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Relative stability of the neuropsychological profiles of non-verbal learning disabilities (NVLD) and basic phonological processing disabilities (BPPD) from middle childhood to early adolescence.

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Relative Stability of the Neuropsychological Profiles of Non-Verbal Learning Disabilities (NVLD) and Basic Phonological Processing Disabilities (BPPD) from Middle Childhood to Early Adolescence

By

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ABSTRACT

The present study is a longitudinal comparison of relative neuropsychological assets and deficits for young and older children with Nonverbal Learning Disabilities (NLD) and Basic Phonological Processing Disabilities (BPPD). The sample for the investigation was comprised of clinic-referred children who had been diagnosed with either NLD or BPPD by an experienced clinical neuropsychologist. A total of 18 children, nine in each of the NLD and BPPD groups were selected. The children were between 7 and 8 years of age at first testing, and 9 and 14 years of age at second testing, inclusive. The NLD and BPPD groups were compared across young and older ages on a number of achievement, verbal, visual-spatial, motor/psychomotor, tactile-perceptual, and concept-formation/problem-solving measures. Results of the comparisons confirmed the pattern of relative neuropsychological assets and deficits as predicted by the NLD and BPPD models for both young and older children. An examination of age-related profiles of neuropsychological functioning suggested that the children with BPPD demonstrated age-appropriate development with regard to their neuropsychological deficits, but the children with NLD demonstrated a pattern of worsening with regard to some of their neurospychological deficits. Specifically, the performance of the children with NLD declined significantly in areas related to Arithmetic and Complex-Tactile abilities. Children in both LD subtypes demonstrated age-appropriate development of the majority of their respective neuropsychological assets. The failure to confirm all of the age-related predictions based upon the NLD and BPPD models, along with the neuropsychological implications of the findings, are discussed.

DEDICATION

I would like to dedicate this thesis to my parents and my sister. It is because of their support and constant encouragement that I have come this far. I want to thank them for helping me achieve my goals, and sticking with me through the good and bad.

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Chapter One: Introduction

In the learning disabilities (LD) literature, the contrasting groups methodology held sway for many years. This technique involved comparing a "LD" group with some sort of a "control" group. Rourke (1989) summarized the flaws in the studies that utilized this approach. First, the bulk of these studies failed to include a comprehensive conceptual model that could be used to elucidate the skills involved in perception, learning, memory, and cognition that may be deficient in children with LD. Second, in a large portion of these studies, there was often no consistent formulation of the criteria for identifying LD. Numerous studies employed vaguely defined or even undefined groups, whereas others used ratings by teachers and school personnel to determine groups of children with LD. Finally, most studies utilizing the contrasting groups methodology were grossly insensitive to developmental considerations. Because the neuropsychological functioning of some subtypes of children with LD may vary as a function of age (considered as one index of developmental change), the inconsistencies present in the results of contrasting groups research could reflect differences in the ages of the participants.

The drawbacks associated with the contrasting groups methodology necessitated a more viable research option. Johnson and Myklebust (1967) documented the heterogeneity of a sample of individuals deemed LD and demonstrated that such learning disabled individuals could be reliably grouped into more homogenous subgroups. Their findings were supported by other investigators in the field (Mattis, French & Rapin, 1975; Petrauskas & Rourke, 1979). Subtyping research grew from the realization that persons with LD could be grouped into reliable subtypes based on sets of shared neuropsychological assets and deficits (Rourke, 1989).

The history of subtyping research at the University of Windsor laboratory has been particularly extensive. Utilizing the notion of a developmental neuropsychological approach, Rourke and colleagues have, over a number of years, carried out a series of investigations that have led to the delineation of two major subtypes of LD. The two subtypes have come to be labeled Nonverbal Learning Disabilities (NLD) and Basic Phonological Processing Disabilities (BPPD). Furthermore, the two subtypes are characterized by specific patterns of neuropsychological assets and deficits. Research efforts at the University of Windsor laboratory have explored various aspects of these two subtypes of LD including the areas of speech/language, academic, and psychosocial functioning. The investigations that sought to explore the developmental progression of the two subtypes of LD are most germane to the present study.

Developmental Dimensions of Neuropsychological Assets and Deficits related to Learning Disabilities

Several investigations in the Windsor series were important in contributing to the knowledge base regarding the neuropsychological assets and deficits of older children with LD and, to a lesser extent, younger children with LD (Rourke, Dietrich & Young, 1973; Rourke & Finlayson, 1978; Rourke & Strang, 1978; Rourke & Telegdy, 1971; Rourke, Young & Flewelling, 1971; Strang & Rourke, 1983). Although many of these studies were cross-sectional in nature, they delineated patterns of neuropsychological assets and deficits observed in young (5- to 8-years of age) and older (9- to 14-years of age) subtypes of children with LD. The developmental nature of the syndrome of NLD could be gleaned from these studies due to methodological commonalities that facilitated comparisons across studies. For example, the criteria employed for selecting individuals with LD were consistent across the studies. The children were markedly deficient in at least one academic core area, obtained Wechsler Intelligence Scale for Children (WISC) Full Scale IQs within the normatively average range, were free of primary emotional disturbance, had adequate visual and auditory acuity, lived in homes and communities where socioeconomic deprivation was not a factor, had experienced only the usual childhood illnesses, and had attended school regularly since the age of 5 1/2 or 6 years (Rourke, 1989).

Rourke, Young, and Flewelling (1971) categorized children with LD on the basis of their pattern of performance on the Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1949). Specifically, three groups, each containing 30 children with LD, were formed on the basis of the relation between their VIQ and PIQ scores on the WISC. One group, designated the HP-LV (high performance and low verbal scores), consisted of subjects whose PIQ scores were at least 10 points higher than their VIQ scores. A second group, designated V=P, was composed of subjects with VIQ and PIQ scores within 4 points of each other. The third group, designated HV-LP (high verbal and low performance scores), had VIQ scores at least 10 points higher than their PIQ scores. Children selected ranged in age from 9 to 14 years.

The test scores obtained on a standard neuropsychological battery were compared for the three groups formed using these criteria. The primary objective of the study was to assess the relationships between such discrepancies and selected verbal, auditory-perceptual, visual-perceptual, and problem-solving abilities.

Data analyses indicated that the HV-LP group outperformed the HP-LV group on tasks that involved verbal and auditory-perceptual skills. Conversely, the HP-LV group outperformed the HV-LP group on tasks that primarily involved visual-perceptual skills. The performance of the V=P group was intermediate to the HV-LP and HP-LV groups on most of the neuropsychological tasks evaluated.

When Wide Range Achievement Test (WRAT) scores on the Reading, Spelling, and Arithmetic subtests were compared, a pattern emerged wherein the HV-LP group demonstrated high Reading and Spelling scores in the context of low Arithmetic scores. The opposite trend, although not statistically significant, was evident in the HP-LV group.

This study was crucial because it highlighted the importance of psychometric intelligence discrepancies such as VIQ/PIQ differences for indicating vastly different groups of persons with LD. Furthermore, it was noted that the pattern of relative strengths (i.e., verbal and auditory-perceptual) and weaknesses (i.e., visual-spatial) exhibited by the HV-LP group was similar to what would be expected in adults who were experiencing the debilitating effects of a significant lesion confined to the right cerebral hemisphere. Conversely, the opposite pattern of relative strengths and weaknesses exhibited by the HP-LV group was similar to what would be expected in adults experiencing a substantial lesion of the left hemisphere.

This finding suggested that groups of learning disabled children, selected on the basis of VIQ/PIQ discrepancies, exhibited patterns of performance that implicated the differential impairment of skills ordinarily thought to be subserved primarily by one or the other cerebral hemisphere. The second study in the Windsor series was carried out to gather further evidence relating the performances of the LD groups to the differential functioning of the two cerebral hemispheres, utilizing tests from a different adaptive domain.

Rourke and Telegdy (1971) examined the motor performances of three groups of participants who exhibited patterns of VIQ-PIQ discrepancies virtually identical to those in the Rourke et al. (1971) investigation. The sample was comprised of 45 male children between the ages of 9 and 14 with LD (15 in each of the HP-LV, HV-LP, and V=P groups). The motor and psychomotor tasks were chosen to reflect varying degrees of complexity and visual-spatial skills necessary for success. Accordingly, the psychomotor measures chosen ranged from those with simple demands (e.g., Grip Strength) to those with more complex demands (e.g., Grooved Pegboard). Furthermore, performance was evaluated independently for each hand, which allowed speculation about the relative intactness of each of the cerebral hemispheres.

In accordance with the previous investigation, it was hypothesized that the individuals categorized as HP-LV, who evinced a relative superiority on tasks primarily involving visual-perceptual skills, would do better than those categorized as HV-LP on psychomotor tasks which involved complex visual-motor coordination regardless of the hand employed. This expectation would be consistent with the view that visual-spatial and visual-motor abilities are mediated, to a large extent, by the right cerebral hemisphere.

Results indicated a clear superiority of the HP-LV group on most measures of complex motor and psychomotor abilities, regardless of the hand employed. The clearest discrepancy in performance across the groups was observed on the most complex psychomotor measures employed (i.e., Mazes, Grooved Pegboard). On these tasks, differences were evident for both right and left hand trials with the following pattern of relative superiority between the groups: HP-LV > V=P > HV-LP. The results were consistent with the view that WISC VIQ-PIQ discrepancies reflected the differential integrity of the two cerebral hemispheres in older children with LD (Rourke & Telegdy, 1971).

In combination with the findings of Rourke et al. (1971), these findings suggest that individuals in the HV-LP group exhibit a relative strength on tasks thought to be subserved primarily by systems within the left cerebral hemisphere (e.g. speech-sounds discrimination) and a relative weakness on tasks thought to be subserved primarily by systems within the right hemisphere (e. g. visual-spatial-organizational skills). The opposite pattern of strengths and weaknesses characterizes the performance of the individuals in the HP-LV group, suggesting a relative superiority of right versus left hemisphere systems.

Whereas the neuropsychological test performance of older children with LD was characterized in the aforementioned studies, the neuropsychological test performance of younger children with similar VIQ/PIQ patterns was examined in subsequent studies. Rourke, Dietrich, and Young (1973) divided 82 children with LD aged 5 to 8 years into three groups according to criteria similar to those employed in the previous two investigations. This generated three groups of individuals namely: HP-LV, V=P, and HV-LP. The neuropsychological test scores of the children in the three groups were then compared. Neuropsychological data included verbal, auditory-perceptual, visual-perceptual, and problem solving tasks similar to those employed in the Rourke et al. (1971) study, and motor and psychomotor tests similar to those employed by Rourke and Telegdy (1971).

The young children with LD demonstrated a pattern of group performance on the verbal, auditory-perceptual, visual-perceptual, and problem solving tasks similar to that found for the older children in the Rourke et al. (1971) study. Specifically, the HV-LP group outperformed the HP-LV group on tasks that involved verbal and auditory-perceptual skills (i.e., Speech Sounds Perception) while the HP-LV group outperformed the HV-LP group on those tasks assessing visual-perceptual skills (i.e., Target Test). The performance of the V=P group was intermediate to the other two groups on most measures. The young children with LD did not demonstrate a pattern of performance on the motor and psychomotor tests similar to that found in the Rourke and Telegdy (1971) study. For the younger children with LD there was an absence of any significant inter-group differences on the majority of the psychomotor measures. The psychomotor performance of the HP-LV group did not exceed that of the other two groups. As a result, it was concluded that the patterns of performance on the verbal, auditory-perceptual, and visual perceptual measures were similar in younger and older children with LD. However, the patterns of motor and psychomotor performance evident in older children were not apparent in younger children with LD.

Having explored the correlates of VIQ-PIQ discrepancies among younger children with LD, the research at the University of Windsor laboratory turned to establishing external correlates of the derived subtypes. In particular, the specific WRAT Reading, Spelling, and Arithmetic patterns that had been observed in the subtyping studies involving older children were further investigated.

In the first of these investigations (Rourke & Finlayson, 1978), children with LD between the ages of 9 and 14 were divided into three groups on the basis of their patterns of academic performance. The participants in Group 1 were uniformly deficient in reading, spelling, and arithmetic. Group 2 was composed of participants whose arithmetic performance, although clearly below age expectations, was significantly better than their performance in reading and spelling. The participants in Group 3 exhibited at least average reading and spelling scores, whereas their arithmetic performance was significantly impaired.

Although all three groups performed well below age expectations in arithmetic, the performance of groups 2 and 3 was superior to that of group 1. Furthermore, groups 2 and 3 did not differ from one another in their impaired levels of arithmetic performance. The neuropsychological test scores of the three groups were then compared. Specifically, scores on 16 neuropsychological tests which had been investigated in prior studies were included in the Rourke and Finlayson (1978) study.

