and social interaction abilities. Teachers tend to interact with LD students more than their peers (Bryan & Wheeler, 1972) for mostly management issues (Dorval, McKinney, & Feagans, 1982), and make more negative evaluative statements when they do interact with them (Bryan, 1974).

Some studies have attempted to examine WISC-R differences between subjects considered to be LD and BD based on school diagnoses. Vance, Fuller, and Ellis, (1983) compared LD and BD students attending special education classes using discriminate analysis. They found that the BD group performed lower than the LD group on the Verbal, Performance, and Full Scale scores, as well as most of the subtests. No attempt was made to distinguish between the patterns of performance for the two groups, as they were quite similar. Another study labelled LD children as either displaying behavior problems or not, and found that Picture Arrangement scores were significantly greater than Comprehension or Similarities scores (Wickers & O'Sheel, 1983). They felt that social cues could be read by LD students with behavior problems, yet the LD students had difficulty with understanding verbal communication, and rules and regulations of social interchange.

LD and JD Studies

Another group of investigators have examined the relationship of learning disabilities and behavior disorders by researching adjudicated delinquents. Estimates regarding the prevalence of learning problems in the juvenile delinquent (JD) population have been reported as being as high as 90% (Compton, 1974). A large scale research project (Campbell, 1978) was designed to study institutionalized and imprisoned youths comparing JD's and normal students. They found that 16% of nonadjudicated JD's had a LD as compared with 39% of the adjudicated JD's, even though there were no differences found between the two groups on any behavioral measures. This along with other findings have led many professionals to propose that LD individuals were more likely to be adjudicated because of their learning disabilities not their crime.

According to Sobel (1979) who reported on numerous studies, JD's had WISC-R scores below the norm, reading grade levels at least one year below grade level, and poor school attendance. The JD's tended to be defiant and antisocial, as well as likely to cause disturbances in their school settings. After completing the study, Sobel noted that academic remediation in itself would not reduce recidivism. Sobel felt that treatment of this population must be long-term and that it focus on skill acquisition which would be of pragmatic use to the juvenile delinquents when they are released.

Alley, Deschler and Warner (1979) reported that LD youths are twice as likely to be adjudicated for their crimes, although self-reporting measures indicated that they were no more likely to engage in delinquent acts than their non-LD delinquent peers. A study by Berman & Seigal (1976) found that JD's had lower IQ scores on the WISC, lower scores on all components of the Halstead-Reitan Neuropsychological Test Battery (HRNTB), and extremely low Speech Sounds and Trails (A and B) scores. Their results indicated that 71% of the delinquent group were cognitively impaired on at least one of the subtests.

Robins, et al. (1983), studied unincarcerated, clinically diagnosed versus nonclinical delinquent youths, and found similar discrepancies as the Berman, et al. study. They found that the clinical sample yielded significant discrepancies on cognitive, perceptual and motor tasks, more soft signs, auditory perception difficulties, and visual problems. They were also more likely to be repeat offenders. This pattern was indicated in a study (Broder, Peters, and Zimmerman, 1978) where it was found that of incarcerated, delinquent youth, 36.5% were LD as compared to 18.9% of the control group. When looking at all LD students, they found that 39% were delinquent. Jacobson (1974) indicated the data may indicate that the primary cause of JD is LD and concluded that LD children are twice as likely to become delinquents as non-LD children, and that being LD may precipitate a delinquent lifestyle.

Sobotowicz, Evans, and Laughlin (1987) assessed four groups of children (LD, LD with JD, JD, and controls) using a large number of neuropsychological instruments. They found that normals outperformed all others on complex, abstract, and/or language related measures; however, the interesting finding here was that the pure JD group scored higher on cognitive measures than the LD or LD/JD groups, which is in difference with the LD and BD comparisons described in the last section.

A number of studies have implicated various dysfunctional cortical structures associated with the LD/JD. An examination of seriously assaultive adolescents, found that anterior left hemisphere and short term memory deficits were typical of the population (Krynicki, 1978), and another found that left frontal and temporal lobe deficits, with the intimate ties they had with the subcortical limbic system, were responsible for delinquents' aggressive actions (Yeudall, 1978). The Luria Nebraska Neuropsychological Battery was used to examine delinquents of serious crimes and who had high recidivism rates (Brickman, McManus, Grapentine, & Allessi, 1984). The results implicated a number of structures associated with expressive speech, memory, and rhythmic functioning, primarily the left frontal lobe. Bryant, Scott, Golden, and Tori (1984) reported that violent criminals showed brain damaged patterns on the Luria Nebraska 73% of the time, as compared to the control criminals (28%).

LD and BD Neuropsychological Studies

A number of authors of studies that have been designed to explore deficits in psychosocial functioning have posited that these deficits, as measured by standardized tests, may be associated with specific cerebral dysfunction. Several investigators have used cognitive and neuropsychological tests to discriminate between subtypes of learning disabilities in recent years. Barkley (1981) suggests that a matrix model of LD subtypes could be utilized to categorize LD subjects. On the horizontal axis would be the academic skills and on the vertical axis would be neuropsychological functioning. This way one could separate out the unique contribution of cognitive constructs to academic and behavioral performance.

McKinney (1984) using the Classroom Behavior Inventory (CBI), the WISC-R, and the Peabody Individual Achievement Test used hierarchical cluster analysis to find four types of LD children. Subtype 1 (33% of the sample) was characterized by average verbal skills with deficits in sequential and spatial skills. They were also deficient on Independence and Task Orientation on the CBI. Subtype 2 (10% of the sample) had the highest subscale scatter and the lowest academic achievement. They were seen as more considerate, less hostile, yet less task oriented than any other subgroup. Subtype 3 (47% of the sample) had above average conceptual skills. These children were more extroverted, less considerate, and more hostile than any other group. Subtype 4 (10% of the sample) subjects were more impaired on achievement measures than subtypes 1 or 3, and demonstrated no evidence of behavior problems.

Another study using the WISC-R (Glosser and Koppell, 1987) found three groups of LD subtypes and their associated behavioral characteristics. One group of children, considered to be left hemisphere impaired, presented behavioral profiles of dysphoria, anxiety, and social withdrawal. Those considered to have right hemisphere deficits had low rates of dysphoria/anxiety and increased somatic complaints. Those children with nonlateralized disabilities showed characteristic attention deficit disorders and had more pervasive emotional disturbances. A large, comprehensive examination of LD subgroups using the WISC-R was undertaken to determine the accuracy of the WISC-R and included cross-validation (Holcomb, Hardesty, Adams, and Ponder, 1987). They found six groups that displayed differential patterns of performance. Three separate groups were characterized by reading, sequencing, and attentional problems; two groups had low IQ's and were possibly not true LD's; and one group had superior IQ's with motor coordination deficits and severe emotional problems. The interesting finding of the gifted group is worth noting, as it may be that having a disability and a superior intellect can be extremely frustrating.

Nolan, Hammeke, and Barkley (1983) attempted to examine the relationship of intellect, achievement, and behavior using the Wide Range Achievement Test (WRAT) as the academic measure, the Luria-Nebraska Neuropsychological Battery, WISC-R, and parts of the Halstead-Reitan Neuropsychological Test Battery. They found that the traditional measures of neuropsychology were able to discriminate between the poor reading and spelling groups as determined by WRAT scores, whereas the WISC-R was not. Neither assessment technique had discriminative power to distinguish the poor mathematics group from the other groups. An extensive study to derive subgroups of LD children and their behavioral characteristics was undertaken by a group at the University of Texas (Nussbaum and Bigler, 1986). They used the older children's version of the HRNTB, the WISC-R, the Reitan-Indiana Aphasia Screening Test, the WRAT, the Child Behavior Checklist, and the Personality Inventory for Children. They statistically derived three subgroups of LD children. The first group exhibited the most severe and generalized deficits in cognitive performance, the second showed a moderate degree of impairment and greater verbal deficits, and the third group showed the least amount of impairment and slightly more visuo/spatial/motor deficits. On the behavior ratings there were few differences found between the groups. All subjects showed elevations on the scales for Depression, Withdrawal, Hyperactivity, Adjustment and Anxiety. The low verbal group had significantly higher Internalizing and Depression scales.

Similar findings represented by Petrauskas and Rourke (1979), Rourke and Finlayson (1978), and Rourke (1982) indicated that LD subgroups can exhibit specific language disabilities and relative strengths for visual-perceptual abilities, reading disabled children who have normal verbal abilities with visual processing difficulties, and a mixed deficits group. However, in a recent analysis of the relationship between cognitive profiles and behavior problems, Rourke and Fuerst (1991) found that both internalizing and externalizing disorders were significantly more prevalent in the nonverbal LD type.

Rourke (1987) provides a theoretically sound explanation for the Windsor Taxonomic Research findings of the high prevalence of psychosocial disturbance in nonverbal LD over the verbal LD category. Using Goldberg and Costa's (1981) model of intellectual functioning, Rourke (1987) reports that it is the right hemisphere, responsible for processing information that has no descriptive system and is modality nonspecific, has more intermodal than intramodal connections. According to the model, the large associative zone is required to examine relationships to develop effective ways to solve novel problems. Rourke argues that it is the right hemisphere white matter, responsible for interhemispheric and interregional connections, that is dysfunctional in LD children that demonstrate pathological behavioral problems. Despite several arguments for deficient left hemisphere functioning being related to psychosocial disturbance, evidence is mounting for Rourke's hypothesis.

A review of the implications of right hemisphere dysfunction and nonverbal learning disabilities specifically addressed social implications and adaptive functioning associated with this LD (Semrud-Clikeman and Hynd, 1990). They specifically examine the roles of each hemisphere and how the right hemisphere may play a more important role in cognitive and behavioral functioning than previously acknowledged. They felt that the right hemisphere mediates social perception, judgement, and self-help skills. An individual with disabilities may have deficits in self awareness and attention as well, so they are not able to monitor their behavior. Semrud-Clikeman and Hynd (1990) noted that the ability to utilize facial recognition responses accurately is essential to social communication, cues that are first perceived using right hemispheric processing capabilities.

Assessment practices have tried to differentiate among LD subtypes with Attention Deficit Disorder (ADD) and with hyperactivity (ADDH). According to Douglass (1976), LD's are different from controls on continuous performance tests and react to all types of stimuli, relevant or not, a finding characteristic of ADHD. Another study (Lahey, Schaughency, Frame, and Strauss, 1985), using the Luria Nebraska Neuropsychological Test Battery and the WISC-R, found that both ADD and ADDH subjects scored significantly lower on VIQ, but not PIQ. Moffitt and Silva (1988) found that delinquents with ADD had more cognitive impairments, especially in visuospatial and visual motor integration tasks. A comparison of LD, hyperactive and LD/hyperactive groups (Breen and Barkley, 1984) found that the LD group was less deviant on all six scales of the Personality Inventory for Children (PIC). However, they found that the LD/hyperactive group had the worst performance on the Achievement, Intellectual Screening, and Development scales than either the purely hyperactive or LD group. They also found that the LD group was significantly lower than either of the hyperactive groups on these scales. Although it is apparent that there is some discriminative ability to distinguish between hyperactive and non-hyperactive LD's, other factors such as behavioral functioning aid in the differential diagnosis.

Hynd, Hern, Voeller, and Marshall (1991) provide convincing evidence of physiological aspects of ADD(H) being related to dysfunctional right frontal lobe functioning. Reporting on recent findings implicating the right hemisphere, including neuropsychological studies, cerebral blood flow, medication effects on metabolic rates, and neuroimaging studies, Hynd, et al. delineates the specific physiological correlates of the deficient right frontal lobe and found similar characteristics for dyslexics. The authors report that the deficient right frontal lobe, which is reduced in size compared to the normal right greater than left asymmetry, may be the result of abnormal developmental processes. This leaves the ADD(H) individual with an inability to provide cortical control over the subcortical mechanisms thought to regulate attention and concentration. Semrud-Clikeman and Lorys-Vernon (1988) support these ideas, indicating that underactivation of the frontal lobes results in an inability to regulate attention and inhibit responses, which is treated successfully with methylphenidate, a stimulant medication, which reactivates the system. The authors also found that the FFD factor of the WISC-R fails to distinguish between ADD/H, ADD/H with concurrent Conduct Disorder, and clinic controls.

Pontius and Ruttinger (1974) proposed that the Wisconsin Card Sorting Task, any maze learning task, and a test of word fluency would assess frontal lobe dysfunction. They felt that it is well known that frontal lobe function is associated with the emotional processes, so it would be important to assess this level of functioning as well as traditional left/right temporal and parietal functioning as is normally looked at in LD individuals. A study by Bulkhuisen (1987) found that antisocial behavior was directly linked to frontal dysfunction. In a recent review of frontal lobe dysfunction and antisocial behavior, Kandel and Freed (1989) report that although this relationship requires further investigation, trends are beginning to emerge that support such a link between deficient frontal lobe functioning and behavioral dysfunction.

