Children's Word-Finding Test (Revised): Diagnostic utility, developmental influences, and construct dimensions in a heterogeneous clinic-referred sample.

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CHILDREN'S WORD-FINDING TEST (REVISED): DIAGNOSTIC UTILITY, DEVELOPMENTAL INFLUENCES, AND CONSTRUCT DIMENSIONS IN A HETEROGENEOUS CLINIC-REFERRED SAMPLE

by

Rosemary S. Waxman

A Thesis
Submitted to the Faculty of Graduate Studies and Research through the Department of Psychology in Partial Fulfillment of the Requirements for the Degree of Master of Arts at the University of Windsor

Windsor, Ontario
Canada

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ABSTRACT

The present work examined the clinical utility, and construct dimensions of the Children's Word Finding Test (Revised; CWFT-R) within a developmental framework. Participants consisted of 361 diagnostically heterogeneous children between the ages 6 through 8 years inclusive who were assessed on a comprehensive neuropsychological battery of tests in the Windsor-Detroit region. CWFT-R performance of the 7- and 8-year-old clinic-referred children was compared to a 7- and 8-year-old sample of normal children who had been utilized in previous research. Results of the analysis of variance indicated significant differences between each of the normal-clinical comparisons in which the normal children consistently performed better. Comparisons between the performance of the 6-, 7-, and 8-year-old clinic-referred children revealed a developmental trend such that the older children consistently outperformed their younger counterparts. Using partial correlations to control for age effects, the data of the 361 clinic-referred children were subjected to Principal Components Analysis, which generated a 3-factor solution accounting for 55% of the total variance. Correlations between the CWFT-R and measures of verbal ability, phonological processing, nonverbal problem-solving and visual-spatial skills were examined. CWFT-R correlated with each of the measures included in the current work, but shared the most variance in common with measures of verbal ability and general word knowledge. Consistent with previous findings (Pajurkova, 1974) CWFT-R performance for the 6- and 8-year-old groups demonstrated the greatest association with WISC/WISC-R VIQ followed by FSIQ, and PIQ respectively. In comparing the factor analytic solutions derived with and without age as a covariate, significantly different factor structures emerged. It was concluded that
the CWFT-R has considerable diagnostic utility in the neuropsychological assessment of children in that it appeared to be sensitive to both verbal and nonverbal abilities, beyond those skills measured by the WISC/WISC-R. The test was further shown to be sensitive to the range of impairments that may be manifested in a diagnostically heterogeneous sample. Results were discussed in terms of the influence of developmental maturation on cognitive abilities, and the observed differential relationship between various neuropsychological ability domains.
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CHAPTER I
INTRODUCTION

A primary goal in the neuropsychological assessment of children is to evaluate the functional integrity of the brain through which precise functional deficits and cognitive impairments can be discerned. From this information, appropriate intervention is designed and implemented. In this vein, the importance of empirically, psychometrically and practically sound neuropsychological measures is paramount. Indeed, in the absence of sufficiently sensitive neuropsychological tests, many children with subtle learning difficulties are likely to go unrecognized and be denied augmentative educational and/or psychological services from which they could derive significant benefit. This can be particularly harmful in the case of school-aged children, where in addition to their existing impairments these youngsters may also fail to learn new material in an age-appropriate fashion, placing them at a greater disadvantage in comparison to their normal age-mates.

It has been demonstrated that standard measures of neuropsychological and intellectual functioning tend to be more sensitive to the deficits associated with chronic right cerebral damage and less routinely able to detect comparatively chronic left cerebral lesions (Klove, 1959; Klove & Reitan, 1958). Reed and Fitzhugh (1966) proposed that performance requirements of traditional measures of verbal abilities depend on previously acquired knowledge in contrast to the demands of visuoconstructive or concept formation tasks which involve some element of novelty and are thought to rely on provided task-related information. This suggests that the introduction of a comparable
measure of verbal ability may be of considerable assistance in the diagnosis of left
cerebral dysfunction and associated subtle impairments.

In an attempt to address this shortcoming of traditional neuropsychological test
batteries, Reitan (1972) developed a test of verbal problem-solving, the Word Finding
Test (WFT), which has since been adapted and updated for use with children (Pajurkova,
Orr, Rourke & Finlayson, 1976; See Appendix I & II). Despite the demonstrated clinical
utility of the WFT, research on the Children’s Word-Finding Test (CWFT) and the
Children’s Word-Finding Test (Revised; CWFT-R) has been relatively slow to develop.
The present exploratory work is intended to examine the diagnostic utility, developmental
sensitivity and construct dimensions of the CWFT-R in a heterogeneous clinic-referred
sample.