Results of this investigation showed that Group 3 demonstrated inferior visual-spatial abilities and superior verbal abilities compared to Groups 1 and 2. It is interesting to note that all participants in Group 3 had a higher VIQ than PIQ. Indeed, participants in Group 3 performed particularly poorly on those skills and abilities thought to be subserved by structures and systems within the right cerebral hemisphere. This pattern of performance is precisely the pattern demonstrated by older children with the HV-LP profile. In contrast, most of the participants in Groups 1 and 2 exhibited lower VIQ than PIQ scores. They were markedly deficient only in those skills and abilities thought to be subserved primarily by structures and systems within the left cerebral hemisphere. Overall, their pattern of performance was very similar to that expected for groups of older children with LD who exhibit the WISC HP-LV pattern.

The results of this study were important in implicating discrepant functional integrity of the cerebral hemispheres in the various subtypes of LD. Furthermore, this study illustrated a relationship between patterns of performance on the WISC and academic achievement levels (i.e., Reading, Spelling and Arithmetic on the WRAT).

To take the investigation one step further, Rourke and Strang (1978) sought to compare the same three groups of 9- to 14- year-old children with LD on measures from a different neuropsychological domain, namely, motor and psychomotor abilities. Of particular interest in this investigation was the question of whether further evidence could be gathered to support the view that children with LD suffer from differential impairment of functional systems thought to be subserved primarily by structures and systems within the left or the right cerebral hemispheres.

This goal was met through an analysis of the right- and left-hand performance of these groups of right handed children with LD on selected motor, psychomotor, and tactile-perceptual measures. The motor skills battery, as in previous studies, included tests spanning a wide range of demand capacities from simple to complex. Similar to the Rourke and Finlayson (1978) study, the investigators divided 45 children with LD into three groups on the basis of their WRAT reading, spelling, and arithmetic achievement. The children with LD in these groups were equated for age and WISC FSIQ.

Data analyses revealed no statistically significant differences between or among the groups on a simple motor measure, over and above those that would be expected to be exhibited by the exclusively right-handed children employed in this study (i.e., better performance for the dominant hand). The expected superiority of performance for Groups 1 and 2 over that of Group 3 was clearly in evidence on two of the complex psychomotor measures, namely the Mazes (Kløve, 1963) and Grooved Pegboard (Kløve, 1963) tasks bilaterally. However, differential hand superiority was found between the groups only on the Tactual Performance Test (TPT). Groups 1 and 3 displayed a pattern of poor left-hand performance relative to right-hand performance on this measure. Group 2 displayed the opposite pattern of poor right-hand performance relative to left-hand performance. Furthermore, the performance of Groups 1 and 2 on the "both hands" measure of the TPT was superior to that of Group 3. Finally, comparisons favoring the performance of Groups 1 and 2 over that of Group 3 on the composite tactile-perceptual measure were significant for both the right and left hands. Among subjects in Group 3 there was a tendency for their right-hand performance to be superior to their left hand performance.

Some evidence was gathered in favour of the hypothesis of differential functional integrities of the two cerebral hemispheres. Certainly, the marked discrepancy between the performance of Groups 2 and 3 on the Tactual Performance Test would offer clear support for this hypothesis. It was clear from this study that individuals in Group 3 demonstrated a relative weakness on measures of abilities ordinarily thought to be subserved primarily by structures and systems in the right cerebral hemisphere and a relative strength on measures of abilities ordinarily thought to be subserved primarily by structures and systems within the left cerebral hemisphere. Children in Group 2 presented with the opposite pattern of relative strengths and weaknesses.

In the next study of this series, Strang and Rourke (1983) selected Group 2 and 3 children between the ages of 9 and 14 according to the criteria employed in the studies by Rourke and Finlayson (1978) and Rourke and Strang (1978). The aim of this investigation was to examine the problem solving abilities of the individuals comprising Groups 2 and 3. The groups were equated for age and WISC Full Scale IQ. The dependent measure employed was the number of errors on each of the six subtests of the Halstead Category Test (Reitan & Davison, 1974) and the total number of errors on this test.

Results indicated that individuals comprising Group 3 made more errors on the Category Test than did those in Group 2. The level of performance of the children in Group 3 on the Category Test was one standard deviation below age expectation, whereas the children in Group 2 performed at an age-appropriate level. Moreover, individuals in Group 3 performed in a particularly deficient manner on the final three subtests of the Category Test. These three subtests place the greatest demands on visual-spatial analysis and the capacity to benefit from informational feedback. It was hypothesized that the children in Group 3, who also exhibited impairments in tactile-perceptual, visual-spatial-organizational, and psychomotor skills, may have had difficulties in developing early reasoning skills and later higher-order concept formation and problem-solving skills, such as those tapped by the Category Test, because these skills are built upon the earliest and most basic skills (which were, in this group of children, deficient). Thus, it may be that deficiencies in basic skills led to inadequate sensorimotor experience during development, which was necessary for forming a foundation for the later, higher-order cognitive skills. The children in Group 2 had adequate basic tactile-perceptual, visual-spatial-organizational, and psychomotor skills. Thus, they would have been able to benefit from sensorimotor experience throughout development and lay the cognitive groundwork necessary for the development of the later higher-order skills.

Two further studies in this series of investigations sought to extend the aforementioned findings to groups of younger children with LD. The findings illustrated that younger children and older children in Groups 1, 2 and 3 had similar patterns of performance on verbal, auditory-perceptual, and visual-spatial abilities. However, the motor, psychomotor, and tactile-perceptual skills of the younger and older children were not entirely consistent (Ozols & Rourke, 1988,1991). Lastly, it was not possible to examine higher-order reasoning and concept formation abilities in an adequate fashion in these younger children, who are, in Piagetian terms, still functioning within the stage of concrete operational thought (Rourke, 1989).

Rourke (1989) summarized the most salient conclusions to be drawn from these subtyping studies. First, there appear to be reliable (internally valid) subtypes of children with LD that can be delineated on the basis of their patterns of academic achievement. Second, these subtypes are externally valid (i.e., they can be differentiated in terms of neuropsychological variables not utilized in the initial classification). Third, there are some similarities between older (9- to 14-year old) and younger (7- to 8-year old) children with LD. Fourth, the children in Groups 2 and 3 demonstrate equivalent levels of impairment in mechanical arithmetic, although their impaired performances reflect qualitatively distinct errors or difficulties. These differences in errors appear to be a function of the patterns of neuropsychological assets and deficits exhibited by children who manifest the two LD subtypes.

Most of the errors made in mechanical arithmetic by the children in Group 2 were associated with two factors, namely problems in reading and inexperience with the subject material. The latter resulted from the fact that remedial programs for older children in Group 2 often focused on ameliorating their impairments in reading and spelling, thus giving inadequate attention to the development of mathematical abilities. On the other hand, the children in Group 3 exhibit errors for a wide variety of reasons, including deficient visual-spatial organization, difficulties with visual detail, procedural errors, failure to shift psychological set, deficiencies in graphomotor skills, problems in retrieving information from memory, and poor judgement and reasoning. The errors made by children in Group 3 can be attributed to difficulties in two broad categories of skills: First, errors may be due to difficulties with visual-spatial-organizational and psychomotor skills as well as concept-formation and hypothesis testing abilities. Second, errors may be due to a failure to deploy verbal memory skills due to difficulty employing such skills, which results from difficulty understanding when this information is needed during the course of the arithmetical procedure (Rourke, 1989).

These subtyping studies are outlined for two reasons. First, the two subtypes of LD that are the topic of this study, namely, NLD and BPPD, were derived from these studies. Second, these earlier investigations examined subtypes of LD in older and younger children. It is important to take note of the developmental trends established in this series of studies, given that the present investigation is a longitudinal design.

In the University of Windsor laboratory, the three groups in the previous series of studies were re-named as Group R-S-A (Group 1; for Reading, Spelling, and Arithmetic); Group R-S (Group 2; for Reading and Spelling); and Group A (for Arithmetic). The pattern of neuropsychological assets and deficits associated with those individuals in Group R-S and Group A are now referred to as BPPD and NLD respectively. Information summarizing their primary, secondary, and tertiary neuropsychological assets and deficits are presented in Tables 1 and 2 for NLD and BPPD, respectively. It is thought that for each of these two subtypes of LD, the primary neuropsychological assets/deficits give rise to the secondary assets/deficits, which in turn give rise to the tertiary assets/deficits. Furthermore, the neuropsychological assets and deficits are thought to eventuate in particular patterns of speech and language, academic, and socioemotional/adaptive characteristics (Rourke, 1989).

Children with BPPD display the neuropsychological assets of average to above average abilities in tactile perception, tactile attention and tactile memory; visual perception, visual attention and visual memory; motor and psychomotor functioning; capacity to deal with novel material, adequate exploratory behaviour, and concept formation and problem solving.

Table 1
Neuropsychological Assets and Deficits of NLD

Neuropsychological	Assets	Deficits
Primary	Auditory Perception Simple Motor Rote Material	Tactile Perception Visual Perception Complex Psychomotor Novel Material
Secondary	Attention(auditory;verbal)	Attention(tactile;visual) Exploratory Behaviour
Tertiary	Memory(Auditory;Verbal)	Memory(tactile;visual) Concept formation Problem Solving
Verbal	Phonology Verbal reception Verbal repetition Verbal storage Verbal associations Verbal output (volume)	Oral-motor praxis Prosody Phonology>Semantics Content Pragmatics Function
Academic	Graphomotor(late) Word Decoding Spelling Verbatim Memory	Graphomotor(early) Reading Comprehension Mechanical Arithmetic Mathematics Science
Socioemotional/ Adaptational	???	Adaptation to novelty Social Competence Emotional Stability Activity Level

Adapted from Rourke (1989)

Table 2
Neuropsychological Assets and Deficits of BPPD

Neuropsychological	Assets	Deficits
Primary	Tactile Perception Visual Perception Complex Psychomotor Novel Material	Auditory Perception Simple Motor Rote Material
Secondary	Attention(tactile;visual) Exploratory Behaviour	Attention(auditory;verbal)
Tertiary	Memory(tactile;visual) Concept formation Problem Solving	Memory(Auditory;Verbal)
Verbal	Oral-motor praxis Prosody Semantics>Phonology Content Pragmatics Function	Phonology Verbal reception Verbal repetition Verbal storage Verbal associations Verbal output (volume)
Academic	Graphomotor(early) Reading Comprehension Mechanical Arithmetic Mathematics Science	Graphomotor(late) Word Decoding Spelling Verbatim Memory
Socioemotional/Adaptat Ional	Adaptation to novelty Social Competence Emotional Stability Activity Level	

Adapted from Rourke(1989)

The neuropsychological deficits related to BPPD include some dimensions of auditory perception, auditory attention, and auditory memory; and verbal attention and verbal memory.

The neuropsychological assets and deficits of children with BPPD are thought to give rise to a particular pattern of speech and language assets and deficits characterized by normal ability in prosody, semantics, content and pragmatics in the face of poor phonology, verbal reception, verbal repetition, verbal storage, verbal associations, and verbal output. In the academic domain, reading comprehension (late), mathematics, and science tend to be relative assets while graphomotor skills, word decoding, reading comprehension (early), spelling, verbatim memory, and mechanical arithmetic are deficiencies.

Conversely, children with NLD present with neuropsychological assets relating to auditory perception, auditory attention, and auditory memory, simple motor skills, dealing with rote material, and verbal attention and memory. The neuropsychological deficits related to NLD include tactile perception, tactile attention and tactile memory; visual perception, visual attention and visual memory; complex psychomotor skills, ability to deal with novel material, little physical exploration; and concept formation and problem solving.

These neuropsychological assets and deficits are thought to give rise to speech and language abilities characterized by good skills in phonology, verbal reception, verbal repetition, verbal storage, verbal association and verbal output in the face of deficits in oral motor praxis, prosody, semantics, content, pragmatics, and function. In the academic domain graphomotor skills (late), word decoding, spelling, and verbatim memory are relative assets whereas graphomotor skills (early), reading comprehension, mechanical arithmetic and science tend to be relative deficits.

Specific Developmental Considerations

Several investigations have been carried out in the University of Windsor Laboratory and elsewhere that have examined specific developmental considerations related to the NLD and BPPD subtypes.

Ahmad and Rourke (2000) conducted a cross-sectional investigation to compare the neuropsychological profile of primary assets and deficits for children and adults with NLD and BPPD. Based on past research the investigators predicted a significant worsening (relative to developmental norms) in areas of neuropsychological deficit from childhood to adulthood in groups with NLD. This worsening was not expected for the groups with BPPD. The findings were generally consistent with this hypothesis. The difference in the complex tactile category, which comprised the Tactual Performance Test, did not reach significance. However, all other areas of neuropsychological deficit for the NLD group (e.g., visual-spatial, eye-hand, simple tactile, and problem solving) were found to be significantly worse (relative to age-based norms) in the adult group than in the child group. The apparent worsening was most severe in the area of problem solving. Furthermore, the results did not reveal any significant trends in severity (increase/decrease) for BPPD for any of the composite areas.