One of the few studies directed at determining the differences between those with purportedly anterior (A) versus posterior (P) deficits yielded interesting behavioral differences (Nussbaum, Bigler, & Koch, 1988). They noted that tests of motor, attention, sequential processing and complex thinking are constructs thought to be associated with anterior regions. The posterior regions are associated with tactile and visual perception, namely the parietoccipital region. The authors found that there were significant differences between those subjects they were able to classify as having A or P deficits. The A group was more socially withdrawn, aggressive, hyperactive, and externalizing, whereas the P group scored higher (although not significant) on the anxiety scale. They concluded that those with anterior deficits were at greater risk for behavioral problems.

Part of the difficulty in determining relationships between LD, ADD, and BD may be due to the influence of higher level cognitive processes, such as metacognition. A study of metacomponential functioning in LD, EMH and Controls (Berger & Reid, 1989) found that the best predictor of higher level cognitive abilities was one's knowledge base and automaticity of accessing the information. They found that LD students did not spontaneously use attentional and mnemonic devices, having difficulty with the encoding and recall of information. The authors postulated that poor higher level cognitive functions may affect social competence and result in inappropriate behaviors.

Summary of the Literature

Given what is reported above, the review of the literature does support the notion that LD is related to BD, and that specific skill deficits typically found in LD can result in deviant behavior profiles. However, it is important to resolve some of the discrepancies found in the studies conducted to date. Through the establishment of stable underlying and interrelated abilities based on standardized scores, rather than the use of the scores themselves, it is expected that differential abilities will be related to behavioral problems in children. As noted earlier, the model to be developed and tested in this research project, is an attempt to establish stable underlying abilities by synthesizing the works of Luria (1973) and Goldberg and Costa (1981).

Based on an extensive clinical database of individuals in the Soviet Union, and citing a large array of studies, Luria (1973) suggested that the brain is a system of related constructs that are arranged in three principal functional units (one for regulating tone or waking; one for obtaining, processing, and storing information; and the superstructure above all else, the unit for programming, regulating, and verifying mental activity). The units are considered to be hierarchical in structure, diminish in the specificity of their functions as one ascends the hierarchy, and become increasingly lateralized for different functions. Of importance here is that the primary (projection) zones are highly sensory specific, the secondary (projection-association) zones are for gnostic and praxis functions. The tertiary zones of overlapping work concertedly on most tasks.

Goldberg and Costa (1981) suggest that the two hemispheres may work together when processing information, yet have different processing modes and accomplish different aspects and stages of cognition. The right hemisphere processes novel, nonverbal visual-spatial-perceptual information simultaneously, and the left hemisphere processes verbal, routinized information sequentially. Similar to the ideas put forth by Horn and Cattell (1966), the fluid abilities of the right hemisphere allow it to process the novelty of incoming information; whereas, the left hemisphere accesses the familiar or crystallized aspects of a stimulus. Many higher level processes are thought to utilize both hemispheres simultaneously. For instance speech seems to involve both hemispheres, with the right hemisphere processing the spatial configuration for words or grapheme comprehension and the left involved with phonetic interpretation and sequencing of text. Bilaterally represented, both Broca's and Wernicke's areas seem to have lateralized differences in how different components of language are processed (Kolb & Whishaw, 1985). That said, the model to be developed and tested in this research project is a synthesis of these two seminal works (Goldberg & Costa, 1981; Luria, 1973) related to what we know, or think we know, about the theory of brain-behavior relationships.

CHAPTER III

METHOD

Research Questions

The following research questions were addressed:

1) Given the WISC-R subtest loadings on the final model presented, is the model a reliable representation of the models of Luria (1973) and Goldberg and Costa (1981)? Structural equation factor analysis goodness of fit indices between the model and the data set were used to address this question.

2) Given a reliable model of cognitive constructs based on the models of Luria (1973) and Goldberg and Costa (1981), are any of the empirically identified cognitive constructs significantly related to behavioral functioning? The Child Behavior Checklist (Achenbach & Edelbrock, 1982) was used to assess behavioral functioning.

Subjects

The sample, chosen from archival data, consisted of 88 children between the ages of 6 and 11 assessed at a neuropsychological clinic affiliated with a large suburban midwestern hospital corporation. The mean age of the sample was 108.47 months (approximately 9 years old) and consisted of 61 boys and 27 girls, with 82 being right handed and 6 left handed. There was a fairly equal breakdown across grade levels. The sample consisted of 22 first graders, 16 second graders, 16 third graders, 14 fourth graders, 13 fifth graders, and 6 sixth graders.

The subjects were included in the study if they met the following criteria. All subjects scored within the average range on the WISC-R, having a Full Scale IQ score between 120 and 80, with at least one significant subscale, factor score, or subtest strength or weakness. According to Sattler (1988), a significant difference is defined as: 1) a VIQ-PIQ difference (12 points, $p < .05$); 2) a VC-PO-FFD factor score difference (14 points, $P < .05$); or 3) a subtest difference from another subtest (4 to 6 points, $P < .01$). The academic inclusion criteria for LD students was a discrepancy between ability and academic functioning, as measured by the Woodcock Johnson Psychoeducational Test Battery - Revised, Woodcock Reading Mastery Test - Revised, Key Math Diagnostic Test - Revised, Test of Written Spelling - Revised, Developmental Test of Visual Motor Integration, Peabody Picture Vocabulary Test - Revised, or the Test of Written Language - Revised. A LD student was considered to meet the discrepancy criteria if they had at least one of these academic standard scores one standard deviation below the full scale score on the WISC-R. For example, a student with a Full Scale IQ on the WISC-R of

100 must have had at least one global or subscale academic measure with a standard score of 85 and 7 respectively or less.

In addition to these criteria, subjects were screened for the existence of current medical conditions that might impact their intellectual and/or behavioral functioning. Subjects with seizure disorders, degenerative or other debilitating chronic diseases, or those on medications impacting cognitive functioning were not included in the data set. Previous illnesses reported on parent questionnaires included chicken pox (n = 35), fractures of the extremities (n = 10), roseola (n = 7), hearing or vision problems (n = 7), respiratory problems (n = 7), drug reactions (n = 5), concussion/loss of consciousness (n = 5), measles (n = 4), growth problems (n = 2), and one each for asthma, colic, meningitis, and absence seizures. Archival data sets obtained consisted of the demographic data, WISC-R subtest and deviation measures, achievement measures, and CBCL teacher and parent rating forms.

Procedure

Instrumentation

The WISC-R is the most commonly used measure of cognitive functioning in empirical research and has adequate technical quality. Although it provides a Full Scale, Verbal, and Performance IQ only, factor analytic studies have revealed a third factor labelled the Freedom from Distractibility (FFD) factor (Kaufman, 1975). The Verbal subtests include Information, Similarities, Vocabulary, Comprehension, Arithmetic, and Digit Span, with the first four loading on the Verbal Comprehension factor, and the last two on the Freedom from Distractibility factor. The Performance subtests include Picture Completion, Picture Arrangement, Block Design, Object Assembly, and Coding, with the last subtest also loading on the FFD factor and the others loading on the Perceptual Organization factor.

The CBCL is an empirically and rationally constructed instrument designed to provide a comprehensive and clinically relevant description of the subject's personality characteristics. It consists of broad-band Internalizing and Externalizing scale scores, as well as narrow band subscales that were derived through factor analytic techniques. On the CBCL Teacher Rating Form, the scales consist of the Anxious and Social Withdrawal subscales loading on the Internalizing factor, the Inattentive, Nervous-Overactive, and Aggressive subscales loading on the Externalizing factor, and the Unpopular, Self-Destructive, and Obsessive Compulsive subscales considered to be non-specific mixed subscales. For the Parent Rating Form, the Schizoid-Anxious, Depressed, Uncommunicative, Obsessive-Compulsive, and Somatic Complaints subscales load on the Internalizing factor; the Hyperactive, Aggressive, and Delinquent subscales load on the Externalizing factor; and Withdrawal subscale not loading significantly on either broad-band factor.

Data Collection

Each subject record was evaluated to determine if it met the conditions for inclusion on the demographic, cognitive, and academic measures. The descriptive data entered for each subject was the case identification number assigned, and attribute data including chronological age, grade, sex, handedness, and illness history. The Full Scale, Verbal, and Performance IQ's, as well as the subtest scores were entered for the WISC-R. The mother and teacher CBCL raw subtest scores were entered, as T-Scores derived on the instrument have a lower end cutoff of 55. It should be noted that since this procedure causes a negative skew in the data set, raw scores were used for the regression analysis.

Statistical Procedures

The statistical program used to test the cognitive model was LISREL VII. This program allows for a priori determination of underlying latent factors that can be used to predict observable and measurable variables, such as the subtest scores on the WISC-R. The LISREL VII solution provides coefficients that indicate the extent to which a given observed variable is explained by a hypothetical latent variable. Due to the standardized nature of the WISC-R subtests (mean = 10, standard deviation = three), the unweighted least squares solution was utilized. The unweighted least squares solution provides for a hierarchical decomposition of the covariance matrix of WISC-R subtest scores and minimizes the squared deviations between the predicted values and observed values (Kim & Mueller, 1978). If the hypothesized model represents the data observed, the difference between the observed and estimated covariance matrices is relatively small, indicating an adequate fit.

LISREL VII provides a number of statistics that document how well the observed variables represent the latent variables (Joreskog & Sorbom, 1988). Coefficients of determination are provided for observed and latent variables in second order analysis. A second order analysis is undertaken when it is assumed that shared variance among first order factors can be explained by fewer underlying constructs. The coefficient of determination indicates how well the hypothesized latent constructs jointly predict performance on the observed measures and how well the second order factors jointly predict the first order factors in a nonrecursive structural equation. The amount of variance for each observed and latent variable is estimated and provided by squared multiple correlation estimates. Chi-square statistics test the null hypothesis that the a priori model accurately represents the reproduced covariance matrix. If the hypothesized model is found to be substantially different than the actual data set, the chi-square will be relatively large, and as a result will be significantly different from zero. Conversely, if the model fits the data set well, and there is little difference between the observed and hypothesized values, the chi-square will be relatively small, indicating a confirmation of the model presented. However, it should be noted that the chi-square analysis is sensitive to sample sizes, and small differences between the observed data and hypothesized model would result in significant chi-square values.

Joreskog and Sorbom (1988) recommend analysis of the goodness of fit (GFI), adjusted goodness of fit (AGFI), and root mean square residual (RMR) indices as they are less sensitive to the size of the sample. The difference between GFI and AGFI is that the latter is corrected for the degrees of freedom (using mean squares instead of sums of squares in the equation) with both indices ranging from 0 to 1, with 1 indicating a perfect fit. Although opinions vary as to what constitutes a "good" fit, general consensus indicates a AGFI of .90 or better is indicative of an adequate fit of the data set (Bentler & Bonnett, 1980). The RMR is an estimate of the average of the fitted residuals (i.e. error in the goodness of fit). Standardized residuals are provided with positive residuals indicating that the model has underestimated a relationship between two estimated parameters and negative values indicative of an overestimation. In the latter case, the error matrix fails to become what is termed positive definite, and the model is not identified. In these cases, and in cases where the covariance matrices are not positive definite, modification indices are provided that indicate the change in values for chi-square if fixed or constrained parameters are relaxed. Finally, it should be noted that LISREL VII provides T-values of parameter estimates and completely standardized solutions of correlation coefficients for all parameters.

Due to the exploratory nature of the cognitive model and the restructuring of cognitive constructs, stepwise multiple regression techniques were undertaken to examine the relationship between the factors and the CBCL, utilizing the SPSSX 4.1 statistical program. The program provides for removal of variables that fail to meet the probability level of less than .10, recalculating the equation after each variable it removes. After all nonsignificant variables are removed, the program examines those removed variables to determine if any have a probability level of .05 or less and then enters them in the equation, recalculating at each step. This removal and re-entry of variables continues until no more variables meet the criteria for removal or re-entry. The statistics provided include the change in the squared multiple correlation coefficients for a variable's contribution to the equation, standardized regression coefficients and their standard error, partial correlation coefficients, and the associated F tests for significance.

Data Analysis and Model Revision

To address the two research questions, a number of data analysis procedures and alterations of the original model based on theoretical and practical considerations were required. The model presented in Table 1, based on the works of Luria (1973) and Goldberg and Costa (1981), was not considered to be orthogonal, as it is well known that performance on any given subtest of the WISC-R requires several of these interdependent constructs. As expected, the multicollinearity of the data set required a reduction in the number of constructs presented and a priori factor loadings for LISREL VII to estimate the model. When using structural modelling with LISREL VII, these initial factor loadings are often derived from previous research. However, previous empirical studies on the WISC-R had not explored a comprehensive neuropsychological model of the mental abilities required to perform the different subtests and their interrelationship.