Cognitive Development

The development of cognition has long been proposed to correspond with
maturation of the central nervous system. Despite inconsistencies in the literature
regarding the age at which various neuronal and cellular processes transpire (e.g.,
estimates of adult patterns of myelination in the corpus callosum range from one year to
beyond the first decade of life; for review see Janowksy & Carper, 1996) it is widely held
that the brain, behavioural and cognitive repertoires undergo considerable change from
eyear to middle childhood. Although much of the research concerned with the
correspondence between neural and cognitive development has been somewhat
speculative, researchers have established a direct link between cognitive and brain
maturation (Hudspeth & Pribram, 1990; Stauder, Molenaar, & Van der Molen, 1995). In
one study (Stauder et al., 1995), analyses of Evoked Related Potentials while performing
a volume conservation task revealed a differential involvement of brain regions (e.g.,
parietal versus frontal) in children who had attained the concept of conservation in
comparison to those who had not.

More recent neurobiological studies; however, have indicated that the formation
and function of the brain involves a reciprocal relationship between biological processes
and the child’s environment (Hudspeth & Pribram, 1990; Janowsky & Carper, 1996). In
this vein, many researchers have begun to examine the associations between cognitive
and neurobiological events during development instead of trying to sort out whether
biological changes effect, cause and/or mediate cognition or are the result of a cognitive
transition (Janowsky & Carper, 1996).

The developmental theory of Piaget fits within this theoretical framework and
defines cognitive development according to four distinct biological stages associated with
each of the major epochs from infancy to adulthood. More specifically, Piaget
conceptualized cognitive development as the interdependent influence of assimilation and
accommodation through which one must incorporate incoming information into existing
systems and adapt such systems to permit appreciation of new forms of information
(Brainerd, 1978). Among his four proposed stages of intellectual development, entry into
the stage of concrete operations is oft characterized as the turning point in cognitive
development (Brainerd, 1978).

Children enter the concrete-operational stage in middle childhood (between 7 and
8 years), and following a normal course of development, are expected to have attained
many features of adult intelligence by the time they progress to the stage of formal
operations in adolescence (roughly by 11 to 15 years). As the title suggests, this stage is
marked by the acquisition of mental operations applied to information the child has already perceived. Indeed, the application of operations to concrete or directly perceivable stimuli is the key feature that differentiates concrete-operational thought from formal-operational thought characteristic of late adolescence and adulthood (Brainerd, 1978).

Piaget described several operations thought to index the transition from the preoperational to the concrete-operational stage of development, which include conservation concepts (e.g., volume, number, length) spatial and logico-arithmetic operations, relational contents (seriation, multiple seriation and transitive inference) and class concepts (classification, multiple classification and class inclusion). Among these operations, the presence of conservation concepts is considered the best indicator that a child has passed from preoperational to concrete-operational thought (Brainerd, 1978). Correspondingly, conservation tasks are commonly employed in research aimed at examining biological and behavioural correlates of children’s cognitive capacities and development. To this end, Wright, Gallagher & Noppe (1976) assessed the association between the performance of second grade children (n=54) on a series of volume conservation tasks and tests of concept attainment. The authors found significant correlations between children’s performance on the conservation and concept attainment measures, and proposed that an appreciation of relations, and three-dimensional thought were the underlying skills responsible for success on these tasks. In agreement with Piaget’s theory of cognitive development, their findings attest to the presence of higher-order thought (i.e., problem-solving and/or concept formation skills) in school-aged children.
More recently, Halperin, Healey, Zeitchik, Ludman and Weinstein (1989) examined the effects of maturation on various linguistic and mnestic abilities in normal children aged 6 to 12 years. Their analyses indicated significant developmental trends on the Boston Naming Test and semantic fluency, such that children of increasing age performed better. Similarly, in their investigation of developmental influences on verbal fluency and confrontation naming skills, Riva, Nichelli and Devoti (2000) found age-related improvement in performance associated with the Boston Naming Test and semantic fluency. Taken together, these results provide greater evidence in support of the importance of maturation on cognitive functioning, particularly during the early school-aged years.

**Differential Effect of Cerebral Lesions on Neuropsychological Functioning**

Since its inception within the discipline of psychology, neuropsychology has been interested in the functional asymmetry of the cerebral hemispheres. Indeed, the extant literature has unequivocally established that the left and right hemispheres are anatomically and functionally distinct (For review see Heilige, 1993; Rourke, Bakker, Fisk & Strang, 1983; Segalowitz & Gruber, 1977).

Despite the widespread assertion that the distinctiveness of the hemispheres is related to the unique functions mediated by each, many researchers have pointed out that the principal differences may be more closely related to the manner by which information is processed by each respective side of the brain (Goldberg & Costa, 1981; Goldberg, Podell & Lovell, 1994; Rourke, et al., 1983; Witelson, 1977, 1983). Although several theories of information processing and cerebral lateralization have been proposed with an accompanying array of descriptive nomenclature, there is a large degree of consistency in
their distinctions between left and right hemisphere processes (Allen, 1983).