DelDotto, Rourke, McFadden, and Fisk (1987) conducted a longitudinal investigation showing that children who exhibited the NLD profile tended to maintain their pattern of performance on neuropsychological and psychosocial measures into late adolescence and early adulthood.

Del Dotto, Fisk, McFadden and Rourke (1991) conducted a longitudinal investigation of individuals with NLD with two main goals. First, they wanted to determine whether, and to what extent, the academic and neuropsychological ability repertoire of individuals with NLD remains stable or changes over time. Secondly, they wanted to gather information about psychosocial and personality functioning in the syndrome of NLD. Participants were five individuals who fell between the ages of 9 and 15 years at the time of initial evaluation and between 16 and 23 years at follow-up. Participants had to meet a number of criteria at initial testing in order to be selected. Each participant attained centile scores greater than or equal to 50 on both the Reading and Spelling subtests of the WRAT in combination with an arithmetic centile score less than or equal to 25. Furthermore, participants had to display deficits in at least three of the five following areas: WISC-R PIQ less than VIQ by 10 points, bilateral deficits in psychomotor functioning, bilateral deficiencies in somatosensory skills, TPT left hand poorer than right hand score and finally, a score of at least one standard deviation below the age-appropriate mean on the Category Test. At follow-up, individuals were re-administered a battery of neuropsychological, personality, and adaptive behaviour measures.

The results suggested that the academic and neurocognitive abilities of these individuals were stable over time. At the time of follow-up subjects continued to exhibit above-average word-recognition and spelling abilities in the context of markedly deficient mechanical arithmetic skills. Furthermore, their neuropsychological protocols continued to be characterized by bilaterally impaired somatosensory abilities, left-sided tactually guided problem-solving deficits, bilaterally deficient fine finger dexterity skills, poor nonverbal concept-formation capacities, and somewhat underdeveloped visual-spatial abilities. No consistent pattern of psychosocial disturbance was discernible on the objective personality measures.

Casey, Rourke, and Picard (1991) sought to examine whether, and to what extent, the features of the NLD syndrome changed in predictable directions during middle childhood and early adolescent years. The investigators predicted that there would be a relative stability (i.e., age-appropriate development) of rote verbal skills, reading, spelling, simple motor skills and tactile-perceptual abilities. Conversely, they predicted a relative decline (i.e., failure to make age-appropriate gains) in visual-spatial and problem solving abilities, mechanical arithmetic skills, and complex psychomotor and tactile-perceptual abilities. It was further predicted that there would be an increase in the severity of psychosocial disturbance, especially of the internalized variety, and a concomitant decrease in externalized forms of psychopathology (e.g. hyperactivity, delinquency).

The results of the cross-sectional analyses were consistent with the majority of predictions formulated regarding the developmental dynamics of the NLD syndrome. More specifically, with increasing age, the children with NLD demonstrated a corresponding (age-appropriate) development of verbal, simple tactile, and simple motor skills, and abilities that coincided with similar gains in the academic skills of word-recognition and spelling. The older children with NLD did not make age-appropriate gains, when compared with aged-based norms, on neurocognitive measures that emphasized visual-perceptual, complex tactile, psychomotor, and problem-solving skills and abilities. In addition, older children with NLD were found to be further behind their normally achieving age peers in mechanical arithmetic skills as compared to the younger children with NLD. A clear pattern was evident in the data reflecting psychosocial and behavioural maladjustment of these children. The older children demonstrated an overall greater degree of psychosocial disturbance as compared with the younger children, a difference related primarily to increasing disturbances of the internalized variety.

The Present Investigation

The aim of the present investigation is to further the understanding of the developmental progression of NLD and BPPD. The majority of studies in the literature examining the developmental progression of these two LD subtypes have been cross-sectional in nature. Those that have been longitudinal have focused exclusively on NLD. In the current investigation, the test performances of children with NLD or BPPD at younger ages will be compared with their performances at older ages. Composite category averages consisting of combined scores on different tests relating to the same functional domain, will be compared for each LD subtype. It is believed that by examining the performances of children for whom longitudinal data are available more can be learned regarding comparative development in NLD as opposed to BPPD. There are two goals for the present investigation.

Goal One

To inspect the neuropsychological profiles for the young and older children with NLD and BPPD, respectively, to ensure the relative similarity of the average profiles across age groups.

Goal Two

To compare composite category averages for the young versus the older children for both NLD and BPPD subtypes.

Hypothesis 1: (a) The neuropsychological profiles for the young and older children with NLD will be highly correlated and characterized by similar relative patterns of neuropsychological assets and deficits. (b) The neuropsychological profiles for the young and older children with BPPD will also be highly correlated and characterized by similar relative patterns of neuropsychological assets and deficits. (c) Relative to the correlations of the children within the two LD subtypes, the correlation between the profiles of the young children with NLD and BPPD, and the older children with NLD and BPPD will be low.

Hypothesis 2: (a) Composite category averages involving areas of neuropsychological deficit will be significantly worse (relative to age-based norms) in the group of older children with NLD as compared to the young children with NLD. (b) This worsening is not expected for the children with BPPD.

For the children with NLD, domains in which performance is expected to decline are represented by the following variables: visual-spatial (WISC- Block Design and Object Assembly subtests, Target Test); complex tactile (Fingertip Writing, Finger Agnosia and Astereognosis for both the right and left hands); complex motor (Maze Coordination and Grooved Pegboard Test for both the right and left hands); problem solving (Tactual Performance Test- both hands trial, and total errors on the Category Test); arithmetic (WRAT arithmetic subtest).

The children with BPPD will exhibit neither an increase nor a decrease in performance (i.e., relative stability) in areas of neuropsychological deficit represented by the following variables: verbal I (WISC- Information, Similarities, and Vocabulary subtests); verbal II (Speech-Sounds Perception Test, Auditory Closure Test, and Sentence Memory Test); and reading and spelling (WRAT Reading and Spelling subtests).

Hypothesis 3: There will be no significant increases/decreases in areas of neuropsychological assets for either of the LD subtypes. Children with NLD and BPPD will exhibit age-appropriate development with regard to their respective neuropsychological assets.

Performance is expected to remain relatively stable for the children with NLD on domains represented by the following variables: verbal I (WISC- Information, Similarities, and Vocabulary subtests); verbal II (Speech-Sounds Perception Test, Auditory Closure Test, and Sentence Memory Test); simple tactile (tactile imperception and suppression for both the right and left hands);

simple motor (Grip Strength and Holes for both the right and left hands) and reading/spelling (WRAT Reading and Spelling subtests).

Domains in which performance is expected to remain relatively stable in the children with BPPD are represented by the following variables: visual-spatial (WISC- Block Design and Object Assembly subtests, Target Test); complex motor (Maze Coordination and Grooved Pegboard Test for both the right and left hands); problem solving (Tactual Performance Test-dominant, non-dominant and both hands trials and total errors on the Category Test) and arithmetic (WRAT arithmetic subtest).

Chapter Two: Method

Participants

Eighteen participants were selected, nine in each of the NLD and BPPD groups. The NLD and BPPD groups were balanced with respect to time interval between testings. Ages at test and re-test for individuals in both NLD and BPPD groups are displayed in Table 3. Average age at first and second testing was 8.1 and 10.6 years for the children with NLD, and 8.2 and 10.6 years for the children with BPPD.

Participants were selected from a population of clinic-referred children who were diagnosed with either NLD or BPPD by an experienced clinical neuropsychologist based upon the results of a complete neuropsychological assessment. All children had been living in Windsor, Ontario and surrounding communities. All tests were administered by a well trained psychometrist. Children selected for both NLD and BPPD groups met the following criteria: chronological age between either 7 and 8 years inclusive (young children group) at the time of first testing and between 9 and 14 years inclusive (older children group) at the time of second testing; WISC FSIQ score of 80 or above; centile score of 30 or below on at least one subtest of the WRAT; no primary sensory deficit; no evidence of educational or enviromental deprivation; no primary emotional disturbance; English as the primary language; and available data from a complete neuropsychological assessment battery.

Table 3
Ages of Children in Both NLD and BPPD Groups.

NLD		BPPD	
Test	Re-test	Test	Re-test
8yrs,(6)	10yrs,(6)	8yrs(3)	10yrs(2)
7yrs,(5)	9yrs(3)	7yrs(4)	9yrs(3)
7yrs(2)	9yrs(9)	7yrs(8)	9yrs(8)
7yrs(5)	10yrs(5)	7yrs(7)	11yrs(5)
8yrs(8)	10yrs(3)	8yrs(8)	10yrs(7)
8yrs(5)	12yrs(10)	8yrs	12yrs(3)
7yrs(8)	9yrs(11)	8yrs(4)	11yrs(8)
8yrs(5)	12yrs(4)	8yrs(8)	10yrs(9)
8yrs(9)	10yrs(6)	8yrs(11)	10yrs

Average Time Between Testings NLD:2.5yrs. BPPD:2.4 yrs.

*Note: The numbers in parentheses represent ages in months.

Measures

Results from the administration of the following tests in each of the following composite categories were utilized for comparisons: Verbal I- Wechsler Intelligence Scale for Children (Wechsler, 1949)- Information, Similarities and Vocabulary subtests; Verbal II- Speech-Sounds Perception Test (Reitan & Davison, 1974), Auditory Closure Test (Kass, 1964), and Sentence Memory Test (Benton, 1965); Visual-Spatial- Wechsler Intelligence Scale for Children (Wechsler, 1949) Block Design, and Object Assembly subtests, Target Test (Reitan & Davison, 1974); Simple motor- Grip Strength (Reitan & Davison, 1974), and Graduated Holes (Kløve, 1963; Knights & Moule, 1968; Rourke & Telegdy, 1971); Complex motor- Grooved Pegboard Test (Kløve, 1963), and Maze Test (Kløve, 1963); Simple tactile- Tactile Perception (Reitan & Davison, 1974); Complex tactile- Fingertip Writing (Reitan & Davison, 1974), Finger Agnosia (Reitan & Davison, 1974), and Astereognosis (Reitan & Davison, 1974); Concept formation/problem solving- Halstead Category Test (Reitan & Davison, 1974) and Tactual Performance Test (Reitan & Davison, 1974); Reading/Spelling- Wide Range Achievement Test (Jastak & Jastak, 1965), Wide Range Achievement Test-Revised (Jastak & Jastak, 1984)-Reading and Spelling subtests; Arithmetic- Wide Range Achievement Test (Jastak & Jastak, 1965), Wide Range Achievement Test-Revised (Jastak & Jastak, 1984)- Arithmetic subtest. See Table 4 for a more detailed description of these tests.

Although many of the tests and subtests utilized in the present investigation were related, in some way, to more than one of the above-mentioned composite categories, each test/subtest was included within the one composite category that appeared most appropriately related to the task demands of the particular test. The WRAT Arithmetic subtest was put in a category by itself. Table 5 details the tests included in each of the composite categories.

With respect to the composite categories, two additional variables were formed for the NLD group. One was labeled "decline" and consisted of the average of the WRAT Arithmetic subtest, visual-spatial, complex motor, complex tactile, and problem solving composites. The other was labeled "stable" and consisted of the average of the verbal I, verbal II, simple motor, simple tactile, and reading/spelling composites.

Because no composite domains were predicted to decline for the group with BPPD, only a "stable" variable was formed made up of the average of the seven composite scores for which predictions for the group with BPPD were rendered. These included- WRAT Arithmetic subtest, verbal I, verbal II, visual-spatial, complex motor, problem solving, and reading/spelling.

Data Analyses

All tests were calculated in terms of norms for age and gender. Test scores were converted to *T* scores. *T* scores greater than 50 were adjusted to reflect better scores on all tests.

Goal 1: *T* scores on all administered measures for the young and older children with NLD and BPPD were plotted. Average scores on composite domains, for both children with NLD and BPPD were also plotted. Spearman rank-order

Table 4
Tests/Subtests Utilized in the Investigation

TEST/*SUBTEST* NAME	DESCRIPTION
Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1949) *Information Subtest.*	Orally presented questions involving elementary factual knowledge of history, geography, current events, literature, and general science. Score: number of items correct. Task requirement: retrieval of acquired verbal information. Stimulus: spoken question of fact. Response: spoken answer.
WISC (Wechsler, 1949) *Similarities Subtest.*	The most essential semantically common characteristic of word pairs must be stated. Score: number correct. Task requirement: verbal abstraction. Stimulus: spoken question. Response: spoken answer.
WISC (Wechsler, 1949) *Block Design Subtest.*	Arrangement of colored blocks to form designs which match those on printed cards. Score: total score for speed and accuracy of block placement. Task requirement: arrangement of blocks to match a printed design. Stimulus: printed geometric design. Response: manipulation and arrangement of blocks.
WISC (Wechsler, 1949) *Object Assembly Subtest.*	Formboard (puzzles). Parts of each formboard are to be arranged to form a picture. Score: total score for speed and accuracy of assembly. Task requirement: spatial arrangement of parts to form a meaningful whole. Stimulus: disarranged parts of picture. Response: complex manipulation and arrangement of parts.
WISC (Wechsler, 1949) *Vocabulary Subtest.*	Spoken definition of words. Score: number of words correct. Task requirement: verbal definition. Stimulus: spoken word. Response: spoken definition.