To test a model of such complexity, it was necessary to provide LISREL VII with a number of starting values and use a nonrecursive, second order factor analysis when testing for the establishment of the underlying theoretical constructs. It was decided that due to the nature of the scaled scores derived from the test and the many abilities required to perform each of the subtests, that several of the factors could not be distinguished on the basis of these scores. The constructs were first collapsed according to the Processing factors and Higher Order factors, with the former thought to represent Receptive, Expressive, Sensory-Motor, Memory and partially the Cortical Tone factors in Table 1, and the latter representing the Cortical Tone, Crystallized and Fluid Concept Formation factors. Collapsing across expressive and receptive domains, the final model yielded factors that were modality specific. This final model adheres to the separation of abilities posited by Goldberg and Costa (1981). The new factors, Crystallized Primary and Fluid Primary are considered to have the least amount of shared variance of the Processing factors.

At the next level is the identification of the Secondary zones that are less modality specific in nature and have higher levels of cross-modal and sensory-motor integration requirements. These first dichotomies roughly adhere to Luria's primary and secondary levels of the second functional unit, the unit for obtaining, processing, and storing information. These were separated based on crystallized or fluid abilities, to yield Crystallized Secondary and Fluid Secondary Factors.

Finally, a more tertiary level variable was created called Cognition, that was considered to be highly dependent on cortical tone, short and long term memory. Non-modality specific, processing at this level most likely meets the criteria for Luria's third functional unit and the tertiary zones of overlapping. The unit for programming, regulating, and verifying mental activity is considered to be interdependent with cortical tone (Luria, 1973) and the

Cognition and Cortical Tone factors in the model are proposed to be similar to each other, with the latter influencing the entire system.

The starting values for the WISC-R subtests on these factors were based on the exploratory factor analysis conducted by Kaufman (1975), who found a three factor solution for the WISC-R standardization sample across the age groups coinciding with the sample of the study. Kaufman felt that the orthogonal maximum likelihood solution best represented the data set and presented his three factor solution consisting of Verbal Comprehension, Perceptual Organization, and Freedom from Distractibility. However, an examination of the loadings across age levels did indicate a good amount of variability in factor loadings, with several WISC-R subtests loading on other factors indicating factorial complexity. Based on Kaufman's analysis and collapsing across age levels 7 1/2 to 10 1/2, the final model consisted of constructs based on large (.50 or greater) and medium (.30 to .49) factor loadings, with small factor loadings discarded from the model.

Large loadings on the Verbal Comprehension and Perceptual Organization factors comprised the modality specific Crystallized (Information, Similarities, Vocabulary, Comprehension) and Fluid (Picture Completion, Block Design, Object Assembly) Primary factor loadings. Medium loadings on the Verbal Comprehension and Perceptual Organization factors comprised the less modality specific Crystallized (Arithmetic, Picture Completion, Picture Arrangement) and Fluid (Picture Arrangement, Similarities, Comprehension) Secondary factors. Finally, the medium FFD factor loadings (Information, Similarities, Vocabulary, Block Design) comprised the Cognition factor and the "true" FFD subtests (Arithmetic, Digit Span, Coding) were estimated by the LISREL VII program to verify the assumption of the Cognition factor posited earlier. Finally second order factors consisting of loadings hypothesized to represent the different impact that each Higher Order factor would have on the Processing factors were initially put forth. However, theoretically it became important (and advantageous statistically) to examine the unique contribution each factor could have in allotting different amounts of variance to the Processing factors.

The various assessment of fit indices described earlier were assessed and alterations in the model were explored. The final model is best described as a Conditional Distribution model in which few parameters were free to be estimated by LISREL VII (Joreskog & Sorbom, 1988). This was necessary to explore the relationship between the observed variables and their loadings on the highly interdependent underlying cognitive constructs. Finally, the model was examined by entering the mean covariance matrix for Wechsler's original standardization sample for ages 7 1/2 through 10 1/2 and then each age level separately to validate the findings for the sample.

Although the model was heavily constrained as few parameters were estimated, it was predicted that following several analysis of different models that the model based on Kaufman's maximum likelihood exploratory loadings would be found to accurately represent the data within the context of the overall theoretical paradigm and provide an initial assessment of a neuropsychological model for further research.

Once stability of the model was established, the factors were saved and regressed with the CBCL broad and narrow band factors, as originally conceived. Due to the low number of girls in the sample, it was not acceptable to regress the girls' CBCL factors on the cognitive factors. Therefore, only the boys' CBCL narrow and broad band factors for the parent and teacher versions of the CBCL was subjected to multiple regression analysis. Due to the multicollinearity of the factors the stepwise procedures were done in a hierarchical manner, in that the CBCL narrow band factors were first analyzed for their relationship to the cognitive factors, followed by the CBCL broad band Internalizing and Externalizing factors.

CHAPTER IV

Results

The Cognitive Model

Sample Characteristics

As described in the previous chapter subjects had to meet several criteria for intellectual and achievement measures to be included in the study. First they had to demonstrate an average overall potential as measured by the WISC-R. They were then screened for the determination of a significant difference between either scale scores or specific subtests. Once these criteria were met, subject records were examined to determine if they had at least one significant weakness in academic functioning as measured by the WJPTB-R, WRMT-R, Key Math -R, TOWL-R, TOWL-R, VMI-R or PPVT-R. The means and standard deviations for these measures are presented in Table 2. The significant weakness in academic functioning demonstrated by the subjects was related to their overall potential rather than the mean for the population. The mean for the population for standard scores is 100, with a standard deviation of 15. For the scaled scores the mean is 10 with a standard deviation of three.

The necessarily large number of different academic

Table 2

Sample Descriptive Statistics for WISC-R and Achievement Measures

Measure	*N*	Standard Scores[a]			Subtest Scores[b]					
WISC-R	88									
		FSIQ	VIQ	PIQ						
M		103.1	104.3	101.4						
SD		11.3	13.0	12.2						
					I	S	A	V	C	DS
M					10.3	11.9	9.6	11.2	10.7	9.2
SD					2.5	3.0	2.8	2.9	2.6	2.7
					PC	PA	BD	OA	CD	
M					10.9	11.1	10.2	9.9	9.2	
SD					2.4	2.6	3.2	2.7	3.0	

Note. Table continues.

Table 2 continued.

Measure	n	Standard Scores[a]			Subtest Scores[b]
WJPTB-R	24				
		Read	Math	Written	
M		101.8	99.0	88.7	
SD		19.1	18.1	21.9	
WRMT-R	54				
		Readi	Basic	Comprehend	
M		93.5	90.6	90.1	
SD		13.8	13.8	15.0	
Key Math-R	63				
		Total	Concept	Operation	
M		94.6	96.2	94.3	
SD		14.8	14.8	16.7	

Note. Table continues.

Table 2 continued.

Measure	n	Standard Scores[a]			Subtest Scores[b]			
TOWS-R	41							
		Predictable	Unpredictable	Total				
M		89.2	87.3	88.2				
SD		13.3	13.5	13.4				
TOWL-R	42							
					Theme	Content	Syntax	Spell
M					9.7	8.0	7.3	6.5
SD					3.8	3.3	2.9	3.2
VMI	64							
M		84.0						
SD		21.8						

Note. Table continues

Table 2 continued.

Measure	n	Standard Scores[a]	Subtest Scores[b]
PPVT-R	51		
M		99.6	
SD		15.8	

Note. VIQ = Verbal Intelligence; PIQ = Performance Intelligence; I = Information; S = Similarities; A = Arithmetic; V = Vocabulary; C = Comprehension; DS = Digit Span; PC = Picture Completion; PA = Picture Arrangement; BD = Block Design; OA = Object Assembly; CD = Coding; WJPTB-R = Woodcock Johnson Psychoeducational Test Battery; Read = Reading Composite; Math = Mathematics Composite; Write = Writing Composite; WRMT-R = Woodcock Reading Mastery Test; Readi = Readiness; Basic = Basic Skills; Comprehend = Comprehension; Concept = Basic Concepts; TOWS-R = Test of Written Spelling; TOWL-R = Test of Written Language; Theme = Thematic; VMI = Developmental Test of Visual Motor Integration; PPVT-R = Peabody Picture Vocabulary Test. [a]M = 100, SD = 15. [b]M = 10, SD = 3.

measures reported was the result of the assessment procedures of the assessment clinic from which the data were gathered. Since the clinic tailors their protocol based on specific referral questions, a standard battery is not typically administered. In addition, if a child had been tested on certain measures at another location prior to the assessment, they were not administered the same instrument again to guard against practice effects. This condition held true for intellectual assessments as well. However, a child who was not assessed on the WISC-R was not included in this study. Although a number of different neuropsychological instruments are typically administered to subjects, the clinic does utilize the Halstead Reitan or Reitan Indiana Neuropsychological Test Batteries for most cases.

An examination of the descriptive statistics for the sample reveals that the intellectual and academic measures are similar to the normative sample for most measures. As average intelligence was required of all subjects, the means and variances for the WISC-R scaled and subtest scores appear to be appropriate (i.e., several of the subjects would be above average on some measures while low on others). There are notable exceptions to the standardization sample, with the Similarities and Vocabulary subtests means slightly above average and the FFD subtests (Arithmetic, Digit Span, and Coding) slightly below average.

These findings are not surprising considering the characteristics of the sample. For Similarities and Vocabulary, tests of Verbal Comprehension or Crystallized Primary Ability, the high scores could be reflective of the educational and experiential opportunities offered to these individuals. Recall that the sample consists of individuals referred for neuropsychological testing in a suburban hospital affiliated clinic. As the abilities measured by these subtests are reflective of educational experiences in enriched environments, it would be predicted that they are less susceptible to neuropsychological disorders over time. The opposite is likely for the FFD subtests, as these tests are more sensitive to the impact of attentional and processing disorders. In addition, Attention Deficit Disorder is one of the common referral questions for neuropsychological testing.

The sample is similar to the standardization population on most of the achievement measures with several notable exceptions. As a whole the sample had slightly below average performance on Woodcock Reading Mastery Test - Revised subscales. This is not atypical considering that reading problems are the most common problems exhibited by learning disordered populations, with estimates indicating that as many as 85 - 90% of classified learning disabled students exhibit reading problems (Kaluger & Kolson, 1978). Reading is a complex task and proficient readers must utilize several cognitive skills to process words fluently, attend to syntactic and semantic structures, and comprehend material at both the factual and inferential levels. As successful writing requires these skills with the additional criteria of self expression and graphomotor reproduction, it is not surprising to find such low means on the written expression measures. Researchers have found that one of the highest relationships found in academic skill areas is the relationship between reading and writing. (Hammill and McNutt, 1981). As is true in the above areas, spelling requires many cognitive processes, and the low overall scores on the Test of Written Spelling - Revised reveals that difficulties in this area may impact the reading and writing achievement of the sample in this project. A final area of extreme difficulty for the sample appears to be visual-motor integration using graphomotor skills, as indicated by the below average performance on the Developmental Test of Visual Motor Integration.

Structural Model of Latent Factors

To correctly utilize the LISREL VII statistical package, an analysis of the covariance matrix of the data set is required. This required the use of the PRELIS procedure to convert the correlation matrix for the sample into a covariance matrix. The two-tailed zero order correlation matrix reported in Table 3 did show the typical verbal-performance dichotomies for most variables, with

Table 3

Sample Zero Order Correlations for WISC-R Subtests

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Information	__										
2. Similarities	37	--									
3. Arithmetic	57	52	--								
4. Vocabulary	56	48	43	--							
5. Comprehension	53	39	34	63	--						
6. Digit Span	43	32	49	26	26	--					
7. Picture Completion	17	30	24	07	20	14	--				
8. Picture Arrangement	17	13	19	24	18	03	22	--			
9. Block Design	28	40	50	26	13	18	41	23	--		
10. Object Assembly	03	19	18	01	-06	04	38	31	60	--	
11. Coding	-01	01	18	-01	09	17	15	19	09	18	--

Note. Decimal points omitted. Correlations more than .21 significant at $p < .05$.

Verbal subtests significantly related to each other (.26 to.63) and Performance subtests significantly related to each other (.22 to .60), with the exception of Coding, which failed to significantly correlate with any other measure (-.01 to .19). Unlike the Wechsler standardization sample, several of the correlations were nonsignificant and some were even negative. Although nonsignificant, the negative correlations between Object Assembly and Comprehension, as well as between Coding and Information/Vocabulary could be considered as departures from the normative samples reported by Wechsler (1974). The mean Wechsler correlation matrix reported in Table 4 was obtained by calculating the average correlations for ages 7 1/2, 8 1/2, 9 1/2, and 10 1/2, each having a stratified random sample of 100 boys and 100 girls. In contrast to the correlations found for the sample, all of the two-tailed zero order correlations were significant for the mean Wechsler data. The correlations did show that several of the Verbal subtests were highly correlated with the Performance subtests, however, Wechsler did not report the correlations for Verbal subtests on the Performance Scale IQ and vice versa. Unfortunately, Wechsler did not report the correlations for Digit Span and Mazes for the deviation scores as well.