Specifically, a strong body of research indicates that the left hemisphere is intimately involved in linguistic, symbolic, and analytic functions whereas the right hemisphere seems to be prominent in visual-spatial, holistic and integrative processes (Heillige, 1993; Rourke, et al., 1983; Witelson, 1983). Thus, it is not necessarily that the left hemisphere is dominant for language per se, but rather, that the nature of linguistic material demands the mode of information processing for which the left hemisphere is specialized.

A substantial body of literature has been devoted to documenting the specialized functions of the cerebral hemispheres and the resulting cognitive and behavioural impairments associated with selective injury to the brain. It has similarly been shown that the pathological characteristics of cerebral lesions have a significant effect on neuropsychological functioning.

Hom and Reitan (1984) examined the differential effect of lateralized cerebral lesions among 92 adults with rapidly and slowly growing cerebral neoplasms. Corresponding with a series of studies conducted by Fitzhugh, Fitzhugh & Reitan (1961, 1962a, 1962b, 1963), the authors found that both the neuropathological characteristics and the location of cerebral lesions have a significant influence upon measures of psychometric intelligence and neuropsychological functioning. Specifically, patients with more malignant cerebral neoplasms exhibited greater impairments than patients with comparatively slowly progressive neoplasms on all but one of the test measures employed. Their results also indicated that the Halstead-Reitan neuropsychological tests were considerably more sensitive to the presence of cerebral damage than the Wechsler scales.
With respect to the comparisons between right versus left cerebral lesions, the results of Hom and Reitan (1984) demonstrated a differential effect on Wechsler-Bellevue performance where lesions to the left were associated with lower Verbal subtest scores while lesions to the right were associated with lower Performance subtest scores. Thus, both pathophysiology and lateralization of cerebral damage appear to be important variables in neuropsychological outcomes.

Klove (1959) and Klove and Reitan (1958) have found that deficits related to chronic left cerebral damage tend to be less consistently detected through the application of traditional neuropsychological tests than deficits related to chronic right cerebral damage. It has been suggested that the failure to reliably discover the presence of left cerebral dysfunction is a considerable shortcoming of the neuropsychological test batteries in use with adults (Reitan, 1972). It has been further recommended that this weakness can be remedied through the development of neuropsychological measures which would more closely resemble the task requirements of right hemisphere tests (i.e., complex problem-solving) while demonstrating increased sensitivity to the presence of impairments typically associated with left hemisphere dysfunction (i.e., linguistic functions).

Neuropsychological Assessment: Psycholinguistic and Problem-Solving Abilities

Although there is no universally employed test battery, neuropsychological assessment is typically predicated upon the principle of obtaining a thorough sample of the range of abilities and skills thought to be subserved by the brain (Rourke et al., 1983). Among the ability domains included in neuropsychological evaluation, psycholinguistic
proficiency or verbal ability and nonverbal problem-solving skills are widely held as integral components of one's adaptive ability and global cognition.

The descriptive label verbal ability encompasses a broad range of skills that reflect some facet of linguistic functioning. Many of the measures used in the assessment of children's verbal skills are significantly correlated with academic achievement (e.g., WISC VIQ; Figueroa & Sassenrath, 1989; BNT; Riva et al., 2000) and global cognition (e.g., WRAT Reading; Slate, 1995). Common measures used in the assessment of children's verbal ability include fluency (semantic, lexical and phonemic), vocabulary, auditory analysis, confrontation naming, letter identification, single-word reading, repetition and comprehension. Despite their availability and utility in documenting language impairment, most tests are designed to evaluate a specific component of linguistic functioning, and as such, their generalizability is restricted to the specific skill area being assessed (e.g., phonetic skills). To this end, Halperin et al. (1989), found that four common measures used in the evaluation of verbal ability (i.e., Boston Naming Test, Peabody Picture Vocabulary Test-Revised, Paired Associate Learning and Verbal Fluency) assess distinct and relatively independent cognitive and linguistic functions in normal children. It is therefore important from a methodological standpoint that verbal skills be described and evaluated according to the specific component of language under consideration. The component skills and abilities that contribute to the general construct of verbal ability likely differ in both quantitative and qualitative respects and therefore need to be identified to permit adequate comparison of different research protocols and to be of assistance in clinical recommendations for remedial services.
Similar issues manifest in the assessment of problem-solving and concept formation abilities aimed to reflect the capacity to generate and utilize efficient problem-solving strategies, and adapt one's behaviour to relatively complex task demands (Rourke et al., 1983). Differences among research protocols and clinical test batteries exist in both the weight assigned to this ability domain and the specific tests or underlying skills selected for evaluation (Rourke et al., 1983). However, in contrast to the dissociation among verbal measures, tests of concept formation and/or problem-solving abilities tend to be broader in scope, necessarily involving the integration among multiple ability domains and systems.