Table 4 Continued

Tactile Perception (Reitan & Davison, 1974)	The examinee is required to identify correctly (without vision) the hand or face (left or right) which receives tactile stimulation. The stimulus is produced by a light touch. Following this determination of the examinee's ability to perceive unilateral stimulation, simultaneous bilateral hand stimulation and contralateral hand-face stimulation are interspersed with unilateral stimulation. The score is the number of errors for each hand and each side of the face under all conditions.
Target Test (Reitan & Davison, 1974)	The examinee is required to make a delayed response in reproducing visual-spatial configurations of increasing complexity tapped out by the examiner. The score is the number of items out of 20 correctly reproduced.
Auditory Closure Test (Kass, 1964)	The examinee is required to blend into words 23 progressively longer chains of sound elements presented on tape. The score is the number of words correctly identified.
Sentence Memory Test (Benton, 1965)	The examinee is required to repeat sentences of gradually increasing length (from 2 to 26 syllables). These are presented on a tape recorder. The score is the number of sentences correctly repeated.
Speech-Sounds Perception Test (Reitan & Davison, 1974)	The examinee is required to attend to 30 tape-recorded nonsense syllables and to select the correct response alternative from among three printed choices. The score is the number of sounds correctly identified.
Halstead Category Test (Reitan & Davison, 1974)	This test consists of 186 visual-choice stimulus figures which are presented to the examinee individually on a milk-glass screen located on the front of the apparatus. An answer panel is provided for the examinee. This consists of four answer buttons which are individually identified by the numbers 1,2,3, and 4. The child's task is to view the stimulus figure and to offer his/her answer by depressing one of the four answer buttons. A pleasant bell sounds after each correct response and a harsh buzzer sounds after each incorrect response. The bell and buzzer, therefore, provide the essential information necessary for determining the concept underlying the stimulus figures. In successive sequences of trials, the abstraction of numerosity, oddity, spatial position, and relative extent is required for successful responding. The final subtest of the Category Test is of a summary nature and therefore does not have a principle to be discerned. The examinee is told to try to remember the correct answer based in his/her previous observation of the item and to give the same answer again. The score is the number of errors.

Table 4 (continued)

Maze Test (Kløve, 1963; Knights & Moule, 1968; Rourke & Teledgy, 1971)	The examinee is required to run a stylus through a maze which has the blind alleys filled and is placed at a 70 degree angle. Three scores are obtained: the number of contacts with the side of the maze, the total amount of time during which the stylus contacts the side of the maze, and the speed (total time from start to finish). These are electrically recorded. There are two successive trials with each hand. The scores are the totals for the two trials with the dominant hand and the two trials with the non-dominant hand.
Grooved Pegboard Test (Kløve, 1963, Knights & Moule, 1968; Rourke, Yanni, MacDonald, & Young, 1973)	The examinee is required to fit keyhole-shaped pegs into similarly shaped holes on a 4" x 4" board beginning at the left side with the right hand and at the right side with the left hand. The examinee is urged to fit all 25 pegs in as rapidly as possible. One trial is performed with the dominant hand followed by one trial with the non-dominant hand. The scores obtained are the length of time required to complete the task with each hand and the total number of times the pegs are dropped with each hand.
Tactual Performance Test (Reitan & Davison, 1974)	The examinee is blindfolded and not permitted to see the formboard or blocks at any time. The formboard is placed in a vertical disposition at an angle of 70 degrees on a stand situated on a table immediately in front of the examinee. He/she is to fit blocks into the proper spaces with the dominant hand, then with the nondominant hand, and a third time using both hands. After the board and blocks have been put out of sight, the blindfold is removed and the examinee is required to draw a diagram of the board representing the blocks in their proper spaces. In all, six measures are obtained. Scoring is based on the time needed to place the blocks on the board with the dominant, the non-dominant, and both hands. A fourth measure is the sum of the time taken with the right, left, and both hands. The Memory component of this test is the number of blocks correctly reproduced in the drawing on the board; the Location component is the number of blocks correctly localized in the drawing.
Fingertip Number-Writing Perception (Reitan & Davison, 1974)	The examinee is required to verbalize (while prevented from using the aid of vision) which of the numbers 3, 4, 5, or 6 has been written on his/her fingertips. A different finger of the right hand is used for each trial until four trials have been given for each finger. The procedure is then repeated for the left hand. The score is the number of errors made with each finger for each hand.

Asterognosis (Coin Recognition) (Reitan and Davison, 1974)	The examinee is required to identify, by tactile perception only, 1-, 5-, and 10-cent pieces placed in their right and left hand, and then each coin is placed simultaneously in both hands. The score is the number of errors made with each hand under each condition.
Finger Agnosia (Reitan and Davison, 1974)	The examinee is required to identify (while prevented from using the aid of vision) the finger which has been touched. Each of the five fingers is stimulated four times in a random order. First the right hand and then the left hand is stimulated. The score is the number of errors made with each finger for each hand.
Strength of Grip (Reitan and Davison, 1974)	The Smedley Hand Dynamometer is used to measure strength of grip. The child is required to squeeze the dynamometer three times with the dominant hand, alternating between hands, on each trial. The mean pressure which the hand exerts on the three trials is recorded (kilograms) for each hand.
Graduated Holes Test (Kløve, 1963; Knights & Moule, 1968; Rourke & Telegdy, 1971)	The child is required to fit a stylus into a series of progressively smaller holes. The idea is to hold the stylus in the center of the holes for a 10-second period without contacting the edge. Two scores are obtained: the number of contacts with the edge of the hole, and the duration of the contact. These are recorded electrically. The test is performed once with the right hand and once with the left hand.
Wide Range Achievement Test/Wide Range Achievement Test-Revised (Jastak & Jastak, 1965; Jastak & Jastak, 1984)	
Reading Subtest	Standardized test of oral word-reading achievement. The child is given a list of printed words that they must say out loud.
Spelling Subtest	Standardized test of written spelling achievement. Words are spoken to the child one at a time and the child must write them down.
Arithmetic Subtest	Standardized test of written arithmetic achievement. The child is given a series of arithmetic problems they must solve on paper, within a given time frame.

adapted from Rourke (1989)

Table 5
Test/Subtest Distribution in Composite Categories

Composite Category	Tests/Subtests
Verbal I	INFO, SIMIL, VOCAB
Verbal II	SSPT, AUDCLO, SMEM
Visual-Spatial	BLKDES, OBJASS, TARGET
Simple Motor	GSR, GSL, HSR, HSL
Complex Motor	PEGSR, PEGSL, MAZER, MAZEL
Simple Tactile	TIMP, TSUPP
Complex Tactile	TACR, TACL
Concept Formation/Problem Solving	CATTOT, TPTBT
Reading/Spelling	READ, SPELL
Arithmetic	ARITH

Abbreviations: INFO, WISC Information subtest; SIMIL, WISC Similarities subtest; VOC, WISC Vocabulary subtest; WISC Comprehension subtest; SSPT, Speech-Sounds Perception Test; AC, Auditory Closure Test; SMEM, Sentence Memory Test; TARGET, Target Test; BLKDES, WISC Block Design subtest; OBJASS, WISC Object Assembly subtest; GSR/L, Grip Strength right/left hand performance; HSR/L, Holes right/left hand performance; PEGSR/L, Grooved Pegboard right/left hand performance; MAZER/L, Maze Test Right/Left hand performance,TIMP/TSUPP, Tactile Imperception and Suppression (both right and left hands), TACR/L, Tactile Right/Left hand (includes Finger-tip Number Writing, Finger Agnosia, and Astereognosis); TPTBT, Tactual Performance Test- both hand performance; CATTOT, total errors on Halstead Category Test; READ, WRAT Reading Subtest; SPELL, WRAT Spelling subtest; ARITH, WRAT Arithmetic subtest.

correlation was used to establish the relative similarity of patterns of neuropsychological assets and deficits for the young and older children with NLD and BPPD, respectively. Spearman correlations were also calculated between the profiles of the young children in each LD subtype and between the profiles of the older children in each LD subtype to determine degree of similarity with respect to neuropsychological assets and deficits. All correlations were assessed for magnitude using guidelines set forth by Cohen (1988). These guidelines are presented in Table A1 of Appendix A.

Goal 2:

<u>NLD</u>

For the NLD group, two separate univariate repeated measures ANOVAs were conducted. The first compared the young and older children's scores on the "decline" variable; this consisted of the average of the five composite scores predicted to decline. The second compared the young and older children's scores on the "stable" variable; this consisted of the average of the five composite scores predicted to remain relatively stable. Differences with respect to specific composite categories were subsequently analyzed using 10 paired-sample *t* tests to compare the young and older children's scores on each of the 10 composites. Main effects of the uivariate ANOVAs were analyzed with an alpha of .05. Main effects of the paired sample *t* tests were analyzed with an alpha of .05 adjusted using Bonferroni correction.

BPPD

For the children in the BPPD group, one repeated measures univariate ANOVA was conducted on the variable labeled "stable", which consisted of the average scores on all seven composite categories. Again, specific differences on composite scores were subsequently analyzed using seven separate paired-sample *t* tests. The main effect of the univariate ANOVA was analysed using an alpha of .05. Main effects of the paired-sample *t* tests were analyzed with an alpha of .05 adjusted using Bonferroni correction.

Chapter Three: Results

Goal One: *T* scores on all administered tests, and scores on composite domains, were plotted for groups of young and older children with NLD and BPPD. Spearman rank-order correlations were computed between both young and old NLD and BPPD groups to determine the relative similarity of profiles across ages for each LD subtype. Spearman correlations were also calculated between the profiles of the young children in the two LD subtypes, and the older children in the two LD subtypes.

Hypothesis 1

(a) It was predicted that the neuropsychological profiles of the young and older children with NLD would be highly correlated and characterized by similar relative patterns of assets and deficits. The neuropsychological profiles of average *T* scores on all administered tests for the young and older children with NLD are plotted in Figure 1. Profile scores on the 10 composite categories for both young and older children with NLD are plotted in Figure 2. The profiles of the young and older children with NLD were highly correlated, $r_s = .600$, $p < .01$.

The profiles were characterized, for the most part, by similar relative patterns of neuropsychological assets and deficits. Relative strengths, for both young and older children with NLD, in the composite domains of verbal I, verbal II, simple motor, simple tactile and reading/spelling are noted in Figure 2. Conversely, relative weaknesses, are noted on visual-spatial, complex motor, complex tactile, problem solving, and arithmetic domains.

Figure 1. Graph of *T* Scores on all administered tests for subjects in the NLD condition.

Note. Abbreviations include; viq, piq, fsiq, Verbal, Performance and Full Scale Intelligence Scores on the Wechsler Intelligence Scale for children (WISC); inf, sim, voc, blk, objass, WISC-Information, Similarities, Vocabulary, Block Design and Object Assembly subtests; read, spell, arith, Wide Range Achievement Test- Reading, Spelling and Arithmetic subtests; ssper, Speech Sounds Perception; audclo, Auditory Closure; senmem, Sentence Memory; tacr/l, Tactile Imperception right/hand scores; fagr/l, Finger Agnosia right/left; ftwrr/l, Fingertip Writing right/left; asr/l, Asterognosis right/left; dynr/l, Grip Strength right/left hands; hold/nd, Holes Test of Static Steadiness dominant/non-dominant performances; mzed/nd, Mazes dominant/non-dominant performances; pegd/nd, Grooved Pegboard dominant/non-dominant hand performances; catt, Category Test; target, Target Test; tptbt, Both Hands Trial of the Tactual Performance Test.