A comparison of the zero order sample and mean Wechsler correlations for subtests and deviation scores can be found in Table 5. There appears to be little difference between

Table 4

Mean Wechsler Zero Order Correlations for WISC-R Subtests

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Information	--										
2. Similarities	60	--									
3. Arithmetic	53	43	--								
4. Vocabulary	63	66	49	--							
5. Comprehension	52	56	40	63	--						
6. Digit Span	34	34	41	30	23	--					
7. Picture Completion	36	41	30	41	39	21	--				
8. Picture Arrangement	41	43	30	45	42	20	37	--			
9. Block Design	46	51	42	46	42	31	47	45	--		
10. Object Assembly	42	45	31	41	39	23	48	47	61	--	
11. Coding	27	27	32	30	23	29	19	28	30	23	--

Note. Decimal points omitted. All correlations are significant at $p < .05$.

Table 5

Comparison of Sample and Wechsler Correlations with VIQ, PIQ, and FSIQ

	Sample			Mean Wechsler[a]		
Variable	VIQ	PIQ	FSIQ	VIQ	PIQ	FSIQ
Information	77	19	62	82		75
Similarities	75	33	68	82		78
Arithmetic	74	41	71	70		65
Vocabulary	80	17	64	86		79
Comprehension	74	14	57	78		71
Digit Span	46	18	40			
Picture Completion	27	63	53		70	63
Picture Arrangement	22	59	48		73	66
Block Design	41	72	68		80	74
Object Assembly	07	75	47		78	69
Coding	07	52	34		56	50

Note. Decimal points omitted. Correlations more than .21 are significant ($p < .05$). [a]Cross scale and Digit Span correlations are not reported in the WISC-R technical manual.

the sample and mean Wechsler correlations; although the

Sample correlations were lower for every subtest except for Arithmetic. The lower correlations for the sample are not surprising considering the number of subjects comprising the sample (88) and the mean Wechsler (800 divided by four) correlations.

As noted in the Chapter III, the revised model had a number of parameters that were determined a priori based on the maximum likelihood factor analysis of the WISC-R standardization sample (Kaufman, 1975). The mean loadings for ages 7 1/2 to 10 1/2 are probably overestimates due to the summation and division of the loadings found in exploratory factor analysis. This method can result in an overestimation of the amount of variance each variable contributes to a given factor, and similarly underestimating error variance. This was certainly the case with Similarities, where mean loadings on three factors yielded a total of 1.266 factor loadings. These loadings were reduced to equal a total of one in an equal ratio derived from the Kaufman data.

The factor loadings were utilized to determine the composition of the five Processing factors (Eta) based on whether they were considered to be large (greater than .50) or medium (.30 to .49) loadings, with small loadings (less than .30) discarded. Discarding the smaller loadings reduced the factorial complexity of the model and reduced the number of subtests comprising each factor. Listed in

Table 6 (Lambda Y matrix), the reduced number of loadings yielded the factors used for the LISREL VII analysis. Although leaving several lower loadings out of the model reduced the analysis to a manageable and interpretable level, it also reduced the factorial complexity originally postulated by the model in Table 1. An inspection of Table 6 indicates that the WISC-R subtests are the recipients of the loadings. This is typical of the LISREL VII structural equation estimates described earlier. In an attempt to fit the model to the data set, LISREL VII compares the difference between the observed data and hypothesized model. The values obtained yield information regarding how well the latent factors predict performance on observed measures (Joreskog & Sorbom, 1988).

In a second order factor analysis such as one proposed by the model, the LISREL VII program also requires starting values for the second order latent factors. As there is no particular starting value required of the program (i.e., .1 to 10), this again must be based on prior research or theoretical assumptions. It was hypothesized that each of the Higher Order factors would contribute different amounts of variance to each of the Processing factors based on Luria's model (1973).

As noted earlier, the first functional unit, the one responsible for programming, regulating, and verifying mental activity, is considered to be superposed over the

Table 6

Lisrel Parameter Starting Values for Wechsler Subtests and Processing Factors

	Lambda Y				
Recipient of Loading	Eta Factors				
	CryPri	Crysec	FluPri	FluSec	Cognit
Information	.59				.40
Similarities	.50			.25	.25
Arithmetic		.35			.00
Vocabulary	.71				.31
Comprehension	.62			.30	
Digit Span					.00
Picture Completion		.30	.55		
Picture Arrangement		.37		.48	
Block Design			.63		.33
Object Assembly			.65		
Coding					.00

Note. CryPri = Crystallized Primary; CrySec = Crystallized Secondary; FluPri = Fluid Primary; FluSec = Fluid Secondary; Cognit = Cognition.

entire brain (Luria, 1973). In his examination of frontal lobe patients, Luria describes how several of his patients could perform tasks that were well known or routinized, while failing on tasks that required immediate problem solving skills. He does note that the regulatory function of speech is deficient in these patients, but goes on to add, "...it is only the higher forms of organization of conscious activity that significantly disturbed, and the more elementary levels of their activity remain undisturbed." (Luria, 1973, page 198). In his discussion of memory and frontal lobe functioning Luria (1973) reported that many of the frontal lobe patients maintained memories of established stereotypes or knowledge, but were impaired in their ability to use strategies for retrieval and maintain consistent attention for active retrieval of information.

The notions put forth by Luria in his theory formed the basis of the starting values for the second order factors. Each of the Processing factors received an equal amount of variance from the Higher Order factors, however, the relative contribution of each varied. As presented in Table 6, the Cortical Tone factor contributed all of the variance to the Cognition Processing factor, half to each of the secondary factors, and a quarter to the primary factors. The Crystallized and Fluid Concept Formation factors contributed the remaining variance to the primary and secondary processing factors. Although it seems more

Table 7

Lisrel Parameter Starting Values for Processing Factors and Higher Second Order Factors

	Gamma		
Recipient of Loading	Ksi Factors		
	CrystCF	FluidCF	CorTone
CryPri	.75		.25
CrySec	.50		.50
FluPri		.75	.25
FluSec		.50	.50
Cognit			1.00

Note. CryPri = Crystallized Primary; CrySec = Crystallized Secondary; FluPri = Fluid Primary; FluSec = Fluid Secondary; Cognit = Cognition; CrystCF = Crystallized Concept Formation; FluidCF = Fluid Concept Formation; CorTone = Cortical Tone.

appropriate that the Cortical Tone factor would influence the Fluid Processing factors, as they are said to tap novel problem solving ability, the option was not evoked in an attempt to keep the model as parsimonious as possible. In addition, the completely standardized solution provided by

LISREL VII reporting the correlations between the factors would indicate if there was indeed a greater influence of the Cortical Tone factor in predicting Primary Fluid Ability.

The LISREL VII program estimated parameters for the FFD variables, Eta, and Ksi latent factors and provided a number of goodness of fit indices. Initial analysis revealed that a large number of the standardized residuals were autocorrelated although not significantly, indicating either the existence of another underlying construct not accounted for by the model or the more probable assumption that the parameters of the model were overestimated and that reduction in the initial starting values would reduce the negative correlations. The latter hypothesis seemed more likely due to results of several of the goodness of fit indices. All models explored throughout the analysis indicated goodness of fit indices within the acceptable values and all chi-square statistics were non-negative. An examination of the standardized residual Q-plot, which visually displays the data against a 45 degree angle revealed a slope greater than one, which is indicative of an excellent fit of the data (Joreskog & Sorbom, 1988). In addition, no modification indices were provided for the observed or latent variables, indicating that the model was within acceptable limits. The final model presented in Figure 1 was a Conditional Distribution model in which most

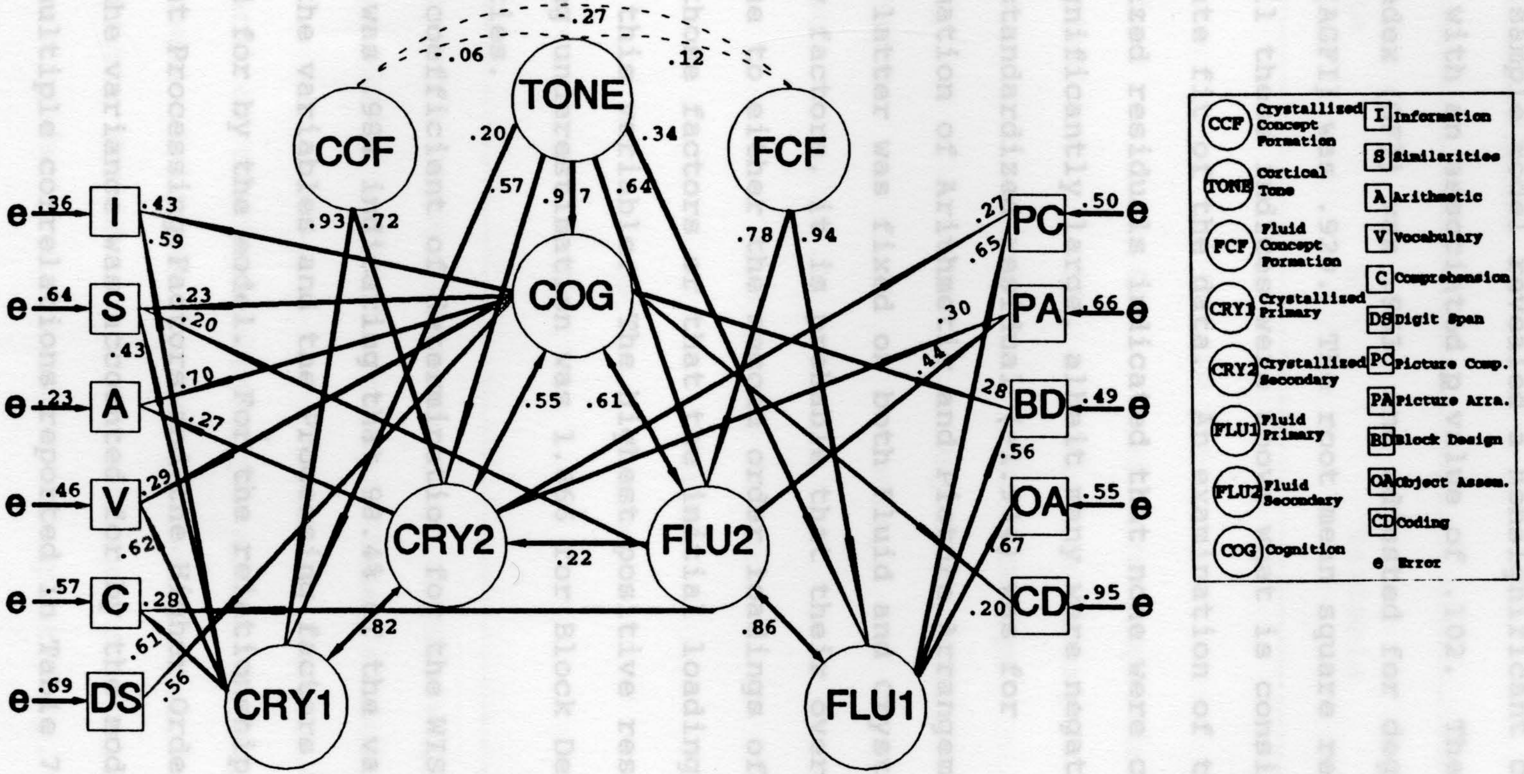

Figure 1. Lisrel Completely Standardized Solution for Sample WISC-R Subtests and Latent Factors

parameters were fixed and the relationship of the hypothesized loadings to the actual data was analyzed.

The sample model revealed a nonsignificant chi-square of 58.50 with an associated p value of .102. The goodness of fit index (GFI) was .951, and adjusted for degrees of freedom (AGFI) was .929. The root mean square residual was .698. All these indices were above what is considered to be an adequate fit of the data. An examination of the standardized residuals indicated that none were considered to be significantly large, albeit many were negative. The highest standardized residual (-1.944) was for overestimation of Arithmetic and Picture Arrangement. Being that the latter was fixed on both Fluid and Crystallized Secondary factors, it is probable that their overestimation may be due to either the second order loadings of Cortical Tone on those factors or that the initial loadings were too high for this variable. The highest positive residual, indicating underestimation was 1.666 for Block Design and Similarities.

The coefficient of determination for the WISC-R subtests was .984 indicating that 98.4% of the variance between the variables and the Processing factors was accounted for by the model. For the relationship between the latent Processing Factors and the Higher Order factors, 100% of the variance was accounted for by the model. The squared multiple correlations reported in Table 7 revealed

Table 8

Sample Squared Multiple Correlations for WISC-R Subtests and Structural Equations

Variable	R^2	Variable	R^2
		WISC-R Subtests	
Information	.64	Picture Completion	.50
Similarities	.36	Picture Arrangement	.34
Arithmetic	.77	Block Design	.50
Vocabulary	.50	Object Assembly	.45
Comprehension	.43	Coding	.04
Digit Span	.31		
		Processing Factors	
CryPri	.92	FluPri	.94
CrySec	.89	FluSec	.89
Cognition	.93		

Note. CryPri = Crystallized Primary; CrySec = Crystallized Secondary; FluPri = Fluid Primary; FluSec = Fluid Secondary.

that several of the variables serve as better measures of the hypothesized latent constructs than others. Information and Arithmetic shared the highest amount of variance with the Processing factors 64% and 77% respectively. All other

WISC-R subtests were modest estimations of the structural equations, except for Coding which appears to share relatively no variance with the identified model. Although low variance estimates may be indicative of a poor fit of the data to a hypothesized model, it is more likely considering the other results that the fixed status limited their predictive validity. The Processing factors were readily identified by the Higher Order factors, with estimates of variance in the upper 80's to low 90's.