Accordingly, verbal and nonverbal skills are often conceptualized as reflecting dichotomous areas of neuropsychological functioning. These ability domains; however, are thought to differ not only in terms of their content areas (i.e., linguistic versus visual-spatial) but more importantly, by the way in which the brain processes and encodes such information (Witelson, 1977, 1983). Neuropsychological tests designed to measure psycholinguistic skills and nonverbal problem-solving abilities have reflected this diversity and differ not only in modality specific stimuli and response requirements, but many have been designed such that they assess the different types of information processing.

Although in practice, such a method of test construction may seem intuitively appealing, the varying formats of verbal and spatial reasoning tests have been cited as a potential source of methodological limitation in psychological research (Langdon, Rosenblatt & Mellanby, 1998). Specifically, traditional measures of verbal ability are typically confounded with previous learning, making it difficult to extract a pure measure
of psycholinguistic proficiency which is not contingent upon one’s level of scholastic achievement. Conversely, tests of nonverbal problem-solving and/or visual-spatial skills tend to assess the application of reasoning abilities to novel problems and situations where all of the information necessary for successful completion of the problem is provided. Hence, “discrepancies between verbal and spatial scores could result from different task demands, rather than differences in primary verbal and spatial reasoning” (Langdon et al., p. 180). Indeed, based on their findings, Reed and Fitzhugh (1966) hypothesized that in the case of cerebral damage, one’s learning potential or adaptive abilities become impaired, while “stored memories” or previously acquired knowledge are relatively spared.

Correspondingly, it has been demonstrated that tests involving complex reasoning or concept formation abilities tend to be more sensitive to the presence of cerebral dysfunction than traditional measures of verbal ability or general intellectual functioning (Nici & Reitan, 1986; Reitan, 1955; Reitan & Wolfson, 1992). This disparity has been hypothesized to result from the novel problem-solving component in nonverbal visual-spatial tests (Pajurkova et al., 1976). Taken together, these findings underscore the importance of measures of verbal problem-solving in the neuropsychological assessment of adults and children.

**Problem Solving in a Verbal Context: The Word Finding Test**

The WFT (Reitan, 1972) was developed to assess problem-solving skills within a semantic context. More specifically, the WFT was constructed to address the absence of verbal reasoning/problem-solving measures which de-emphasize formally acquired language abilities and thus require the application of psycholinguistic skills to novel
situations and problems. In this vein, it was the author's intention to provide a measure of verbal ability that would be more sensitive to the presence of cerebral damage than traditional tests of linguistic functioning.

The WFT is comprised of 20 items, each consisting of five statements. Each statement contains a missing word that is replaced by the nonsense word "grobnick." The test-taker is required to listen to each statement and try to guess the meaning of the nonsense word by assessing the verbal context in which it is presented. Following the presentation of each statement, test-takers are given five seconds to respond. At the end of this five-second interval, the next statement is presented, irrespective of the accuracy of the test-taker's response, and this continues until all five statements for each of the 20 items have been presented. The test is scored such that each correct answer is awarded 1-point with a maximum of 100 points (20 x 5).

The test items were designed such that each successive sentence provides increasingly more information about the meaning of the nonsense word. Reitan (1972) reported that most test-takers are able to correctly identify the "missing" word by the time they hear the last statement of each item. The stimuli are presented through a recording of a male's voice, except for the last item, which is read by a female to ensure the test-taker is attending to the task.

In Reitan's (1972) initial validation study, the WFT performance of normal and brain-impaired adults was compared. Three distinct groups of brain-impaired and normal participants matched according to age, gender and education were formed. They found that in 94% of all comparisons, the brain-damaged participants obtained significantly lower scores than their normal matched counterparts. It was further demonstrated that
there was little overlap between the distribution of WFT performance of the brain-
damaged and normal controls such that a score between 37 and 38 correctly classified
81.4% of the brain-damaged participants and 82.9% of the normal participants. Based on
these findings, Reitan concluded that the WFT is highly sensitive to the effects of
cerebral damage, even amongst a group of adults with heterogeneous cerebral lesions.
He further contended that the problem-solving aspect of the WFT was likely responsible
for the obtained positive results.

In a later study, Reitan (cited in Pajurkova et al., 1976) compared the performance
of adults with left and right cerebral lesions to that of healthy controls on a number of
tests of verbal ability, including the WFT. He found that those adults with left cerebral
lesions performed poorly on all measures of verbal ability, however, the group of adults
with right cerebral lesions performed poorly only on measures which included both a
problem-solving and linguistic component (i.e., the WFT). It was hypothesized that
measures of problem-solving ability activate both cerebral hemispheres in contrast to
more pure linguistic tasks which seem to be specific to the left cerebral hemisphere.