Figure 1

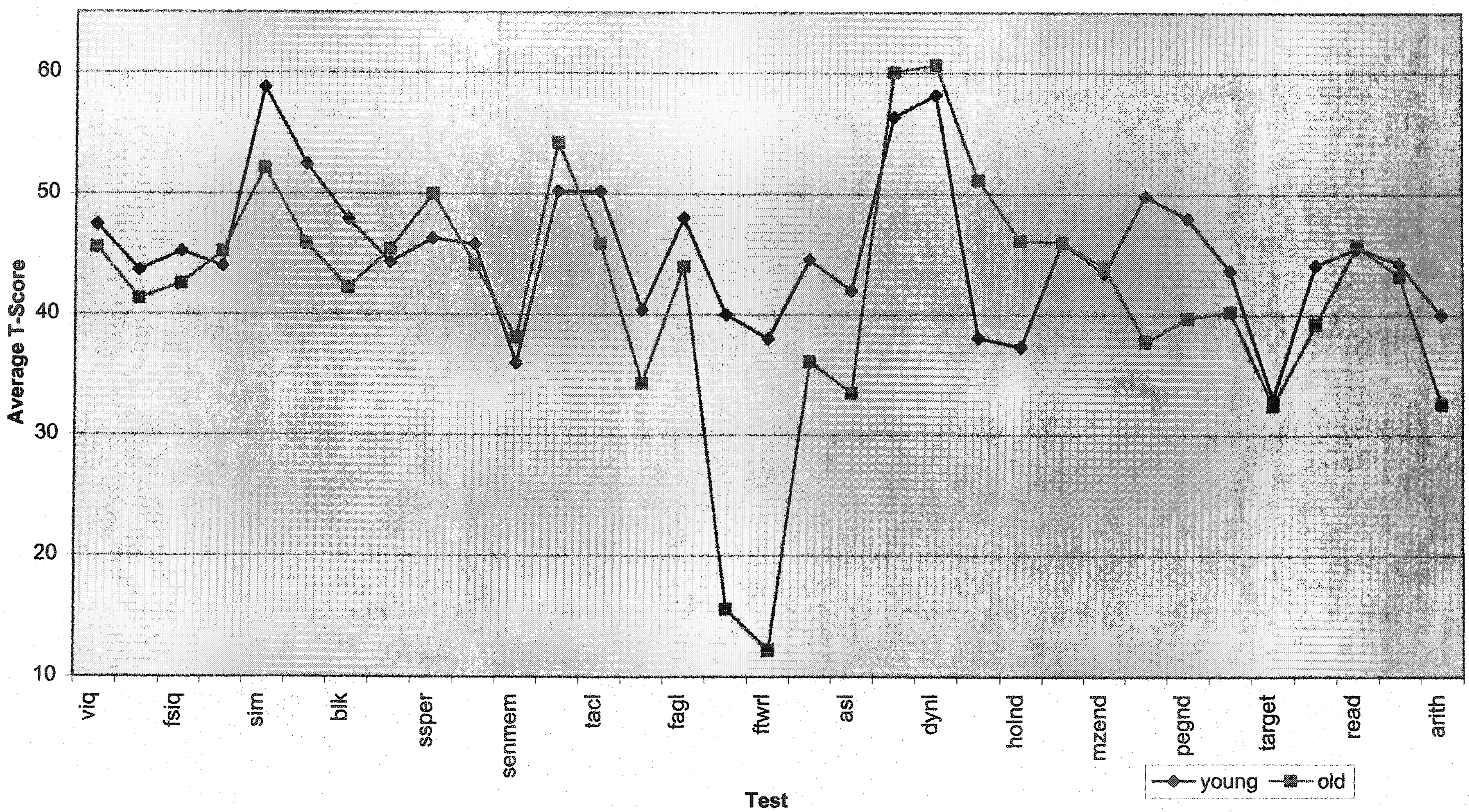
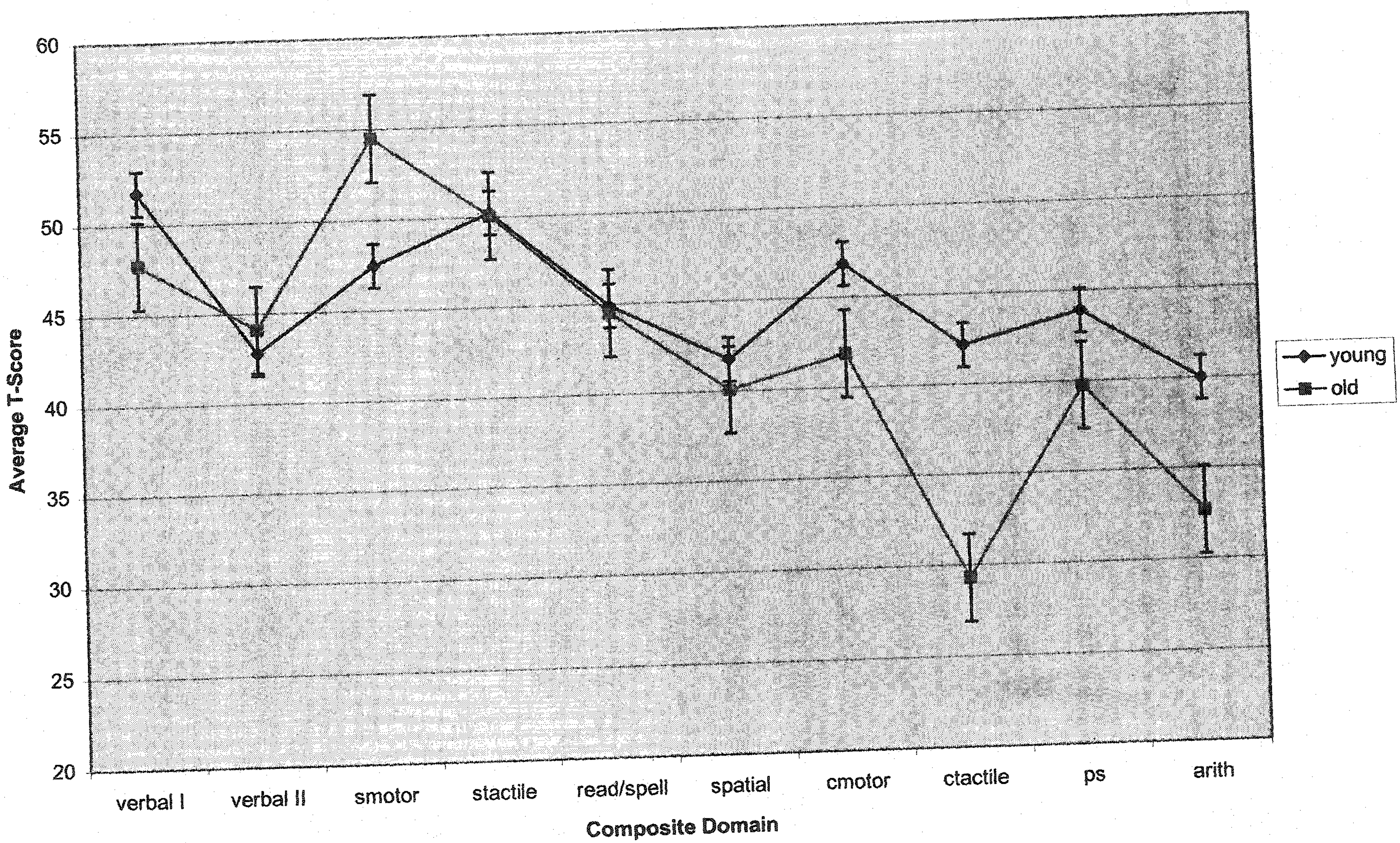

Average T-Score
60
50
40
30
20
10
viq
fsiq
sim
blk
ssper
senmem
tacl
fagl
ftwrl
asl
dynl
holnd
mzend
pegnd
target
read
arith
Test
young
old

Figure 2. Graph of Composite Scores for Subjects in the NLD Group.

Note. Composite Abbreviations; smotor, simple motor; stactile, simple tactile; read/spell, WRAT reading and spelling; cmotor, complex motor; ps, problem solving; arith, WRAT Arithmetic.

Figure 2


60
55
50
45
40
35
30
25
20
Average T-Score
verbal I
verbal II
smotor
stactile
read/spell
spatial
cmotor
ctactile
ps
arith
Composite Domain
young
old

The correlation between the profiles increased to .700 when scores on the Grooved Pegboard Test (GPT) were excluded from the analysis. When the 33 measures used for profile correlation were ranked, the young children ranked 7th and 8th with respect to dominant and non-dominant hand performances on the GPT (higher ranks representing better scores). However, the scores for the older children ranked 24th and 22nd for dominant and non-dominant hand performances on the GPT. Clearly, the young children with NLD performed in a superior manner to the older children on the GPT relative to the other measures administered.

(b) It was expected that the profiles of the young and older children with BPPD would be highly correlated and characterized by similar relative patterns of neuropsychological assets and deficits. The neuropsychological profiles of average *T* scores on all administered tests for the young and older children with BPPD are plotted in Figure 3. Average scores on all composite domains, for both young and older groups, are presented in Figure 4. The profiles of the young and older children with BPPD were highly correlated, $r_s = .710$, $p < .01$, suggesting similar relative patterns of neuropsychological assets and deficits.

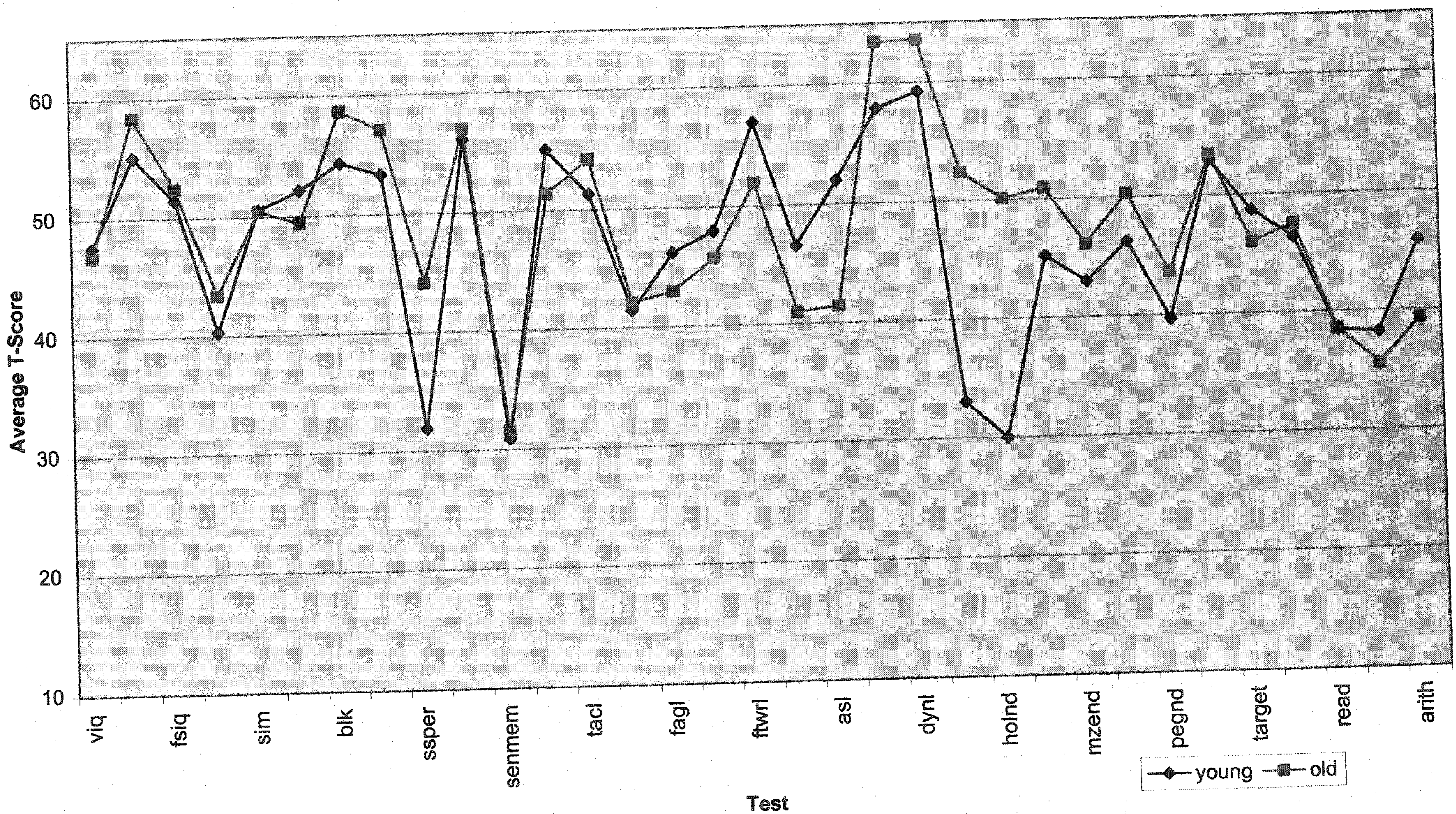
Relative strengths in arithmetic and on visual-spatial, complex motor, and problem solving domains and relative weaknesses in verbal I, verbal II, and reading/spelling domains are noted in Figure 4.

(c) Relative to the correlations between the young and older children within each LD subtype it was expected that the correlations between the profiles of the young children with NLD and BPPD, and the older children with NLD and BPPD

Figure 3. Graph of *T* Scores on all administered tests for subjects in the BPPD condition.

Note. Abbreviations include; viq, piq, fsiq; Verbal, Performance and Full Scale Intelligence scores on the Wechsler Intelligence Scale for Children (WISC); inf, sim, voc, blk, objass, WISC-Information, Similarities, Vocabulary, Block Design and Object Assembly subtests; read, spell, arith, Wide Range Achievement Test- Reading, Spelling and Arithmetic subtests; ssper, Speech Sounds Perception; audclo, Auditory Closure; senmem, Sentence Memory; tacr/l, Tactile Imperception right/hand scores; fagr/l, Finger Agnosia right/left; ftwrr/l, Fingertip Writing right/left; asr/l, Asterognosis right/left; dynr/l, Grip Strength right/left hands; hold/nd, Holes Test of Static Steadiness dominant/non-dominant performances; mzed/nd, Mazes dominant/non-dominant performances; pegd/nd, Grooved Pegboard dominant/non-dominant hand performances; catt, Category Test; target, Target Test; tptbt, Both Hands Score of the Tactual Performance Test.