An examination of t values revealed that two of the FFD variables significantly loaded on the cognition factor, with values of 3.38 for Arithmetic, 2.85 for Digit Span, and a nonsignificant t value 1.42 for Coding. The Higher Order Factors were significant with Crystallized Concept Formation yielding a t value of 3.10, Fluid Concept Formation yielding a t value of 3.85, and Cortical Tone yielding a t value of 1.81, which approached significance. None of the intercorrelations obtained for the latent factors were significant, adding to the notion of the multicollinearity of the data presented. The theta epsilon error terms were also significant for all variables other than Arithmetic.

An examination of the standardized solution presented in Figure 1 revealed that the model did appear to adequately represent the data set and the hypothesized constructs. For the Processing factors, the Vocabulary and Comprehension subtests were the best measures of Crystallized Primary, which shared a large amount of variance with the Crystallized Secondary factor with each of the WISC-R subtests contributing a relatively equal, albeit low, amount to this factor. The Fluid Primary and Fluid Secondary factors were also highly intercorrelated, with the same type of pattern of high correlations for the Primary and lower correlations for the Fluid Secondary factor for the Verbal subtests and a moderate correlation for Picture Arrangement. Since each of the Secondary factors appear to be related to the hypothesized structure of the model, yet not related to one another, an interesting challenge to the notion of a combined Verbal Comprehension/Perceptual Organization construct can be raised. This finding will be discussed further in the next chapter.

For the Higher Order factors, the relationships appear to adequately represent the initial factor loadings presented. Based on the theoretical assumptions of Luria (1973), Cortical Tone and Cognition seem to be highly interrelated and non-modality specific, accounting for variability on both verbal and nonverbal tasks. Both of these factors appear to influence Secondary more than Primary factors; although those Primary and Secondary Fluid abilities are impacted the most. This fits well with the theoretical assumption that processing of novel information requires a higher level of attention, concentration, and vigilance to perform these types of tasks. An interesting relationship evolved between the three Higher Order constructs in that both Fluid Concept Formation and Cortical Tone were negatively related to Crystallized Concept Formation, although the relationship was not strong. This is not surprising considering that the sample was a heterogenous population of children referred for neuropsychological testing due to learning and behavior problems.

Several difficulties with the model occurred when parameters were freed to have LISREL VII estimate the starting and final values. The algorithm of the iterative program attempts to account for more variance by addressing shared variance between interdependent variables and latent factors. Freeing the parameters in the model resulted in several solutions that did not appear to accurately represent the data or the model, with loadings often shifting from one latent factor to another. Despite consistently high goodness of fit indices, many of the models in which the parameters were unconstrained left the meaning of the latent factors not interpretable. However, the contraindication that the fixed Conditional Distribution model best fit the data was the finding that the constraints imposed resulted in the Psi covariance matrix not being positive definite. An exploration of the Psi matrix when all parameters were freed revealed that the difficulty was the result of the Fluid and Crystallized Secondary factors.

These factors were provided with .5 fixed starting values to ensure that they were positive definite throughout the analysis. This will be discussed further in Chapter V.

Despite the contraindications reported above, the Conditional Distribution model did reveal very high indices of fit and was stable for the sample, mean Wechsler, and all age levels. Table 9 compares the chi-square, GFI, AGFI, and RMR indices of fit for each of these populations. One

Table 9

Lisrel Goodness of Fit Indices for Fitted Covariance Matrices for Sample, Mean Wechsler, and Wechsler Age Levels.

Model	N	df	Chi-Square	p	GFI	AGFI	RMSR
Sample	88	46	58.5	.102	.951	.929	.698
MeanWISC-R	200	46	30.6	.961	.990	.985	.427
Age Seven	200	46	74.9	.004	.980	.971	.613
Age Eight	200	46	62.6	.052	.987	.981	.452
Age Nine	200	46	73.9	.006	.988	.983	.526
Age Ten	200	46	59.9	.082	.979	.970	.566

Note. GFI = Goodness of Fit Index; AGFI = Adjusted Goodness of Fit Index; RMSR = Root Mean Square Residual. MeanWISC-R = the Mean Wechsler data ages 7 1/2 to 10 1/2.

will notice the significant chi-square values for ages seven and nine, and other values that approach significance. These findings should not cause alarm. As mentioned earlier the chi-square procedure is sensitive to sample size and for samples of 200 it is surprising that they are not all significant. With such large samples one can expect to find significant chi-square values for most structural equations regardless of how well the data set fits the model. It is more appropriate to examine the other goodness of fit indices, GFI, AGFI, and RMR when sample sizes are large to determine goodness of fit (Joreskog & Sorbom, 1988). All of these indices were found to be within acceptable limits. The best fit of the model occurred at ages eight and nine. It would appear that the relative stability of the model indicates that it does have construct validity and further refinement of the model is in order.

Presented in Figure 2 is the completely standardized solution for the mean Wechsler data, ages 7 1/2 to 10 1/2. Many of the relationships between the mean Wechsler data and the sample data are similar, especially for the latent factors. The differences between the data sets again may be related to sample size, as many of the correlations between factors are much higher for the mean Wechsler data and the subtest errors lower. However, the loadings of the WISC-R subtests do vary in the two samples. One major difference is the relative contribution of the Cognition factor to

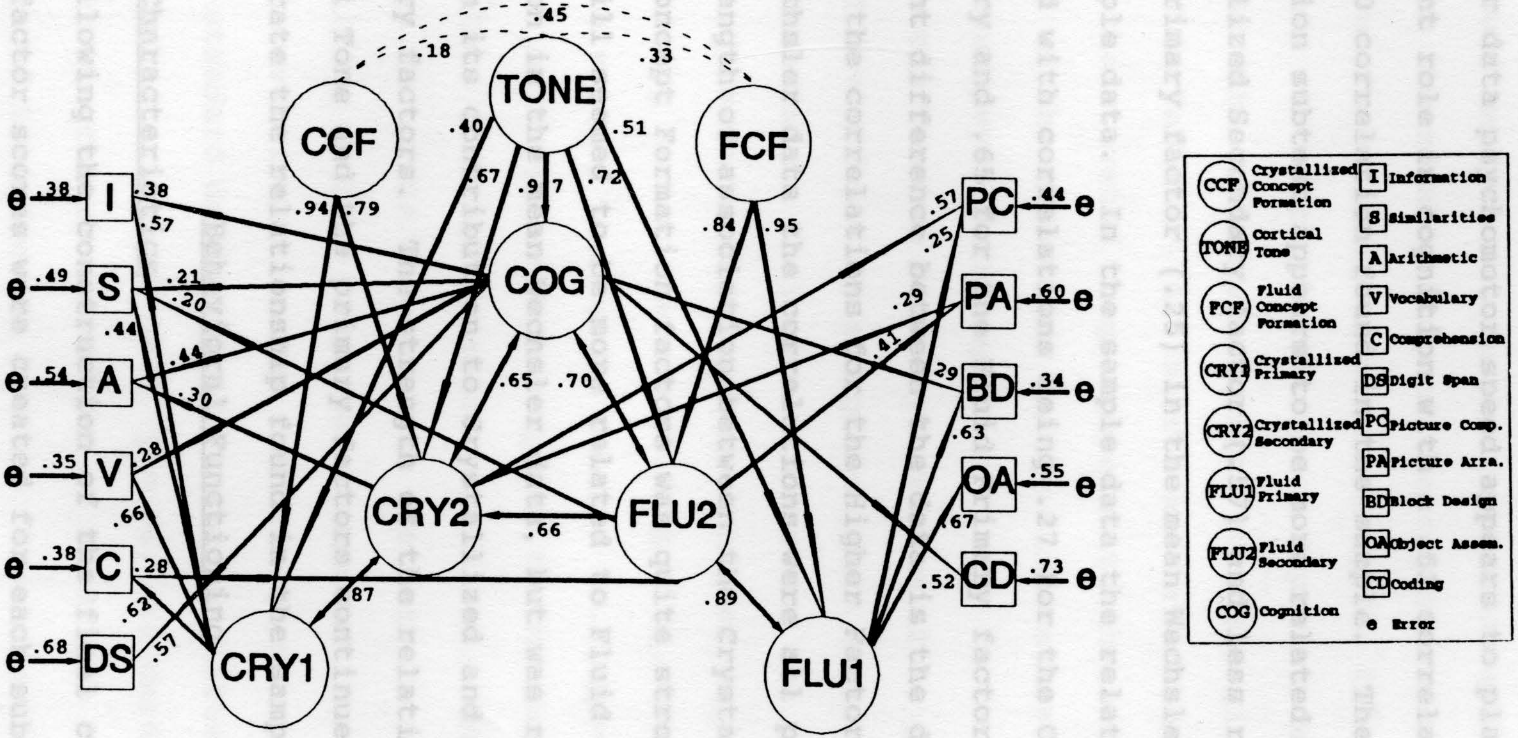

Figure 2. Lisrel Completely Standardized Solution for Mean Wechsler WISC-R Subtests and Latent Factors

Arithmetic. In the sample model the correlation was .70 compared to .44 for the mean Wechsler data. In the mean Wechsler data psychomotor speed appears to play a more important role in cognition with a .52 correlation compared to a .20 correlation found in the sample. The Picture Completion subtest appears to be more related to the Crystallized Secondary factor (.57) and less related to the Fluid Primary factor (.25) in the mean Wechsler data than in the sample data. In the sample data the relationship was reversed with correlations being .27 for the Crystallized Secondary and .65 for the Fluid Primary factors. Another important difference between the data is the difference between the correlations for the Higher Factors. In the mean Wechsler data the correlations were all positive, and the strength of association between the Crystallized and Fluid Concept Formation factors was quite strong. Cortical Tone still seemed to be more related to Fluid Concept Formation in the mean Wechsler data, but was relatively equal in its contribution to Crystallized and Fluid Secondary factors. The strength of the relationship between Cortical Tone and the primary factors continued to demonstrate the relationship found in the sample.

Behavioral Functioning

Sample Characteristics

Following the construction of the final cognitive model, factor scores were created for each subject in the sample for each latent construct. From the initial conception of the project it was hoped that both boys and girls could be included in the regression analysis to determine the relationship of the cognitive constructs to behavioral functioning as measured by the Child Behavior Checklist. For both the teacher and parent versions of the CBCL, the data collected for both boys and girls are reported in Table 9. All narrow and broad band factor means were in the elevated range compared to the normative sample, yet none of the means were in the clinical range indicating significant psychopathology.

For the Teacher CBCL boys (mean = 12.5, $\underline{t}$ = 64, standard deviation 9.3) and girls (mean = 11.9, $\underline{t}$ = 62, standard deviation 8.4) were similar for the Internalizing broad band factor. Boys were much higher on the externalizing factor (mean = 40.5, $\underline{t}$ = 63, standard deviation = 19.6) than girls (mean = 23.2, $\underline{t}$ = 61, standard deviation = 16.9); however compared to the normative sample, the $\underline{t}$ values indicated similar elevations. For the Parent CBCL boys and girls were similar for both Internalizing and Externalizing Scales. Boys had a mean of 19.3, $\underline{t}$ = 65, standard deviation 12.0, for the former and a mean of 25.7, $\underline{t}$ = 67, standard deviation 12.8, for the latter. Girls similarly had a mean of 19.2, $\underline{t}$ = 66, standard deviation of 10.2, for the former and a mean of 25.9, $\underline{t}$ = 66, standard deviation of 11.4 for the latter. The associated $\underline{t}$ scores

Table 10

Sample Descriptive Statistics for the Teacher and Parent CBCL

	Teacher CBCL					Parent CBCL			
	Boys[a]		Girls[b]			Boys[a]		Girls[b]	
Subscale	M	SD	M	SD	Subscale	M	SD	M	SD
Anxious	7.1	6.6	8.0	5.9	Anxious	3.2	2.9		
Withdrawal	6.7	9.5	4.7	3.9	Depressed	7.9	6.5	10.2	6.1
Depressed			4.5	3.9	UnCommunicat	4.4	2.9		
Popularity	5.6	4.0	1.6	2.4	Somatic C/O	1.7	2.1	4.5	3.1
Obsessive	2.9	3.2			Obsessive	5.3	3.9	1.5	1.9
Self Destruct	4.3	3.1	1.8	3.9	Withdrawal	4.2	3.2	5.6	3.6
Inattentive	19.8	8.5	13.8	8.9	Hyperactive	8.5	4.0	8.9	4.4
Nerv-Overactive	5.1	3.2	3.3	3.9	Aggressive	15.5	9.7	14.6	8.3
Aggressive	20.8	16.4	7.9	9.9	Delinquent	3.6	3.1	1.7	3.6

Note. [a]n = 42; [b]n = 24; [c]n = 61; [d]n = 27.

for the Teacher version ranged from 62 to 67 for boys, and 60 to 64 for girls. Similarly, the associated _t_ scores for the Parent version ranged from 60 to 66 for the boys, and 61 to 68 for the girls. The sample consisted of 61 boys and 27 girls, which unfortunately did not allow for a comparison of both boys and girls separately during the regression analysis, therefore only the Parent and Teacher CBCL scores for boys were utilized for the regression on cognitive factors. None of the Parent CBCL factors were significantly related to the cognitive constructs using the stepwise multiple regression techniques described earlier. However, several of the Teacher CBCL factors were significantly related to the cognitive constructs reported earlier and warrant further study.