Pendleton, Heaton, Lehman, Hulihan and Anthony (1985) have also studied the
WFT in an effort to extend the work of Reitan (1972,1973). These researchers examined
the differential effects of focal unilateral and diffuse cerebral lesions and the degree to
which age, education and level of neuropsychological impairment influence performance
on the WFT. The brain-impaired subjects (n=165) were divided into four groups
according to the following classifications: frontal, frontal plus nonfrontal, focal
nonfrontal, and diffuse, and were subsequently compared to a group of normal controls
(n=125) on an expanded version of the Halstead-Reitan Battery (Heaton & Pendleton,
1981). For both the normal controls and the combined group of brain-damaged subjects, WFT performance was found to be significantly correlated with age, education and overall level of neuropsychological impairment. Not surprisingly, their results indicated that those subjects who were younger, had higher levels of education, and less impaired neuropsychological performance tended to earn higher scores on the WFT. Comparisons between the WFT performance of each brain-damaged group to that of the controls revealed significant differences such that all of the brain-damaged groups performed significantly worse than the normal controls. Similarly, when the WFT performance of the combined group of brain-damaged subjects was compared to the control subjects, significant differences in performance were observed. According to their findings, a cutoff score of 37 out of 100 would correctly identify 71% of the brain-damaged subjects and 71% of the normal controls.

In their analysis of the effects of lesion location, their results did not support the test's ability to discriminate between right versus left lesions, nor between differentially localized lesions within the same hemisphere. Thus, the authors concluded that the WFT is highly sensitive to the presence of cerebral lesions, however, it does not appear to be helpful in further localizing them.

Pendleton et al. (1985) hypothesized that the failure of the WFT in differentiating between right and left hemisphere lesions might have been a function of the complexity of the test. Specifically, the authors proposed that impaired WFT performance could result from a wide variety of ability deficits (i.e., receptive language, short-term memory etc.) which could arise from a number of potentially implicated regions of the brain. Conversely, tests of concrete verbal ability, such as those typically employed in the
neuropsychological assessment of adults, are more likely to be helpful in identifying specific ability deficits related to focal left hemisphere lesions. Indeed, it is the absence of sufficiently complex tests designed to tap multiple cognitive systems through the application of psycholinguistic skills that spawned the development of the WFT in the first place.

In contrast to the results of Pendleton et al. (1985), Reitan, Hom and Wolfson (1988) found that the WFT distinguished between patients with left cerebral lesions and patients with right cerebral lesions. These authors compared the performance of patients with right hemisphere lesions ($n = 26$), patients with left hemisphere lesions ($n = 26$) and normal controls ($n = 26$). They found that the group with left cerebral lesions obtained the lowest scores on both the Vocabulary subtest of the WAIS-R and the WFT. On the other hand, the group with right cerebral lesions only performed worse on the WFT in comparison to the controls; their scores on the Vocabulary subtest were almost identical to those of the control group. Reitan et al. indicated that verbal content was likely a limiting factor in the performance of the left brain-damaged group on both tests, whereas the impaired WFT performance of the right brain-damaged group was likely because of the test's abstraction and reasoning requirements.

Reitan et al. (1988) suggested that the discordance between their results and those of Pendleton et al. (1985) could likely be attributed to the differences in methodology and participant selection procedures employed. Specifically, the clinical group utilized by Pendleton et al. was comprised of adults with heterogeneous cerebral lesions. It has been demonstrated that variation in lesion type and location results in significant differences with respect to VIQ-PIQ patterns on the Wechsler scales (Fitzhugh, Fitzhugh & Reitan,
1961, 1962b; Hom & Reitan, 1984), which may have contributed to their failure to find lateralization effects.

In summary, the WFT was developed to address the shortcoming of traditional neuropsychological test batteries in that they fail to include measures which are sufficiently sensitive to the presence of chronic left cerebral damage. The WFT has been shown to distinguish between brain-damaged and healthy adults, although the degree to which the test can adequately localize the site or side of injury has not been conclusively established. In spite of the inconsistent results, it has been demonstrated that the WFT is a valuable adjunct to traditional neuropsychological test batteries. Indeed, the absence of measures of verbal problem-solving have been acknowledged subsequent to the publication of Reitan’s (1972) original work and additional measures of fluid verbal reasoning have been devised (Langdon & Warrington, cited in Langdon et al., 1998). Others, in recognizing the diagnostic properties of the WFT, have since proposed that such a measure may be similarly advantageous in the neuropsychological assessment of children (Pajurkova et al., 1976).