Figure 3

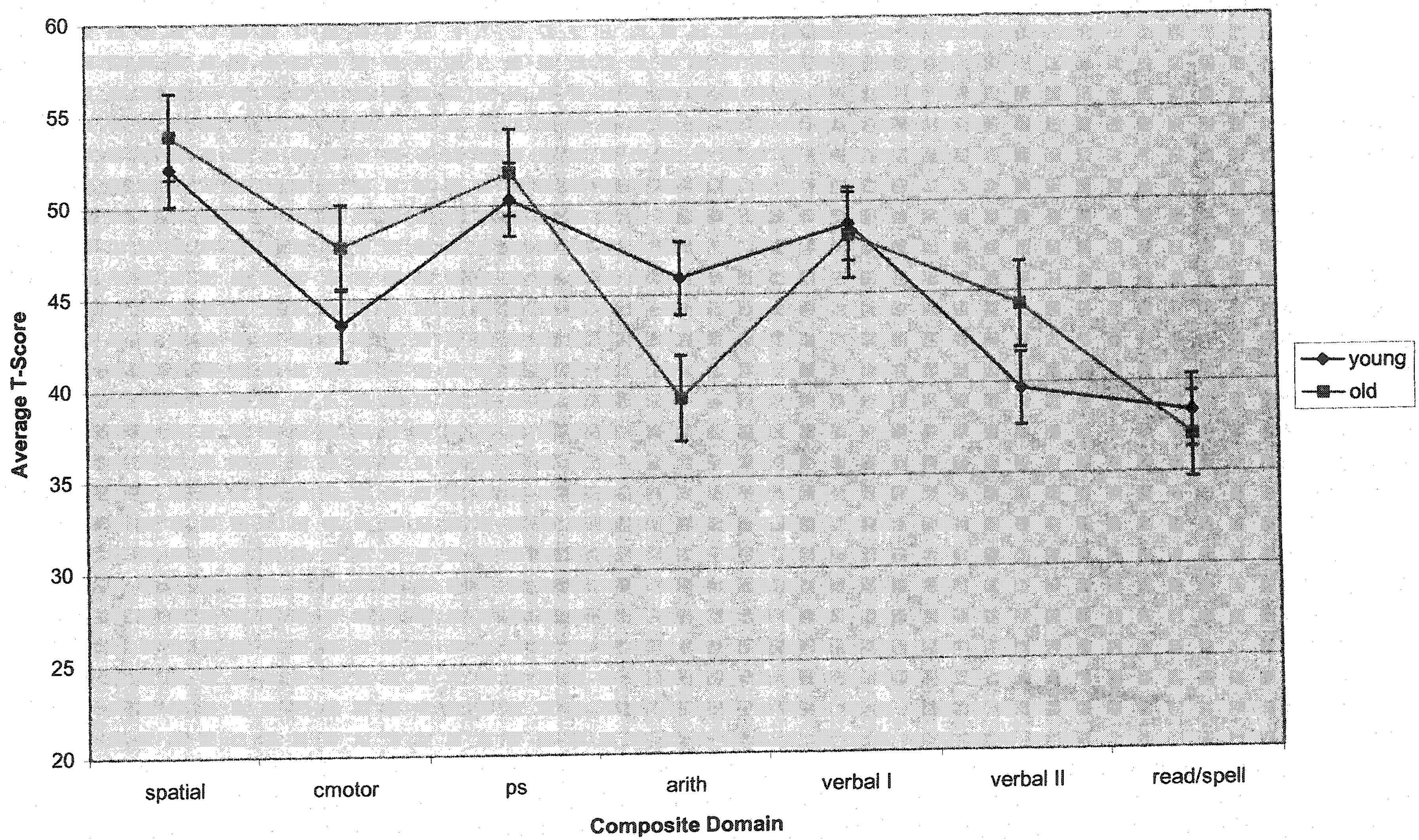


Average T-Score
60
50
40
30
20
10
viq
fsiq
sim
blk
ssper
senmem
tacl
fagl
ftwrl
asl
dynl
holnd
mzend
pegnd
target
read
arith
young
old
Test

Figure 4. Graph of Composite Scores for Subjects in the BPPD Group.

Note. Composite Abbreviations include; cmotor, complex motor; ps, problem solving; arith, WRAT Arithmetic; read/spell, WRAT Reading and Spelling.

Figure 4



60
55
50
45
40
35
30
25
20
Average T-Score
spatial
cmotor
ps
arith
verbal I
verbal II
read/spell
Composite Domain
young
old

would be low. The neuropsychological profiles of *T* scores on all administered tests for the young children in each LD subtype, and the older children in each LD subtype are shown in Figures 5B and 6B, respectively (see Appendix B). The correlation between the profiles of the young children with NLD and BPPD was moderate, $r_s = .358$, $p < .05$, as was the correlation between the profiles of the older children with NLD and BPPD, $r_s = .421$, $p < .05$. Neither of these values differed significantly from the correlations comparing the young and older children within each LD subtype (see Table 6).

When correlations were converted to *Z* scores and compared, the correlation between the profiles of the young and older children with NLD was not significantly different from that of the correlation comparing the profiles of the children with NLD and BPPD at either age. Similarly, the correlation comparing the profiles of the young and older children with BPPD was not significantly different from that of the correlation comparing children with NLD and BPPD at either age.

Goal Two: The second goal of the present investigation was to compare the composite category averages for the young and older children with NLD and BPPD, respectively.

Hypothesis 2

(a) It was predicted that composite category averages reflecting areas of neuropsychological deficit would be significantly poorer (relative to age-based norms) in the older children with NLD than in the young children. The results of the univariate repeated measures analysis on the "decline" variable, which

Table 6
Tests of Significance Between the Various Correlation Coefficients

Comparison	Coefficients	$Z_{difference}$	Significance
r_{s1} vs. r_{s3}	.600 vs. .358	.552	p>.05
r_{s1} vs. r_{s4}	.600 vs. .421	.424	p>.05
r_{s2} vs. r_{s3}	.710 vs. .358	.984	p>.05
r_{s2} vs. r_{s4}	.710 vs. .421	.760	p>.05

Note. r_{s1} Correlation between the profiles of the young and older children with NLD.
r_{s2} Correlation between the profiles of the young and older children with BPPD.
r_{s3} Correlation between the profiles of the young children in each LD subtype.
r_{s4} Correlation between the profiles of the older children in each LD subtype.
$Z_{difference}$ Z- Score value for the difference between each pair of correlations.

consisted of the average of the five composite scores predicted to decline between the young and older children with NLD, was significant, $F(1,4) = 10.65$, $p < .05$. Overall, the older children with NLD performed worse than the young children (relative to age-based norms) with regard to relative neuropsychological deficits.

Table 8 displays the results of the 10 separate paired sample *t*-tests for each of the 10 composite categories. It is apparent that the older children with NLD performed in a particularly inferior manner (relative to age-based norms) on the complex tactile, $t(8) = 4.80$, $p < .05$, and arithmetic composites, $t(8) = 8.03$, $p < .01$. Although the scores of the older children with NLD were lower than the scores of the young children with respect to all five composite categories that were predicted to decline (Figure 2), only their performances in complex tactile and arithmetic domains were significantly worse.

It appears that the significantly poorer performance of the older children with NLD on the complex tactile composite was mostly attributable to their deficient performance on Fingertip Writing (see Table 7). The young children with NLD performed approximately 1 standard deviation (SD) below the mean bilaterally; however, the older children performed greater than 3 SD below the mean bilaterally (relative to age-based norms).

The older children with NLD had poorer arithmetic performances than the young children (relative to age-based norms). The young children performed approximately 1 SD below the mean and the older children performed almost 2 SD below the mean.

Table 7
Means and Standard Deviations of T scores for the Young and Old children in the NLD group on predicted "stable" and "decline" measures

	Young	Old
Intelligence		
VIQ	47.4 (3.6)	45.6 (5.1)
PIQ	43.7 (4.9)	41.3 (6.3)
FSIQ	45.2 (3.9)	42.6 (5.6)
"Stable Domains" Verbal I		
INF	44.0 (5.9)	45.2 (7.2)
SIM	58.8 (2.1)	52.1 (4.7)
VOC	51.8 (4.9)	45.9 (2.2)
Verbal II		
SSPT	46.3 (8.1)	50.0 (6.2)
AUDCLO	45.8 (3.2)	44.1 (5.8)
SENMEM	36.0 (7.2)	38.1 (9.2)
Simple Tactile		
TACR	50.2 (12.0)	54.2 (6.4)
TACL	50.2 (6.5)	45.9 (11.4)
Simple Motor		
DYNR	56.3 (5.7)	60.1 (7.8)
DYNL	58.2 (5.3)	60.7 (4.9)
HOLD	38.1 (16.2)	51.1 (13.8)
HOLND	37.3 (16.3)	46.1 (15.4)
"Decline Domains" Spatial		
BLK	47.9 (7.5)	42.2 (5.3)
OBJASS	44.3 (4.7)	45.4 (9.6)
TARGET	33.0 (14.9)	32.5 (14.8)
Complex Motor		
MZED	46.0 (9.3)	46.0 (9.6)
MZEND	43.4 (10.2)	44.0 (12.2)
PEGD	49.8 (4.9)	37.8 (9.5)
PEGND	48.0 (8.1)	39.7 (16.5)
Complex Tactile		
FAGR	40.4 (21.5)	34.3 (21.1)
FAGL	48.0 (8.6)	44.0 (11.7)
FTWRR	40.0 (8.3)	15.6 (4.4)
FTWRL	38.0 (3.9)	12.2 (2.1)
ASR	44.6 (10.5)	36.1 (15.0)
ASL	42.0 (8.4)	33.5 (8.3)
Problem Solving		
CATT	43.7 (11.9)	40.3 (9.5)
TPT-BT	44.1 (13.4)	39.2 (9.1)
WRAT Read/Spell		
Reading	45.6 (12.2)	45.8 (12.7)
Spelling	44.2 (10.3)	43.2 (11.4)
WRAT Arithmetic		
Arithmetic	40.0 (2.2)	32.6 (2.0)

Table 8
Paired Sample *t* test Results for the 10 Composite Categories for Subjects in the NLD Condition

Within Subjects Factor	*MI*	*M2*	*df*	*t*	Significance
Verbal I	51.74	47.74	8	3.05	.016
Verbal II	42.77	44.09	8	-.738	.482
Spatial	41.74	40.06	8	.889	.400
Simple Motor	47.48	54.50	8	-3.44	.009
Complex Motor	46.82	41.88	8	2.14	.065
Simple Tactile	50.22	50.06	8	.046	.964
Complex Tactile	42.16	29.30	8	4.80	.001*
Problem Solving	43.90	39.80	8	1.44	.187
Reading/Spelling	44.90	44.50	8	.201	.845
Arithmetic	40.00	32.67	8	8.03	.000*

Note. *Indicates significance at an alpha level of .05 adjusted using Bonferroni correction.
MI= Mean T score at first testing.
M2=Mean T score at second testing.

Within the context of the NLD model, decisions regarding significant changes in arithmetic are made relative to scores in reading and spelling. As such, the current finding of a significant difference in arithmetic scores between the young and older children with NLD has to be considered relative to reading/spelling composite scores. The arithmetic scores of the young children with NLD were not significantly different from their scores on the reading and spelling composites, $t(8) = 1.46$, $p > .05$. However, the arithmetic scores of the older children with NLD were significantly less than their scores on the reading and spelling composites, $t(8) = 2.99$, $p < .05$. Table 8 indicates that the scores of the young and older children on the reading/spelling composite are nearly identical; however, their scores on the WRAT Arithmetic measure declined.

(b) It was expected that the children with BPPD would exhibit age-appropriate development with regard to their neuropsychological deficits. The results of the univariate repeated measures analysis on the "stable" variable, which consisted of an average of all seven composite scores for the children with BPPD, was not significant. Overall, the older children with BPPD did not perform in a manner that was significantly different from the young children. Inspection of Table 9 reveals that none of the paired sample *t*-tests for scores in the domains of verbal I, verbal II, or reading/spelling was significant, suggesting that relative deficits in these three areas developed in an age-appropriate manner.

Table 9
Paired Sample *t* test results for the Seven Composite Categories for Subjects in the BPPD Condition

Within-Subjects Factor	*MI*	*M2*	*df*	*t*	Significance
Verbal I	48.75	48.14	8	.269	.795
Verbal II	39.65	44.26	8	2.14	.064
Spatial	52.11	53.93	8	1.13	.291
Complex Motor	43.54	47.78	8	1.50	.173
Problem Solving	50.32	51.79	8	.516	.620
Reading/Spelling	38.33	37.06	8	1.04	.331
Arithmetic	45.89	39.33	8	3.70	.006*

Note. * Indicates significance at an alpha of .05 adjusted using Bonferroni correction.
MI= Mean T score at first testing.
M2= Mean T score at second testing.