Behavioral Correlates of the Model

Table 11 presents the zero order correlations for the CBCL and the latent factor scores established during the development of the cognitive model. An examination of the intercorrelations of the CBCL factors revealed that many were significantly correlated with both Internalizing and Externalizing Broad Band Factors, indicating factorial complexity. The Anxious (.86) and Unpopular (.53) factor did load higher on the Internalizing factor; however, the latter was significantly related to the Externalizing factor as well (.33). The Self Destructive factor was related to the Externalizing factor (.74) more than Internalizing (.25)

Table 11

Zero Order Correlations for Boys Teacher CBCL and Latent Factors

Variable	1	2	3	4	5	6	7	8	9
1. Anxious	--								
2. Unpopular	53	--							
3. Obsessive	26	47	--						
4. Self Destructive	17	24	52	--					
5. Attention	-01	13	16	68	--				
6. Nervous-Overactive	-05	07	17	35	52	--			
7. Aggressive	-07	34	48	54	43	43	--		
8. Internalizing	86	53	51	25	-04	06	04	--	
9. Externalizing	-01	33	43	69	74	61	91	07	--
10. CryPri	-01	04	20	06	10	15	21	08	22
11. CrySec	-32	-06	14	-19	-21	-13	30	-23	11

Note. Table Continues

Table 11 continued.

Variable	1	2	3	4	5	6	7	8	9
12. FluPri	-12	-12	32	-13	-16	-14	04	-02	-07
13. FluSec	-11	-07	33	-14	-15	-20	10	-03	-02
14. Cognit	-05	03	29	-06	-03	-17	19	-02	10
13. CrystCF	-39	-10	-11	-17	-25	04	26	-30	08
14. FluidCF	-11	-14	25	-13	-17	-11	-03	-01	-11
15. CorTone	-06	-03	29	-07	-04	-18	19	-03	09

Note. Decimal points omitted. All correlations more than .22 are significant at $p < .05$. CryPri = Crystallized Primary; CrySec = Crystallized Secondary; FluPri = Fluid Primary; FluSec = Fluid Secondary; Cognit = Cognition; CrystCF = Crystallized Concept Formation; FluidCF = Fluid Concept Formation; CorTone = Cortical Tone.

factor. The Externalizing factors showed the greatest stability, with Attention Problems (.74), Nervous-Overactive(.61), and Hyperactivity (.91) loading quite high on that broad band factor.

In contrast to the high correlations observed for the narrow band and broad band factors of the CBCL, the relationship between the cognitive variables and the CBCL factors was for the most part low and nonsignificant. When examining this correlation matrix it is important to realize that there is an inverse relationship between these variables for the most part as higher scores on the CBCL are indicative of poorer psychosocial functioning. As was found in some of the studies reported in the literature review, the lower one scores on an intellectual measure the likelihood of significant psychosocial disturbance increases.

Many of the correlations observed in the table are nonsignificant; however further examination of the data does reveal some zero order relationships that are significant and their relationship to the cognitive constructs warrants further analysis using multiple regression techniques. The assumption that some of the cognitive constructs found during the LISREL VII analysis would be significantly related to psychosocial functioning was confirmed by the multiple regression stepwise analysis reported in Table 11.

In the multiple regression stepwise procedure both

Table 12

Stepwise Regression Results of the Relationship between Latent Factors and the Teacher CBCL for Boys

Equation										
Step	Variables	R^2 Chg	SigChg	Std B	SE B	Part r_{xy}	F	Sig$F$	FEq	Sig$F$Eq
1.1	Anxious	.099	.042	-.316	.020	-.316	4.44	.042	4.44	.042
	CrySec									
2.1	Obsessive	.101	.040	.318	.041	.458	4.51	.040	4.51	.040
	FluPri									
2.2	Self Destr	.122	.018	-.410	.047	-.369	6.14	.018	5.61	.007
	Obsessive			.532	.045	.454	10.35	.003		
	FluPri									

Note. Table continues.

Table 12 continued

Equation Step	Variables	R^2 Chg	SigChg	Std B	SE B	Part r_{xy}	F	Sig$F$	FEq	Sig$F$Eq
2.3	Unpopular	.091	.031	-.341	.033	-.342	5.04	.031	5.81	.002
	Self Destr			-.413	.044	-.391	6.87	.013		
	Obsessive			.693	.047	.545	16.05	.000		
	FluPri									
3.1	Obsessive	.107	.034	.327	.045	.327	4.80	.034	4.80	.034
	FluSec									
3.2	Self Destr	.134	.012	-.429	.051	-.388	6.91	.012	6.21	.005
	Obsessive			.552	.049	.475	11.38	.002		
	FluSec									

Note. Table continues.

Table 12 continued

Equation Step	Variables	R^2 Chg	SigChg	Std B	SE B	Part r_{xy}	F	Sig$F$	FEq	Sig$F$Eq
4.1	Anxious CrystCF	.152	.011	-.390	.019	-.389	7.17	.011	7.17	.011

Note. CrySec = Crystallized Secondary; FluPri = Fluid Primary; CrystCF = Crystallized Concept Formation; Self Destr = Self Destructive; R^2 Chg = change in R^2; SigChg = significance of R^2 change; Std B = standardized regression coefficient; SE B = standard error of B; Part r_{xy} = Partial correlation; F = F test for variable entering equation; Sig$F$ = significance of F for variable entering equation; FEq = F test for all variables in equation; Sig$F$Eq = significance of F for total equation.

Processing and Higher Order factors were significantly related to several CBCL factors. Both Crystallized and Fluid abilities were related to CBCL factors; however thecentral processing, non-modality specific abilities of the tertiary Cognition and Cortical Tone factors failed to significantly relate to any of the CBCL factors. Several consistencies were found for both Crystallized and Fluid abilities. The Anxious factor was significantly related to both the Crystallized Secondary and Concept Formation factors. For the Crystallized Secondary factor the negative relationship with the Anxious factor yielded a standardized beta weight of -.316, indicating an inverse relationship between the two variables. Barely significant, and accounting for only about 10% of the variance shared between these factors, the relationship appears to limited. With all other shared variance removed from the model, the unique correlation between these variables was .32, indicating a small, but substantive relationship between these two variables. Crystallized Concept Formation similarly was related to the Anxious factor, contributing an additional 15% of the variance to the entire equation, yielding a -.390 standardized Beta weight, and a -.389 partial correlation. Although not substantive separately, Crystallized Secondary and Crystallized Concept Formation account for approximately 25% of the variance for the Anxious factor score. The inverse relationships were observed in both instances and the standard error of Beta low in each case, thus showing a stable relationship between crystallized abilities and anxiety as measured by the CBCL. This also adds credence to notion that the Crystallized Secondary factor is related to the hypothesized model, despite having two performance subtests loading on it (Picture Completion and Picture Arrangement).

The Fluid Primary factor was related to a number of factors thought by many to be indicative of individuals with internalizing disorders. The Unpopular and Self Destructive CBCL factors were both related to the Fluid Primary factor; however an interesting CBCL factor (the Obsessive factor) emerged prior to these variables and in a direction that would not be obviously predicted. The Obsessive factor accounted for 10% of the shared variance in the overall equation for the Fluid Primary factor and 11% of the shared variance in the Fluid Secondary factor. However, unlike the other variables, in the final equations the Beta weights (.693 and .327 respectively) and partial correlations (.545 and .475 respectively) were significantly related in the opposite of what might be predicted, they were both positive. The positive relationship of these factors is not necessarily surprising however, considering that a higher score on the Fluid factors probably yields greater attention, greater vigilance, and more focussed effort.

For the Fluid Primary factor, the Obsessive factor emerged first, accounting for 9% shared variance. Self-Destructive entered the equation demonstrating the inverse relationship of a -.41 standardized Beta weight and negative partial correlation of -.37 with Fluid Primary. Accounting for 12% of the shared variance, its entry into the equation boosted the Beta weight of Obsessive to .53. The overall equation was strengthened as well, yielding an $\underline{F}$ value of 5.61, $\underline{p} = .007$, compared to when Obsessive was in the equation alone ($\underline{F} = 4.51$, $\underline{p} = .040$). The addition of the Unpopular factor contributed 9% of variance to the equation for a shared total variance between the three variables of 31%, indicating a strong relationship. In the final equation for Fluid Primary Obsessive still yielded the strongest relationship with a standardized Beta of .693, with Self Destructive (-.41) and Unpopular (-.34) contributing a lessor amount. Each step produced increasing significant results for the equation, with the final equation $\underline{F}$ value of 5.81 significant at the $\underline{p} = .002$. Partial correlations were strengthened in each case as well, with partial coefficients revealing that 11% of the variance for the Unpopular factor, 15% of the variance for Self Destructive factor, and 30% of the variance for Obsessive can be accounted for by Fluid Primary functioning. These relationships were similar for Fluid Secondary, with the exception of the Unpopular factor failing to emerge as a significant contributor to the overall equation. The

Obsessive factor emerged first, accounting for approximately 11% of the shared variance with Fluid Secondary. The Beta weights were similar between the first and second analysis, however, the partial correlations showed that Fluid Primary (.49) was more related to the Obsessive factor than was Fluid Secondary (.33) in the initial estimation of the relationships with all other variables controlled for. The addition of the Self Destructive factor to the equation again strengthened the relationship of Obsessive to Fluid Secondary. The final Beta weights were -.429 for the Self Destructive factor and .552 for the Obsessive factor, yielding 15% and 23% respectively shared variance with the Fluid Secondary factor. The final equation yielded an F value of 6.21, $p = .005$, indicating a significant amount of variance was accounted for by the relationship of these three variables, with the Self Destructive factor demonstrating the typical inverse relationship, and the Obsessive factor demonstrating a stronger positive relationship.

CHAPTER V

DISCUSSION

Introduction

The overall purpose of this study was to develop and test a model that addressed the complexities of cognitive functioning required for performance on the WISC-R. Neuropsychological theory was used as a foundation for the model. In addition, it was anticipated that this preliminary model could serve to delineate relationships between cognitive functioning and psychosocial disturbance as measured by the CBCL. Given the complexity of the model it became necessary to provide a less intricate, yet more interpretable, model of cognitive functioning based on previous research findings and neuropsychological theory. A systematic examination of the final model revealed that there were similarities between the model and several theoretical assumptions typically held by diagnostic professionals.

Prior to this investigation, researchers have reported exploratory factor analytic techniques that were used to cluster WISC-R subtest factor loadings along the traditional three factor solution, most often referred to as verbal comprehension, perceptual organization, and freedom from distractibility. An analysis of the factor loadings of each of the WISC-R subtests on these three factors reveals that much more factorial complexity exists than can be accounted for when using traditional factor analytic techniques.

The major difficulty with accounting for additional variance of WISC-R performance is that one must develop additional factors and partition the data in some meaningful way so that each of the factors is relatively unique in its contribution to the entire model. By developing an a priori model based on neuropsychological theory, it is possible to account for the complexities observed in exploratory analysis; however, the multicollinearity of the obtained factors creates some difficulty in interpretation and generalizability to cognitive functioning due to the constraints imposed on the model. This is a necessary compromise as the LISREL VII iterative procedure attempts to create orthogonal factors, not factors that are nested within each other. The alternative exploratory techniques described above minimize factorial complexity, and this preliminary attempt at using structural modelling to develop a model of heuristic value attempts to address these complexities, that otherwise are not subject to empirical investigation.

Recent advances in exploring the relationship between learning disorders and behavior disorders have yielded important findings regarding this important relationship.

Although few researchers have examined cognitive strengths and weaknesses to develop subtypes of learning disorders and relate those subtypes to psychosocial factors, a number of investigators have begun to examine this relationship based on standardized subscale and subtest scores. It is then assumed that combinations of these abilities (or disabilities) yield certain relationships to psychosocial adjustment. Unfortunately, due to the global nature of these scores it is not possible to determine which aspects of cognition are related to psychosocial functioning. This study was designed as a preliminary attempt at distinguishing specific cognitive abilities based on neuropsychological theory so that more specific analysis of the relationship of cognitive abilities and psychosocial functioning could be undertaken in the future.