Characteristics and Properties of the Children’s Word-Finding Test and the Children’s Word-Finding Test (Revised)

In light of the utility of the WFT with respect to its ability to detect cerebral dysfunction in adults and the absence of analogous measures of verbal problem-solving in neuropsychological test batteries in use with children, Pajurkova et al. (1976) adapted the WFT for use with child populations. This version has been called the Children’s Word-Finding Test (CWFT) and following further modifications, the Children’s Word-Finding Test (Revised) (CWFT-R).
In a pilot investigation, Pajurkova et al. (1976) composed a 25-item version of the WFT in which 17 of Reitan's (1972) 20 items were retained in their original form, three of Reitan's (1972) items were slightly modified, and five additional items were constructed. This test was administered to 20 9- and 10-year-old boys with no history of learning difficulties or grade failures. Based on the performance of these children, however, further adjustments were indicated, which resulted in a 20-item version with two sample items. The composition of the 20-item version was as follows: eight items were taken from Reitan's (1972) original WFT (three of which were slightly modified), the five newly constructed items from the pilot study were retained, and seven items were specifically constructed for the 20-item version (two of which were used as sample items), now known as the CWFT.

The CWFT was administered via tape recorder to 20 9- and 10-year old learning disabled boys who were referred for neuropsychological evaluation due to significant difficulties in one or more academic subjects (Pajurkova et al., 1976). Additional inclusion criteria for the learning disabled group were as follows: WISC Full Scale IQ between 85 and 115, inclusive; no hearing or uncorrected visual impairment; and not judged to be "culturally deprived" or in need of treatment for emotional problem(s) (Pajurkova et al.). The normal group was composed of 40 male children with no prior history of learning disability or grade failures, who were selected from the classrooms (Grades 3, 4, and 5) of three schools in Windsor, Ontario. There were no significant differences in age, WISC Full Scale IQ (FSIQ; derived or estimated), Verbal IQ (VIQ) or Performance IQ (PIQ) between the learning disabled and normal groups.
Following a similar protocol as the one described in Reitan’s (1972) research, the test was administered individually and presented via tape-recorder. A 10-second delay following each sentence was provided during which participants were required to guess the meaning of the nonsense word through the appreciation of its meaning. The examiner recorded each answer and irrespective of the accuracy of the child’s response, each sentence was presented. The test was scored by assigning one point for each correctly identified word, yielding a maximum score of 100 (five sentences for each of the 20 items).

To evaluate the suitability of the CWFT for the 9- and 10-year old participants, indices of item difficulty \( (pi) \) were derived for each sentence based on the performance of the 40 normal children. Pajurkova et al. (1976) were most interested in the third sentence of each item, as the few accurate responses to the first two sentences were thought to reflect “correct guessing” whereas correct performance on the last two sentences likely demonstrated a “continuance of understanding.” Indices of item difficulty were obtained by computing the average number of correct responses for each sentence for the 20 9-year-old and 20 10-year-old normal children separately. Higher values reflect items of lesser difficulty such that an index of item difficulty of \( pi = .05 \) indicates that an item is difficult, whereas a \( pi = .90 \) indicates that the item is easy (Pajurkova et al.). The authors found that the index of difficulty for the third sentence of each item was comparable between the two age groups and ranged from .10 to .95 for the 9-year-olds, and .10 to .90 for the 10-year-olds. Accordingly, they determined that the CWFT provided a range of difficulty that was appropriate for the 9- and 10-year-old children in their sample.
Group comparisons were subsequently carried out. The authors found that the 10-year-olds did significantly better than the 9-year-olds and the normal children significantly outperformed the learning disabled children, despite the fact that these groups did not differ significantly in WISC FSIQ, VIQ or PIQ. Thus, it would seem that the CWFT is sensitive to the presence of learning disability in children over and above their obtained levels of psychometric intelligence. Closer examination of the distribution of scores between the learning disabled and normal groups revealed that a cutoff score of 53 out of 100 correctly identified all 40 normal children and misclassified only 5 out of the 20 learning disabled children (Pajurkova et al., 1976).