Hypothesis 3

It was hypothesized that both children with NLD and BPPD would exhibit age appropriate (relative to age-based norms) development with regard to their respective neurospychological assets.

The results of the univariate repeated measures analysis on the "stable" variable, which consisted of the average of the five composite domains thought to be relative assets for the children with NLD was not significant. Overall, the older children with NLD did not perform in a significantly different manner from the young children (relative to age-based norms) with regard to neuropsychological assets. Inspection of Table 8 reveals that none of the paired sample *t*-tests comparing composite scores between the young and older children with NLD in the five areas of verbal I, verbal II, simple motor, simple tactile, or reading/spelling was significant. This suggests that the relative neuropsychological assets of the children with NLD in this study developed in an age-appropriate manner (relative to age-based norms). Although not statistically significant, a trend was evident wherein the older children with NLD performed better than the young children (relative to age-based norms) on the simple motor composite (Figure 2). It would appear that this difference was primarily attributable to the Holes Test of static steadiness (see Table 7). On this measure, the young children with NLD scored approximately 2 SD below the mean, whereas the older children performed in an average fashion.

Domains representing relative neuropsychological assets that were predicted to remain relatively stable for the children with BPPD were visual-spatial, complex motor, problem solving, and arithmetic. An examination of Table 9 indicates that the older children with BPPD did not perform in a significantly different manner from the young children in any of the domains except for arithmetic. The difference on the WRAT Arithmetic measure between the young and older children was significant, $t(8)= 3.70$, $p<.05$, but not in the predicted direction. The older children with BPPD did worse than the young children on this measure (See Table 10). Again, within the context of the model developed for BPPD, arithmetic must be considered with reading/spelling composite scores at each age. The arithmetic scores of the young children with BPPD were significantly better than their scores on the reading/spelling composite, $t(8)= 5.92$, $p<.01$. The older children with BPPD did not have scores on arithmetic that were significantly different from their scores on the reading/spelling composite, $t(8)= 1.92$, $p>.05$. Relative to reading/spelling, scores in Arithmetic for the children with BPPD declined.

Table 10
Means and Standard Deviations of Subtests Making up Composite Categories for BPPD Subjects

	Young	Old
Intelligence		
VIQ	47.6 (9.2)	46.8 (6.2)
PIQ	55.1 (4.5)	58.4 (7.2)
FSIQ	51.4 (6.5)	52.4 (5.6)
Verbal I		
INF	40.3 (11.2)	43.4 (6.8)
SIM	50.6 (9.9)	50.4 (5.8)
VOC	52.1 (10.9)	49.4 (5.9)
Verbal II		
SSPT	31.9 (12.9)	44.2 (17.0)
AUDCLO	56.2 (10.6)	57.0 (8.9)
SENMEM	30.9 (8.3)	31.6 (8.7)
Spatial		
BLK	54.3 (6.6)	58.7 (7.7)
OBJASS	53.3 (5.1)	57.1 (6.1)
TARGET	48.7 (7.2)	46.0 (13.4)
Complex Motor		
MZED	45.2 (7.4)	50.9 (6.8)
MZEND	43.0 (8.3)	46.2 (6.8)
PEGD	46.3 (17.4)	50.3 (8.8)
PEGND	39.7 (16.9)	43.7 (14.4)
Problem Solving		
CATT	52.9 (11.4)	53.44 (8.8)
TPT-BT	46.3 (12.1)	47.4 (18.4)
WRAT Read/Spell		
Reading	38.4 (4.1)	38.6 (3.2)
Spelling	38.2 (3.7)	35.6 (4.6)
WRAT Arithmetic		
Arithmetic	45.9 (3.3)	39.3 (3.2)
Additional Tests Administered		
TACR	55.1 (5.9)	51.4 (8.9)
TACL	51.3 (8.7)	54.2 (6.7)
DYNR	57.9 (5.8)	63.4 (4.2)
DYNL	59.2 (3.8)	63.6 (6.9)
HOLD	33.1 (13.2)	52.4 (8.6)
HOLND	30.0 (14.4)	50.1 (12.7)
FAGR	41.4 (19.1)	42.1 (16.7)
FAGL	46.2 (14.3)	43.0 (15.5)
FTWRR	47.9 (14.0)	45.7 (14.9)
FTWRL	57.0 (5.9)	51.9 (10.4)

Chapter Four: Discussion

The results of the present investigation confirmed some of the predictions rendered in regard to comparative development in NLD and BPPD. It was predicted that the neuropsychological profiles of young and older children in each LD subtype would be characterized by similar relative patterns of neuropsychological assets and deficits. It was further predicted that these patterns would be consistent with models developed for NLD and BPPD in the University of Windsor laboratory. Conversely, it was predicted that there would be relatively fewer similarities between the profiles of children with NLD or BPPD at both ages.

As predicted, and most important, each LD subtype was characterized by a similar relative pattern of neuropsychological assets and deficits at each testing. The profiles of the children with NLD at both ages were characterized by relative strengths in the areas of verbal and auditory-perceptual skills, simple motor skills, simple tactile skills and reading and spelling. Relative weaknesses were in the areas of visual-spatial, complex motor, complex tactile, problem solving and arithmetic skills. The profiles of the children with BPPD exhibited a largely opposite pattern of relative strengths and weaknesses. They performed relatively well in the areas of visual-spatial, complex motor, problem solving, and arithmetic, and relatively poorly in areas related to verbal and auditory-perceptual skills and reading and spelling. Thus, patterns of performance manifested by the children in each LD subtype were consistent with models developed for children with NLD and BPPD in the University of Windsor laboratory.

There were no significant differences between the correlations comparing children across subtypes and within subtypes. A major reason for the lack of significant differences has to do with the extremely small sample size utilized in the present investigation, N=9. Furthermore, it is clearly evident from Figures 1 and 3 that the profiles of children in each of these two LD subtypes exhibited neuropsychological assets and deficits characteristic of these two subtypes of LD. It is expected that for this subset of children with NLD, the features of the NLD syndrome will become more conspicuous in the coming years. This should result in a decline in the strength of the correlation between the profiles for the children with NLD and BPPD.

The second goal of the investigation was to compare children in NLD and BPPD subtypes with respect to composite category averages. The first prediction (based on prior research) was that children with NLD would get significantly worse (relative to age-based norms) with regard to neuropsychological deficits. No such worsening was expected for the children with BPPD. Overall, the older children with NLD did more poorly than the young children with regard to composite domains reflecting areas of neuropsychological deficit (see Figure 2). However, the only composite domains that were significantly worse were complex tactile and arithmetic. In comparison, the performance of children with BPPD at second testing was not significantly different from their performance at first testing on any composite domains reflecting areas of neuropsychological deficit.

The second prediction was that children in both NLD and BPPD subtypes would perform in an age-appropriate fashion (relative to age-based norms) with regard to respective neuropsychological assets.

For both subtypes of LD, there was an age-appropriate (relative to age-based norms) development with regard to the majority of their respective neuropsychological assets. Children with NLD demonstrated age-appropriate development of relative assets in composite domains relating to verbal and auditory-perceptual, simple motor, simple tactile and reading and spelling abilities. Children with BPPD demonstrated age-appropriate development on composite domains reflecting relative strengths in the areas of visual-spatial, complex motor, and problem solving. However, the children with BPPD demonstrated a significant decline in arithmetic performance when compared with scores on reading/spelling composites.

The results of the present investigation are generally consistent with those of comparable studies examining developmental trends that have been previously carried out at the University of Windsor Laboratory.

In accordance with the findings of Casey, Rourke, and Picard (1991), the children with NLD in the present study demonstrated age-appropriate development of skills thought to be relative neuropsychological assets. However, compared to that investigation where all domains of neuropsychological deficit declined significantly, the only domains in the present study that declined significantly for the children with NLD were complex tactile and arithmetic. That said, the children with NLD in the present study did demonstrate a pattern of worsening with respect to all domains of neuropsychological deficit comparable to the Casey et al. (1991) investigation.

Ahmad and Rourke (2000) compared the neuropsychological test performances of children and adults with NLD and BPPD. They found that the individuals with NLD demonstrated a significant decline with respect to all areas of neuropsychological deficit except for the complex tactile composite. Conversely, they found that the individuals with BPPD did not reveal any significant increases/decreases with respect to composite domains representing relative neuropsychological deficits. The findings of the present investigation are generally consistent with those of Ahmad and Rourke (2000); however, in the present investigation the only two domains of deficit that declined significantly for the children with NLD were complex tactile and arithmetic. This is interesting because the only domain of deficit that did not decline significantly in the Ahmad and Rourke (2000) investigation was the complex tactile composite. This discrepancy may be explained by examining the way in which the complex tactile composite was constructed in each of the studies. In the Ahmad and Rourke (2000) investigation the complex tactile composite was composed only of the Tactual Performance Test; however, in the present investigation it was composed of the Tactual Performance Test, Fingertip Writing (greatest difference), and Astereognosis allowing for a greater window into the ability repertoire of individuals with respect to complex tactile skills.

Unlike the two above-mentioned investigations the results of the present study were not entirely consistent with those of Del Dotto et al. (1991). These researchers found that the neurocognitive abilities of individuals with NLD were stable over time. The children with NLD chosen for their study were much older than the children in the present investigation. Average age at first testing was between 9 and 15 years and at second testing was between 16 and 23 years. Clearly, they were examining children with NLD who were well into what would be deemed the formal operational period of thought.

Developmental Limitations

There are several limitations to the present study which may explain the failure to confirm some of the predictions. As many of the limitations revolve around developmental issues, a small review of the developmental theory most germane to the present study will now be considered. Jean Piaget put forth a theory of development involving four discrete and non-overlapping stages, each of which correspond roughly to an approximate age period. These are; sensorimotor (birth to two years), pre-operational (two to seven years), concrete operational (seven to eleven years) and formal operational (age twelve onwards). At each of these stages, the child in question is expected to master a constellation of cognitive skills and abilities not present in the previous stage. Of special relevance to the present investigation are the stages of concrete and formal operational thought. Although children at both these levels of thought can use symbols representationally and manipulate them logically, demonstrate conservation (understand a quantity remains the same despite changes in appearance), and seriation (putting things in order), the child in the concrete operational stage cannot apply these abilities to abstract events. For example, children at the concrete operational stage would likely have difficulty with a problem that required them to take a hypothetical view of a situation. From approximately 11-12 years of age and onward people start to develop the capacity for formal operational thought that allows them to use logical operations in an abstract rather than a concrete manner (Piaget, 1954).

This developmental paradigm is applicable to the present investigation for several reasons. The average ages at first and second testing for children in both subtypes of LD clearly precluded an accurate assessment of some of the domains investigated in this study. For example, the Category Test requires a level of abstract reasoning and concept formation that was not likely possessed by the young children in either LD subtype. In fact, the capacity of some of the older children in each LD subtype to demonstrate this style of thinking is questionable. As such, it is unclear as to what, if any significance can be attached to the findings in the problem solving domain for children in either LD subtype.

Second, the ages of the children, in both LD subtpes, at second testing were somewhat heterogenous, possibly corresponding to different developmental periods. This heterogeneity may have had an impact when comparing the young and older children within each LD subtype.

Third, children with NLD tend to be especially deficient at the skills and abilities that accompany the period of formal operational thought. It is conceivable that, for the current subset of children, the features of the NLD syndrome will become more conspicuous in the coming years. Most of the children with NLD in the present investigation were likely still operating within the concrete operational stage of thought, a level in which their unimodal and overlearned rote skills were still appropriate to the cognitive level in which they were operating.

Fourth, the measure of arithmetic ability used in the present study was the WRAT Arithmetic subtest. Although, its usage is normed for individuals between 5 and 75 years of age, it is not a good indicator of arithmetic ability in the young children (7-8 years) utilized in the present study. It is difficult to assess arithmetic ability in children at this age, regardless of the instrument used. As such, any findings of significant increases or decreases in arithmetic scores for the children with NLD and BPPD in the present investigation should be regarded with caution.

Other Limitations

As with any longitudinal investigation, one of the major considerations influencing outcome is the question of practice effects. There was an average gap of 2.5 years between testings for both children in NLD and BPPD subtypes. Due to this interval, practice effects were considered to have had a minimal impact on neuropsychological scores at second testing.

An additional factor that may have impacted the results of the present investigation was the implementation of a remedial intervention programme, for children in both NLD and BPPD subtypes. Information regarding the implementation of such a program was available for five of the children in the NLD group. Records indicated that for all five children at least some efforts had been made at intervention. For three of these five children, records indicated that a program specifically designed for children with the NLD syndrome (Rourke, 1989) was implemented after first testing. Programs for the remaining two children were implemented after second testing. Implementation of a remedial program compatible with BPPD was confirmed for three out of the nine children. Unfortunately, parent and teacher comments regarding the effectiveness of the programs were unavailable.