It should be noted that the overall objective of this study was not to establish a causative link between these factors, only to explore the amount of shared variance each of the factors had with one another. The ultimate objective of future research in this area is to develop, refine, and define this relationship more precisely so that professionals and parents can be aware of the possible psychosocial outcomes associated with specific cognitive strengths and weaknesses. Once this can be accomplished with reasonable certainty, it is possible for those working with children to be more proactive in their intervention techniques, so that children with learning disorders can be monitored for certain coping styles and both learning and behavior can be addressed simultaneously in their efforts.

These objectives must always be tempered by the acknowledgment that individual differences may produce different degrees of psychosocial adjustment and it would detrimental to presuppose that a child's cognitive profile will result in a specific maladjusted behavioral profile. Research (Brophy & Good, 1974) on teacher expectancy effects reveals that children can develop what is termed a self-fulfilling prophecy (i.e., they learn to behave in ways the teacher expects). Therefore, any conclusions drawn from this research must be used to develop a hypothesis of the relationship between cognitive profiles and psychosocial adjustment. The null hypothesis that there is no relationship between a child's cognitive profile and their psychosocial adjustment should be assumed and only with evidence to the contrary should a professional draw upon the knowledge base to develop appropriate interventions. This is essential to guard against a Type I error (i.e., rejecting the null hypothesis because of expectancy effects when it is actually true).

Findings and Conclusions

The Cognitive Model

For the cognitive model, the results reveal that specific types of abilities can be delineated using structural equation modelling based on prior research and neuropsychological theory. These constructs are highly intercorrelated, sharing a large amount of variance with one another, which would be predicted for a model of intellectual functioning. The interrelationships explored during the LISREL VII analysis revealed the relative contribution each hypothesized factor contributes to the observed WISC-R subtest scores, providing an index of how well the model represents the cognitive abilities necessary to perform on these subtests. Factorial complexity was addressed by the model through each subtests loadings on different factors based on prior research. The findings not only appear to adequately fit the neuropsychological clinic sample referred for learning and behavior problems, but also for the standardization samples for the WISC-R, with some variation in the results for each.

The factors in the model were established a priori, by determining the relative degree each subtest loaded on the traditional verbal comprehension, perceptual organization, and freedom from distractibility factors described by Kaufman (1975) and Sattler (1988). Defined broadly as Processing and Higher Order factors, further analysis of what abilities constitutes each of the factors is warranted if they are to have the predictive validity sought in the original model.

The Processing factors consisted of the Crystallized Primary, Fluid Primary, Crystallized Secondary, Fluid Secondary and Cognition factors. An attempt will be made to determine how each of the subtest loadings are related to these factors based on their individual loadings and the shared and unique abilities presented by Kaufman (1979) and Sattler (1988).

The Crystallized Primary factor appears to be a factor that most uniquely describes abilities that are related to a modality specific, verbal fund of information or knowledge gained through experience and education. This factor consists of loadings for Information (.59), Similarities (.43), Vocabulary (.62), and Comprehension (.61). Word knowledge and use for receptive and expressive language would be important to doing well on this factor, as would verbal comprehension and long term memory storage. The long term memory storage for verbal information is different than that of retrieval of verbal information from long term storage, which would appear to be the function of the Cognition factor.

The Crystallized Secondary factor is a factor of abilities that are less modality specific, requiring the assessment of familiar information and sequencing or scanning of verbal information. It consists of loadings for Arithmetic (.27), Picture Completion (.27) and Picture Arrangement (.30). Apparent in this factor is the importance of verbal knowledge of cause and effect and verbal labeling of visual information. Reasoning appears to be another important dimension of this factor, as it is necessary to process several related pieces of information and distinguish essential from nonessential detail. This is apparent in the sequencing of information in Arithmetic and Picture Arrangement or similarly the methodological search for missing information in a visual stimulus necessary to perform well on Picture Completion. The abilities of attention, concentration, and freedom from distractibility would play a role here, as all subtests required sustained vigilance on task to appropriately solve multistep problems. Long term memory for verbal and visual information would be somewhat important as well, for recall of the specific math facts, or a complete visual picture of the object, or the previous social experiences for understanding cause and effect relationships. It is more likely to be influenced by Cortical Tone than Crystallized Primary as working under time constraints is a component of all three subtests for this factor.

The Fluid Primary factor is considered to be modality specific for nonverbal information, requiring cognitive flexibility to solve novel, nonverbal problems. The analog to Crystallized Primary, this factor is represented by Picture Completion (.65), Block Design (.56) and Object Assembly (.67) loadings, and best represents those visual-spatial perceptual abilities typically associated with the perceptual organization factor. Visual-spatial discrimination, analysis, and synthesis are all important skills for this factor, as is holistic processing ability. Psychomotor speed may contribute to this factor; however, Picture Completion does not have this requirement (although speed of visual processing may be of influence here).

The Fluid Secondary factor, consisting of Similarities (.20), Comprehension (.28), and Picture Arrangement (.44) seems to be less modality specific, requiring problem solving abilities for novel verbal and nonverbal information. Not necessarily that the information found in Similarities and Comprehension is novel, it is more the task itself which calls upon some mental flexibility to analyze and synthesize the correct response. Social judgement, anticipation of consequences, and the analysis of cause and effect relationships seem to be important contributing abilities to this factor. Paramount to this factor is the ability to reason, both through logical and abstractive analysis of essential from nonessential details. Expressively, one must reason using these skills and plan their answer to determine the most advantageous response, while discarding irrelevant or interfering responses. It would be predicted that those who are impulsive would have some difficulty with scoring well on this factor, and that their responses would be concrete and minimal, missing the appropriate abstract, categorical, or gestalt response due to their ignoring of subtle clues in the information.

The Cognition factor is considered to be the tertiary Processing variable, having little to do with modality specific types of information and instead provides the processing skills necessary to access those fluid or crystallized abilities found in the other factors. Consisting of loadings from Information (.43), Similarities (.23), Arithmetic (.70), Vocabulary (.29), Digit Span (.56), Block Design (.28), and Coding (.20), Cognition would appear to be a complex, multifaceted factor. A large part of variance in this factor is probably attributable to long term and short term memory retrieval, and for the latter, probably storage. Integrated brain processing and psychomotor speed are relevant here, requiring a certain amount of mental alertness to solve these perceptual reproduction tasks quickly and efficiently. Attention, concentration, and freedom from distractibility are paramount to successful performance on this factor, making the distinction between short term memory and these factors difficult to ascertain. Finally, both verbal and nonverbal conceptualization might impact one's performance on these tasks; however, this variance is probably accounted for by the more modality specific, Higher Order factors.

With respect to the relationship between these factors, the hypothesized model apparently fits the data set well. What is somewhat surprising is that the relationship between the Secondary factors is relatively small (.22). Both Crystallized and Fluid Primary were highly related to their own Secondary factors, (.82 and .86 respectively) while they were less related to the opposing Secondary factors. For instance the relationship between Crystallized Primary and

Fluid Secondary was a -.05, even though the latter consisted of two Verbal Scale and one Performance Scale subtest. Similarly the relationship between Fluid Primary and Crystallized Secondary was only .02. Cognition did demonstrate a higher relationship with the Fluid (.61) and Crystallized (.55) Secondary factors, than it did for the Crystallized (.19) and Fluid (.33) Primary factors.

For the second Higher Order factors, the relationships hypothesized appeared to be consistent with the results of the data. The Crystallized Concept Formation factor was highly related to the Crystallized Primary factor (.93) and to a lessor extent the Crystallized Secondary (.72) factor. Similarly, the Fluid Concept Formation factor was related to the Fluid Primary factor (.94) more than the Fluid Secondary factor (.78). These two Higher Order factors were not highly related as would be predicted and were actually negatively correlated for the sample (-.27). This is not surprising considering that the sample consisted of individuals demonstrating a significant difference between either deviation scale scores or subtest scores. The correlation (.45) between these concept formation factors for the Mean Wechsler standardization group is probably more representative of an average population. Finally, the Cortical Tone factor did indeed influence the Cognition factor the most (.97), the Crystallized (.57) and Fluid (.64) factors moderately, and the Crystallized (.20) and Fluid (.34) factors the least. As was predicted and would be supported by the research described earlier, Cortical Tone had a greater influence on Fluid abilities than Crystallized Abilities.

As was indicated in the preceding chapter, this investigation was an initial attempt at exploring the factorial complexity of the WISC-R by imposing a neuropsychological model of cognitive processing abilities thought to represent brain functioning. Several assumptions were necessary for the model to be tested, and questions regarding those assumptions should be inherent in the analysis of the model's construct validity. Although the analysis of the sample data and Mean Wechsler data yielded similar results, this should not be surprising for the latter considering that the factor loadings were derived from an exploratory maximum likelihood analysis of the actual correlation matrices given in the Wechsler manual. Several of the relationships found in the sample data differed from the Wechsler data, which can be explained by the differences in populations, but also may be due to the inconsistency of the model.

To overcome additional inconsistencies in the model, several restrictions on the various factor loadings and the psi covariance matrix were necessary. These restrictions on the model were extreme, and parameters were often not freed to vary among themselves, leaving primarily a Conditional Distribution model to evaluate. This model had highly intercorrelated and several overestimated parameters, the result of fixing several values based on the exploratory factor analysis of the WISC-R. Several models were explored, and each time several parameters were freed to vary, the results became less clear. During the testing of several of the models, the factors actually lost their meaning (i.e., Crystallized Secondary became more important to Crystallized Concept Formation than Crystallized Primary).

An additional contraindication of the model is the necessary fixing of the psi matrix to become positive definite. An analysis of the freed psi matrix revealed that the Crystallized and Fluid Secondary factors were the cause of the problem. This is not necessarily surprising considering the iterative process of LISREL VII. During this procedure, LISREL VII attempts to find communalities among portions of variance, and then collapses and/or reallocates that variance to similar areas. It is apparent that although these Crystallized and Fluid Secondary factors are related to their respective Primary factors, they also share a good deal of variance with the opposing factors. The restrictions placed on the model hindered this assumption to ensure adequate model consistency.

Despite these contraindications, the model fits the data extremely well. A number of statistics given by LISREL VII were in support of the model. The nonsignificant Chi square values, GFI, AGFI, and RMR were all indicative of an excellent fit of the data. The coefficients of determination for the structural equations and WISC-R subtests indicated that a large portion of total variance was accounted for by the model. The restrictions on the model decreased the amount of variance explained by the factors for each WISC-R subtest, therefore leaving significant error in the equation. This again was necessary for consistency in the model, as freeing parameters increased the squared multiple correlations for the subtests, but decreased the meaning of their loadings. Despite having some negative standardized residuals that indicated the model was overestimated, none of these were significantly different from zero, and there were as many positive standardized residuals as well (indicating underestimation of parameters). Furthermore, another indication that the model was accurate was that LISREL VII failed to give any modification indices for the subtests or factors. Recall that modification indices are given by LISREL VII when freeing a parameter would result in a significant increase in the adequacy of the model.

It is probable that in developing structural equations with factors and variables that are highly intercorrelated such as this, that appropriate measures must be taken to ensure model adequacy. Joreskog and Sorbom (1989) discuss this at length when discussing econometric and longitudinal designs. Due to the multicollinearity of the constructs and the autocorrelation of errors, it is often necessary to restrict parameters and covariances to ensure that one has a testable, meaningful model. When one considers how the brain processes complex information and the number of interrelated abilities that are required to process even the simplest task, it should not be surprising that several of the methods described in this study were necessary to gain a meaningful solution. As with most research in the behavioral sciences, reducing the complexity of the study reduces its heuristic value.

Behavioral Functioning

From the outset of this researvh project, it was hypothesized that by delineating specific cognitive constructs through structural equation modelling that some of the discrepancies found in the literature regarding the comorbidity of learning and behavior disorders could be resolved. This objective was only partially accomplished and further development of the model may yield additional results not demonstrated in this study. In addition, these results since they can be applied only to boys limits their generalizability to the entire population of learning disordered children.

The results of the multiple regression analysis revealed some interesting findings regarding the relationship between specific cognitive abilities and behavioral functioning. Researchers in the past have described what types of behavior patterns are associated with deficient cognitive abilities.

Neuropsychological theory holds that when there is an insult to the brain there is not only a loss of function, but there may be a release of function as well. For instance, ADD(H) is considered to be more a release than a loss of function problem. Research has demonstrated that it is probable that the underactivation of the frontal (probably right basilar region) cortex, that results in undercontrol of subcortical mechanisms, responsible for attention and activity levels (Hynd, et al. 1991). In addition, PET studies have found that lowered glucose metabolism in the premotor and prefrontal cortex are often found in ADD(H) subjects (Zametkin, et al., 1990). Although the breadth of these findings were limited and the issues of loss versus release unexplored, it is possible that several of the findings reflect one or both phenomena.