In addition to the quantitative differences in performance on the CWFT between the learning disabled and normal groups, Pajurkova et al. (1976) noted qualitative differences in their approach to the task. The authors indicated that the children with learning disabilities were more likely than controls to treat each sentence as independent and disconnected units and described the approach of the learning disabled children as "much less systematic" in comparison to their healthy age-matched counterparts. Furthermore, the learning disabled group exhibited a significantly greater proportion of perseverative responses than the normal group, which sometimes extended to subsequent items (e.g., repeating a previously used word that was inappropriate in the context of the new sentence). Such differences between the neuropsychological test performance of brain-damaged and normal children have been similarly suggested by the work of Boll and Reitan (1972), which corresponds with Rourke's (1975) assertion that cerebral dysfunction may be a significant limiting factor in the adaptive functioning of children with learning disabilities.
Utilizing the same sample employed by Pajurkova et al. (1976), the relationship between CWFT performance and WISC summary scores was examined (Pajurkova, 1974). Scores on the CWFT were ranked and compared with ranked WISC VIQ, FSIQ, and PIQ scores. Separate analyses were conducted for the learning disabled and normal groups. In the case of the 9-year-old normal children, a strong positive correlation between CWFT and VIQ emerged; a less robust, but significant correlation between CWFT and FSIQ, and CWFT and PIQ was also evident. A similar pattern of results was obtained for the combined group of normal children (i.e., 9- and 10-year-olds). However, when the same comparisons were made for the 10-year-old normal children, only their VIQ and FSIQ scores were significantly correlated with performance on the CWFT. A similar trend in results as those reported for the normal children (i.e., strongest association between CWFT and VIQ followed by FSIQ, and PIQ, respectively) was obtained when the same analyses were carried out for the learning disabled children; however, none of the correlations between CWFT and WISC IQ scores reached commonly accepted levels of significance ($p > .05$).

To permit comparison of the differences between the obtained correlations, Fisher's $z$ transformations were computed. Statistically significant differences were reported for the correlations between CWFT and VIQ when the 9-year-old normal group was compared to the 9- year-old and 10-year-old learning disabled groups. None of the differences between correlations of CWFT and PIQ were significant, although trends in a direction similar to that found between CWFT and VIQ were evident. Therefore, according to the work of Pajurkova (1974), CWFT performance correlates most strongly with VIQ scores; however, the correlation was found to decline with age.
Although the association between CWFT and PIQ was considerably lower than that reported for CWFT and VIQ, the same pattern of results was obtained which demonstrated a greater association between CWFT and WISC scores in the 9-year-olds in comparison to the 10-year-olds. These findings suggest that with advancing age, the skills and abilities to which the CWFT is sensitive are increasingly distinct from the skills and abilities assessed by the summary scores of the WISC. They also indicate that in the sample of 9- and 10-year-old children employed, performance on the CWFT is most closely related to VIQ in the normal children in comparison to the learning disabled children.

In an effort to reduce administration time while maintaining adequate floor and ceiling levels, Rourke and Fisk (1976) revised the CWFT. This updated version has been called the CWFT-R. The data of Pajurkova et al. (1976) were subjected to a series of statistical analyses in order to establish the minimum number of items required without sacrificing the validity of the test. In the first of a series of analyses, correlations were calculated between each item on the CWFT and group membership (i.e., learning disabled and normal), which were then rank-ordered for each group. Secondly, the data was subjected to a principal component factor analysis, which generated a general factor along which the items were ranked based on their loadings. Lastly, a stepwise multiple regression analysis was performed, which produced 13 items that accounted for 78% of the variance. Items were then rank-ordered based on the obtained beta weights.

Comparisons between the rankings obtained through the three analyses were performed. Only those items that ranked in the top 13 on at least two of the three analyses were ultimately included in the CWFT-R. A distribution plot of the 13 retained items in
the Pajurkova et al. (1976) data revealed that a cut-off score of 33 out of 65 (maximum score = 13x5) accurately classified 90% of the learning disabled group and 97.5% of the normal group (Rourke & Fisk). The range of scores for the learning disabled and normal groups was 16 to 36 and 33 to 51, respectively. In summary then, the CWFT-R has been shown to differentiate between the learning disabled and normal 9- and 10-year-old boys employed by Pajurkova et al. (1976) while significantly reducing administration time. Thus, it would seem that future research and clinical endeavours should take advantage of the improved features of the CWFT-R; however, there is a paucity of research that directly assesses children’s performance on this version of the test.

Indeed, the only direct investigation of children’s CWFT-R performance was undertaken by Martin (1982) in an examination of the test’s clinical utility among a broader sample of children. One hundred children between the ages of 6 and 10 years inclusive (20 subjects per group) with no prior history of learning disability or grade failures served as the normal group. An additional 37 children (17 7-year-olds, 20 8-year-olds) who had been assessed in the neuropsychology department of a local hospital comprised the learning disabled group, and were selected according to the criteria adopted by Pajurkova et al. (1976).

Martin (1982) compared the performance of the normal 9- and 10-year-old participants in her study to those employed by Rourke and Fisk (1976); the children in Rourke and Fisk’s study performed significantly better than the children in Martin’s study. Martin proposed that these discrepant findings might be a result of the differences in administration and selection procedures employed. Specifically, Martin’s normal participants were not directly assessed on intellectual or academic measures for inclusion
in the control group and received the 13-item CWFT-R as opposed to the 20-item CWFT. It was hypothesized that the longer version provided an opportunity for greater practice and task familiarity.