A significant problem in the present investigation was the lack of a legitimate "older" group of children. An inspection of Table 3 reveals that even at re-test the majority of children in both LD subtypes were between 9 and 11 years of age. It is conceivable that a greater number of hypotheses would have been confirmed if the current subset of children had been followed to older ages (12-14 years). It is at these ages that the features of the NLD syndrome would be expected to become more conspicuous.

Finally, although controlled with respect to time between testings and age matching, the small sample utilized for the present investigation results in a number of problems. The results lack generalizability because the extremely small sample size is not a good reflection of the population. The statistical power of the investigation is low, which results in an increased risk of committing a Type II error. The analyses may be missing differences between the young and older children in each LD subtype when the differences actually exist. A possible corollary to this is that a greater proportion of the rendered hypotheses may have been confirmed had a larger sample been available. Despite the various limitations imposed by the current investigation, it is likely that the findings with respect to the "decline" variables for the children with NLD (see Figure 3) are reliable.

The limitations in this longitudinal study render any definitive conclusions regarding developmental changes in NLD and BPPD tentative. These limitations, among others, include a small sample size, and the presence of at least one confounding variable in the form of treatment. That said, one can conclude from the present investigation that development in NLD and BPPD proceeds differently. Although, young and older children in both LD subytpes show age-appropriate development with regard to the majority of their respective neuropsychological assets, children with NLD seem to manifest a worsening of some of their neuropsychological deficits that is not seen in the children with BPPD.

Conclusions

Although it is acknowledged that a longitudinal investigation would be the definitive way to study the developmental progression of a disorder, it is evident here that there are usually many limitations that accompany such a design. These limitations require that the investigation be carried out with rigor in terms of design variables such as the number of subjects, age-matching, and time between testings. It is frequently the case in longitudinal investigations that one or more design variables are questionable. An analysis of the results may uncover valuable developmental patterns, however it is difficult to make definitive statements regarding development. Furthermore, longitudinal investigations are not clinically viable because withholding treatment to children with identified disabilities, such as NLD or BPPD, once identified, would be unethical.

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Appendix A

Table A1

Guidelines for Assessing the Magnitudes of Obtained Correlations

Ranges of Values	Descriptives
r= .10 to .29 or -.10 to -.29	low
r= .30 to .49 or -.30 to -.49	moderate
r= .50 to 1.0 or -.50 to –1.0	high

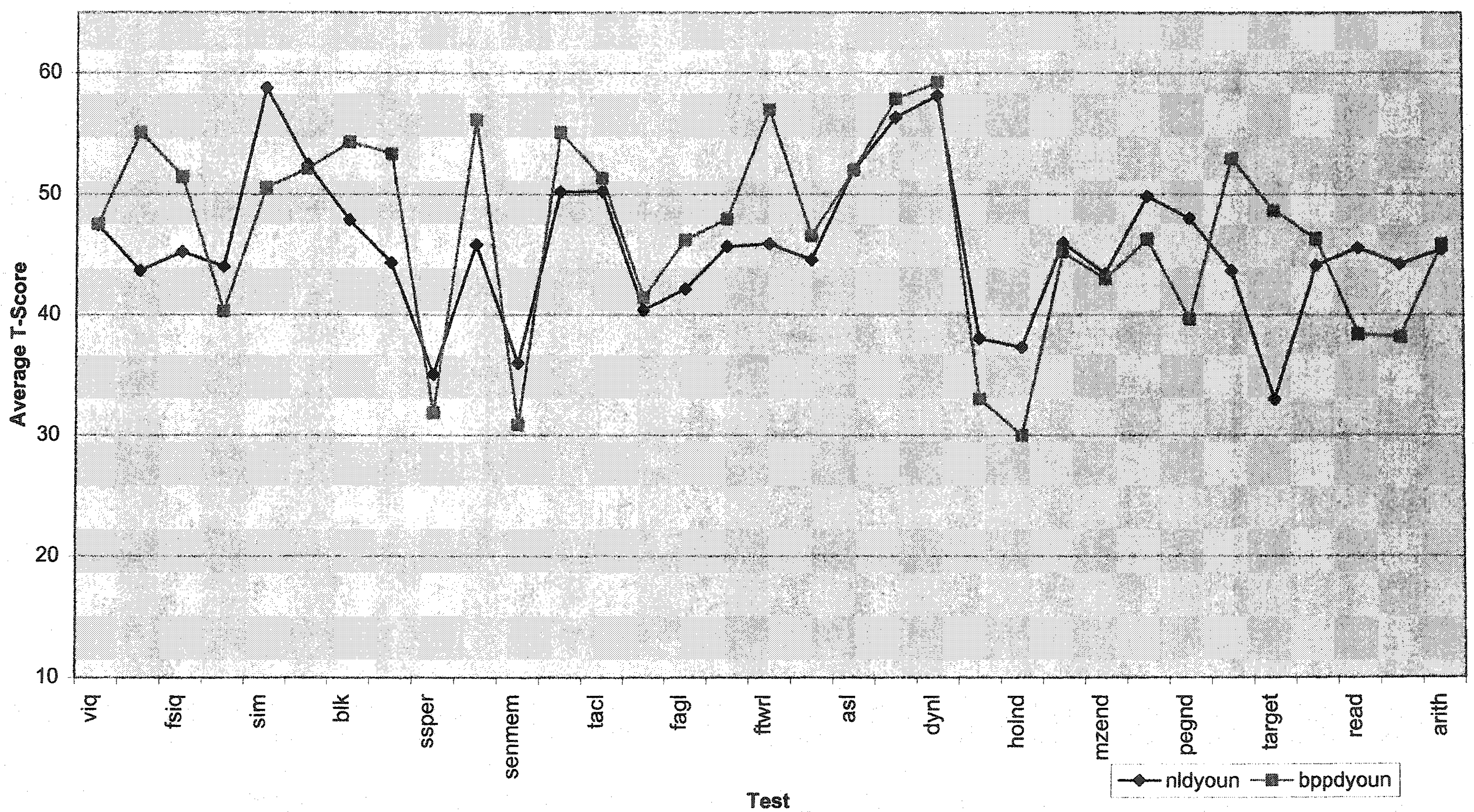
Note. Adapted from Cohen (1988)
r denotes ranges of values of the correlation coefficient.

Appendix B

Figure 5B. Average *T* Scores on all administered Tests for young children with NLD and BPPD.

Note. Abbreviations include; viq, piq, fsiq, Verbal, Performance and Full Scale Intelligence Scores on the Wechsler Intelligence Scale for children (WISC); inf, sim, voc, blk, objass, WISC-Information, Similarities, Vocabulary, Block Design and Object Assembly subtests; read, spell, arith, Wide Range Achievement Test- Reading, Spelling and Arithmetic subtests; ssper, Speech Sounds Perception; audclo, Auditory Closure; senmem, Sentence Memory; tacr/l, Tactile Imperception right/hand scores; fagr/l, Finger Agnosia right/left; ftwrr/l, Fingertip Writing right/left; asr/l, Asterognosis right/left; dynr/l, Grip Strength right/left hands; hold/nd, Holes Test of Static Steadiness dominant/non-dominant performances; mzed/nd, Mazes dominant/non-dominant performances; pegd/nd, Grooved Pegboard dominant/non-dominant hand performances; catt, Category Test; target, Target Test; tptbt, Both Hands Trial of the Tactual Performance Test.

Figure 5B



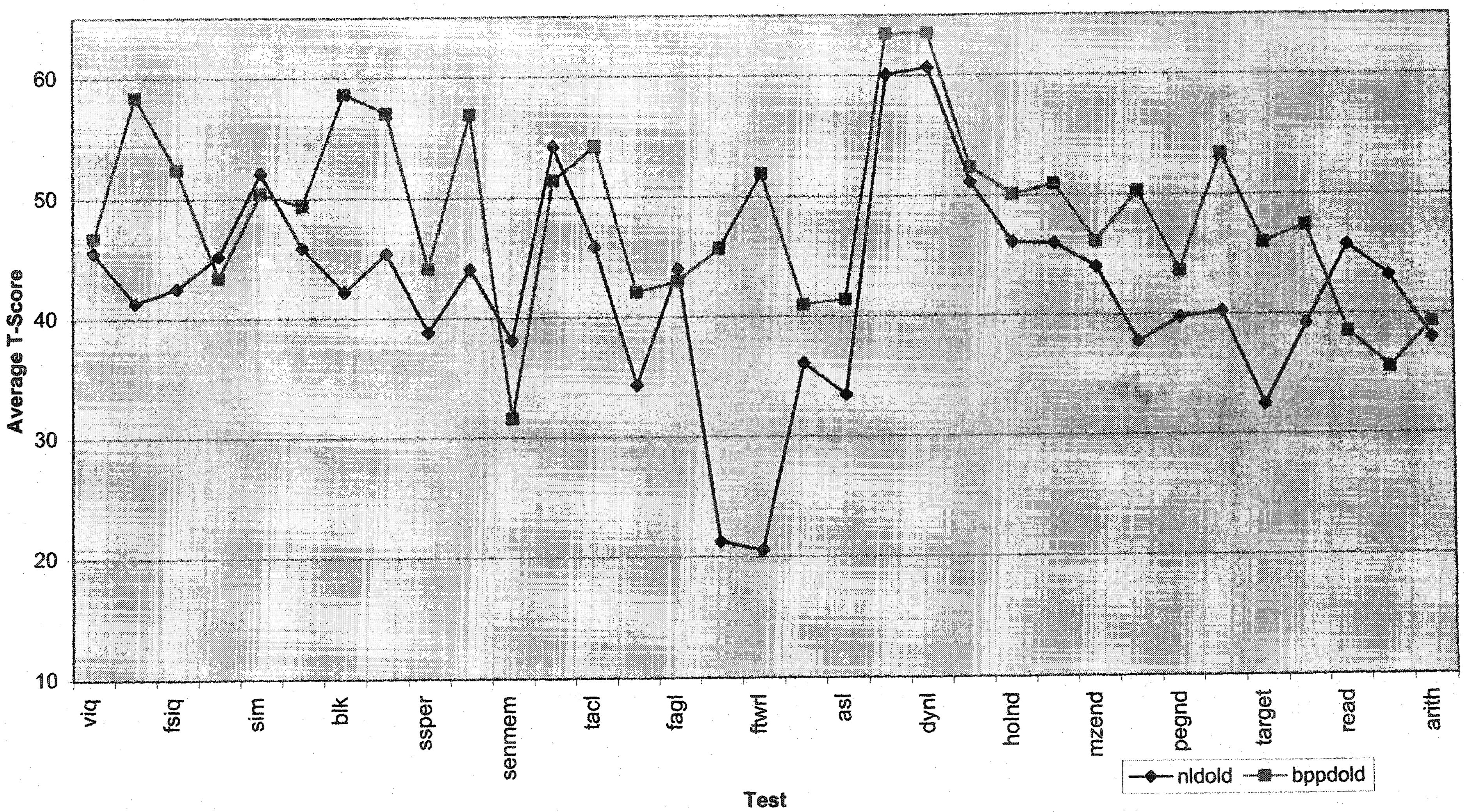
NLD vs. BPPD 73

Appendix B

Figure 6B. Average *T* Scores on all administered Tests for Old children with NLD and BPPD.

Note. Abbreviations include; viq, piq, fsiq, Verbal, Performance and Full Scale Intelligence Scores on the Wechsler Intelligence Scale for children (WISC); inf, sim, voc, blk, objass, WISC-Information, Similarities, Vocabulary, Block Design and Object Assembly subtests; read, spell, arith, Wide Range Achievement Test- Reading, Spelling and Arithmetic subtests; ssper, Speech Sounds Perception; audclo, Auditory Closure; senmem, Sentence Memory; tacr/l, Tactile Imperception right/hand scores; fagr/l, Finger Agnosia right/left; ftwrr/l, Fingertip Writing right/left; asr/l, Asterognosis right/left; dynr/l, Grip Strength right/left hands; hold/nd, Holes Test of Static Steadiness dominant/non-dominant performances; mzed/nd, Mazes dominant/non-dominant performances; pegd/nd, Grooved Pegboard dominant/non-dominant hand performances; catt, Category Test; target, Target Test; tptbt, Both Hands Trial of the Tactual Performance Test.

Figure 6B


Average T-Score
60
50
40
30
20
10
viq
fsiq
sim
blk
ssper
senmem
tacl
fagl
ftwrl
asl
dynl
holnd
mzend
pegnd
target
read
arith
Test
nldold
bppdold

VITA AUCTORIS

Nikhil S. Koushik attained his honours B.Sc. with a double major in Biology and Psychology from the University of Windsor. Throughout, his undergraduate career he had an interest in cognitive processes and neurological functioning. Shortly thereafter he enrolled in the Doctoral program in Clinical Neuropsychology at the University of Windsor, where he continues his studies.