All but one of the significant correlations for the CBCL factors and cognitive factors were in the relationship typically found in this type of research (i.e., as cognitive abilities increased, psychosocial pathology decreased). The one factor that failed to demonstrate this loss-loss relationship was the Obsessive factor on the CBCL. This analysis revealed that as Fluid Primary abilities increased, so did pathology on the Obsessive factor of the CBCL. One possibility is that the strong Fluid ability LD child needs OCD-like traits to provide the structure and sequencing necessary to cope with the environment. Having imposed structure on their holistic perspective, the OCD child may be able to compensate for the lack of structure by overcompensation, excessively focussing on the details that are inherently melded into a gestalt.

Another way of examining this relationship is to think of obsessiveness as the opposite of impulsiveness. Those who lack attention, are easily distracted, and cannot concentrate are often considered to have ADD, which has been associated in the literature with deficient right hemisphere functioning and probably is related to fluid abilities (Voeller & Heilman, 1988; Schaughency & Rothland, 1991). If too little attention is inappropriate then too much is as well. The Obsessive is often highly focussed in their processing of information, can become fixated on certain aspects of stimuli, and has difficulty changing tasks if they are not completed (or perfect). Just as undercontrol is a problem for ADD individuals, it follows that overcontrol is a problem for those with Obsessive Compulsive Disorder. Possibly both of these are related to deficient and extraordinary levels of right hemisphere functioning respectively; however, one must address the loss versus release of function here.

It is possible that an interaction effect between deficient left hemisphere functioning and sufficient right hemisphere functioning could result in OCD, rather than just a higher level of Fluid abilities as the data would indicate here. As with most brain-behavior relationships, there are data that implicate left and/or right hemisphere deficiencies for OCD. However, Flor-Henry (1990) reports that in a study of the neuropsychological correlates of psychopathology, one subgroup of high IQ psychiatric patients, who scored significantly high on Block Design, and had deficits of verbal fluency and visual retention, were characterized behaviorally as suffering from chronic tension and anxiety, as well as obsessional traits. Several studies have implicated left hemisphere deficiencies when examining psychiatric patients with thought disorders. This appears to be especially true for schizophrenia (Flor-Henry, 1990) and applicable to the Parent CBCL, where the factor Schizoid-Anxious is on the internalizing scale.

The other results for the Fluid Primary and Secondary factors are in the direction anticipated in this type of research. The findings support the contention of Rourke and Fuerst (1991) that both internalizing and externalizing pathologies are more common in learning disordered individuals with presumed right hemisphere deficiencies. Although no relationships were found between the cognitive constructs and the Externalizing factors, the Self Destructive and Unpopular factors were found to be related negatively to both the Fluid Primary and Secondary factors. These CBCL factors consist of characteristics typically associated with internalizing disorders; yet the factor analysis of the CBCL found that they were mixed factors, as they loaded on neither internalizing or externalizing broad band factors. Both of these findings support previous research that those with presumed right hemisphere deficiencies have difficulties with relationships and are likely to be distraught enough about their life to engage in self destructive behavior.

The possible cause of this relationship should be considered to be tentative at best. However, many researchers and clinicians have noted that many of the skills associated with fluid abilities or presumed right hemisphere functioning are necessary to understand the nuances of interpersonal exchanges. The problem may be related to a general negative level of affect for both factors, which may be especially true for the Self Destructive factor. This presumed relationship would then have a biological basis for the psychosocial deficits, which would fit with the Hynd, et al. (1991) contention of the correlation between right hemisphere underactivation and psychopathology. As reported earlier, some have postulated that it is more a processing deficit that results in psychosocial deficits, that those with deficient right hemisphere functioning fail to discriminate subtle visual-spatial cues, such as facial and hand gestures. Finally, others have held that the problem is more related to the inability of these individuals to understand the gestalt in social situations. They are unable to decipher the subtle meanings and innuendos typical in complex interpersonal relations, or fail to understand humor and may overpersonalize the comments of others.

As was noted earlier, the establishment of cause and effect relationships was not the objective of this study. Whenever the nature-nurture argument is initiated a plethora of evidence supporting and refuting various positions is presented, with the typical conclusion being that it is both nature and nurture that contribute to an individual's adaptation to the environment. However, it is plausible that the Fluid Primary deficits do create developmental problems and learning comprehension difficulties along the arguments presented by Rourke (1987). When combined with the characteristics found in the CBCL Unpopular and Self Destructive factors, the resultant coping pattern could be quite detrimental for the learning disordered individual. Failing to achieve in school, combined with inadequate interpersonal relationships, either due to aggressive behavior, miscommunication, or withdrawal tendencies, these individuals appear to be a significant risk for self deprecatory behaviors, depression, and possible self destructive thoughts and/or behaviors.

Crystallized abilities have not been entertained as plausible contributors to the above noted behavior problems; however, there is some indication that those with significant crystallized deficits are not immune from pathological psychosocial problems. Only one factor during the regression analysis, the Anxiety factor, showed any meaningful relationship to the cognitive constructs; however, the relationship, when taking both Crystallized Concept Formation and Crystallized Secondary factors into account, was quite strong. This finding supports the contention that internalizing factors such as Anxiety are indeed related to supposed left hemisphere disorders. Again the relationship could be related to maladaptive behavior patterns due to the lack of interaction learning disordered individuals have with others or their failure in school. It would seem appropriate to hypothesize that those deficient in language based activities and general knowledge would have a tendency to be removed from social activities and fear verbal dialogue with others. Anxiety also has been associated with those considered to have OCD described earlier (Strauss, 1990) possibly lending argument to the debate over the loss versus release phenomena for the findings described earlier.

Once again, the exploration of these relationships was not intended to result in a causal analysis. However, it is important to recognize that those with verbal based deficits could have difficulty articulating their needs or experiences, and fail to understand complex social dialogues. The result in many of these cases might be an individual using a preferred coping strategy of avoiding or withdrawing from situations involving these activities. Significant anxiety may be experienced by these individuals resulting in extreme nervousness, overconcern, and somatic complaints, that can ultimately lead to panic disorders or phobic reactions to the much feared events. In addition, the comorbidity of childhood depression has been reportedly as high as 73% for children with anxiety disorders (Mitchell, McCauley, Burke, & Moss, 1988). Both of the disorders have common symptoms such as irritability, fatigue, difficulty concentrating, negative self concept, and sleep problems. However, pervasive worry, fear, and physiological tension, are problems often associated with anxiety disorders (Laurent, Landau, & Stark, 1993). Considering that teachers tend to underidentify individuals with internalizing disorders (Achenbach, McConaughy, and Howell, 1987) it would be important to examine this relationship more thoroughly to ensure that proactive intervention strategies can be developed before the dysfunction associated with these disorders becomes debilitative.

Further support for the relationship between crystallized abilities and internalizing disorders can be gleaned from the zero order correlation matrix. Of all the cognitive factors examined, the only one that had a fairly high (and statistically significant) zero order correlation was Crystallized Concept Formation (-.30). However, stepwise multiple regression analysis did not indicate that this relationship accounted for a significant amount of shared variance between these factors. Therefore no specific hypothesis regarding this relationship is warranted at this time. Further research will be necessary to determine if indeed a relationship exists.

Suggestions for Future Research

One of the most important findings of this study was the development of a neuropsychological model of cognitive functioning based on WISC-R subtest scores. Serving as a foundation to build upon, this model provides a number of goals for future research. A major goal for future researchers could be the refinement of a theoretically sound, empirically verifiable model of cognitive functioning, representing various perspectives, and utilizing different instruments. The ultimate goal is to obtain a verifiable model that could be cross validated across measures; however, this is a long term objective.

For the WISC-R model a number of data analytic strategies that alter the original model may aide in the refinement of the model. Possible considerations include the specification of additional pathways, combining or separating other factors, altering starting values, or freeing constrained parameters may yield additional information regarding the model. All these alterations could be judged against the model put forth in this study by exploring differences in error terms, modification indices, and goodness of fit indices.

In addition to the use of standard intelligence tests to develop the model, introduction of neuropsychological instruments into the model could further enrich the results.

The limitations of the current model are not only related to the interrelationship of the factors and variables, but also due to the limited abilities assessed by the instrument. As one adds variables and samples a larger data base it is possible to fully realize the factorial complexity found in Table 1. This may require shifting between exploratory and structural equation modelling statistical methods. One could choose instruments that are clinically thought to be interrelated on some dimension based on previous research, so as to develop clusters of several test loadings for further theoretical development of the model through structural equation modelling. One could continue to systematically refine specific cognitive constructs espoused here and the extent to which they are measurable by those instruments.

Further refinement of the model is presumed to be a natural precursor to exploring the relationship between cognition and psychosocial adjustment. Just as complex as the intercorrelations among the cognitive factors, measures of behavioral functioning could be analyzed through item analysis and factoring techniques to provide a clearer picture of psychosocial functioning generalizable across age levels and sexes. These instruments could then be utilized for subsequent multiple regression analysis with the obtained factor scores of the cognitive model described above.

A long term objective for these research activities might be the development of specific intervention strategies that address the relationship between cognition and behavior. Ensuring that cautions are made to minimize expectancy effects, professionals could work together to develop a number of intervention strategies that could address global learning and behavior patterns, while allowing for the flexibility in the programs to meet a student's individual needs. An interdisciplinary effort would best be suited for this task, as each could contribute their own expertise to the overall intervention model. This cooperative technique could be tailored to each institution working with children, allowing for a coherent, yet individualized approach to addressing the learning and behavior needs of children.

Summary

The model of cognitive functioning developed and tested in this study was designed to serve as a preliminary foundation for subsequent research aimed at establishing relationships between learning and behavior disorders. Based on previous exploratory factor analytic results, the factors developed from an analysis of the WISC-R subtests were an attempt to address the factorial complexity typically seen in clinical practice. In addition to developing processing factors that crossed the traditional verbal-performance dichotomy, second order factors were developed that accounted for the interrelationships among the processing factors.

Based on a neuropsychological model of cognitive functioning, these factors revealed a relatively stable pattern of correlations with the subtests, regardless of whether the data analyzed was the covariance matrix of the sample, the mean Wechsler, or any of the four WISC-R standardization sample age groups. Due to the complexity of the model and the loadings presented through previous research, the model was found to be sufficient when several parameters were restricted. This methodology resulted in a final model that revealed a Conditional Distribution assessment of the goodness of fit indices found during the structural equation modelling.

The interrelationships of the cognitive factors revealed a fairly consistent assessment of the model and supported the theoretical assumptions posited at the outset of the study. Further study of these relationships may allow for refinement of the model to limit the number of constrained parameters utilized and allow for a better understanding of the cognitive abilities assessed by the WISC-R. The ultimate goal is to develop a model of cognitive abilities that is generalizable to several intellectual and neuropsychological measures simultaneously, exploring the amount of variance each factor contributes to performance on the various instruments.

Additional construct validity obtained through refinement of the model should aide in determining the relationship between cognition and behavior in learning disordered populations. Several of the results in this study are in concert with previous research findings, with several CBCL factors demonstrating significant relationships to the cognitive factors. The overall aim of this research project was to develop proactive techniques that could be used to address both the learning and behavior characteristics of the learning disordered population. Through multidisciplinary input and intervention, the likelihood of significant learning and psychosocial problems may decrease, resulting in a better overall adjustment for these children.

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VITA

The author, James Bradford Hale, was born June 22, 1961 in Chicago, Illinois. Hale first attended the University of Wyoming in the fall of 1979. After a brief departure from school following his sophomore year to enter the U. S. Army Medical Corps, as a Medical and Behavioral Science Specialist, in Fort Sam Houston, Texas, Hale graduated from the University of Wyoming with the degree of Bachelor of Science in Pre Medicine, May, 1985.

Hale continued with his military career in the National Guard upon arrival to his native Illinois in 1985 and worked with learning and behavior disordered students at Washburne Elementary School in Winnetka, Illinois in civilian life. Following this experience, Hale worked briefly at two residential facilities, the Arden Shore Association and Park Ridge Youth Campus, for emotionally disturbed and behavior disordered adolescents.

His interests regarding the interaction of learning and behavior disorders evolved during this period, and in September, 1987, Hale entered the M.Ed. special education teacher certification program in Learning Disabilities and Behavior Disorders at the University of Illinois at Chicago. Within a year Hale was promoted from Graduate Research

Assistant to Assistant to the Dean for Research, where he directed several outside funded research projects, supervised statistical analyses, and wrote methodology sections for several articles and presentations. Following a successful teaching experience at East Prairie Elementary School, Hale obtained a M.Ed. degree and a Type 10 Teacher Certification in Learning Disabilities and Behavior Disorders in June, 1989.

In fall of 1989, Hale was admitted to the Doctoral Program in School Psychology and was awarded a Statistical Consulting Assistantship at Loyola University. That spring, Hale was appointed Faculty Instructor, teaching courses over the next three years in special education, developmental psychology, individual differences, and statistical methods. Awarded a Research Assistantship in the fall of 1990, Hale began to work on several research projects, administrative documents, and grant proposals. This culminated in Hale receiving a University Teaching Fellowship in the fall of 1991. During the spring of 1992, Hale began his Clinical School Psychology Internship at Highland Park High School, Illinois, which ended in the summer of 1993.

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The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is, therefore, accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

8/17/93
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