Significant differences were also reported for the CWFT-R performance of the 7- and 8-year-old learning disabled children in comparison to the 7- and 8-year-old normal children, providing further support for the findings of Pajurkova et al. (1976) and Rourke and Fisk (1976). However, her comparisons of CWFT-R performance in the normal 6-, 7-, 8-, 9-, and 10-year-old children yielded results that deviated from those reported by Pajurkova et al. (1976). Although Martin (1982) found a developmental trend in CWFT-R performance among the normal 6-, 7-, 8-, and 9-year-olds, in contrast to the findings of Pajurkova et al. (1976), she found no differences between the scores of the 9- and 10-year-old children. She suggested that the CWFT-R might be less appropriate for normal children older than 8 years of age due to an insufficient ceiling.

To briefly summarize the extant literature on the CWFT and CWFT-R, the test was developed to evaluate the application of psycholinguistic skills in the context of problem-solving/concept formation abilities. Both the original CWFT and its improved version, the CWFT-R, have consistently been shown to differentiate between learning disabled and normal children (Pajurkova et al., 1976; Rourke & Fisk, 1976; Martin, 1982). In one study, significant differences in CWFT performance were found despite the fact that children had been equated for WISC IQ scores and age. Furthermore, in addition to the quantitative differences in levels of performance, differences in the approach of the learning disabled and normal groups were observed, which have been similarly reported by other researchers in their comparisons of children with known
brain-damage and controls (Boll & Reitan, 1972). Taken together, these results suggest that the CWFT-R is sensitive to the presence of learning disabilities over and above the level of obtained performance on a test of psychometric intelligence, and therefore, the CWFT-R has considerable clinical utility in the neuropsychological assessment of children.

It has also been demonstrated that the CWFT performance of normal 9-year-old children is highly correlated with WISC VIQ and less related to FSIQ and PIQ; however, these associations decline significantly by age 10 (Pajurkova, 1974). Similar developmental trends were observed among the test scores of the learning disabled children, indicating that with increasing age, the abilities to which the CWFT is sensitive are increasingly distinct from the skills encompassed by WISC summary scores. However, whether or not the CWFT-R is sensitive to the range of impairments that might be exhibited among a diagnostically heterogeneous group of children referred for neuropsychological evaluation has not been investigated. Accordingly, it has also not been established whether CWFT-R performance in a heterogeneous clinic-referred sample would exhibit developmental trends similar to those observed in the research of Pajurkova et al. (1976) and Martin (1982). Furthermore, the precise abilities to which the CWFT-R is sensitive have thus far not been examined.

**Rationale and Hypotheses**

The present exploratory study is intended to extend the research of Pajurkova (1974), Pajurkova et al. (1976), and Martin (1982) by assessing the diagnostic utility and ability components of the CWFT-R within a developmental context among a sample of children referred for neuropsychological evaluation.
The CWFT-R, modelled after Reitan’s (1972) original version for adults, was designed to provide a verbal counterpart of the problem-solving and visual-construction tasks that have been shown to be especially sensitive to the presence of brain impairment most commonly attributable to right hemisphere damage. It has been demonstrated that Reitan’s WFT is sensitive to the effects of cerebral damage; irrespective of lesion location, however, the degree to which the test is helpful in localizing the site or side of injury has yet to be conclusively determined. In spite of the inconsistent findings, it has nevertheless been established that the WFT is highly sensitive to the presence of cerebral damage in adults.

In a similar manner, the CWFT and CWFT-R have been shown to differentiate between learning disabled and normal children, despite the fact that these groups were equated for age and WISC IQ scores. Pajurkova et al. (1976) suggested that these results might have significant practical and theoretical relevance concerning the abilities of learning disabled children, and the differential sensitivity of the WISC and CWFT to the various components of cerebral dysfunction.

Pajurkova (1974) demonstrated that WISC VIQ, FSIQ, and PIQ scores were differentially associated with CWFT performance, with stronger associations between the scores of the 9-year-olds in comparison to the 10-year-olds. Differences were also observed between the performance of the learning disabled and control groups: Performance on the CWFT was less related to WISC IQ scores in the learning disabled group in comparison to the normal group.

Taken together, the findings of Pajurkova et al. (1976) and Pajurkova (1974) underscore the need for measures which are sensitive to the presence of psycholinguistic
deficits within a problem-solving framework, beyond those skills tapped by traditional
tests of verbal functioning or psychometric intelligence. It has been demonstrated that
the CWFT-R has the potential to serve as such a measure in the neuropsychological
assessment of children.

In light of the potential benefits of the CWFT-R, it would seem fitting that the
properties of the test be evaluated. Although the CWFT-R has been demonstrated to be
sensitive to learning disabilities, whether or not the CWFT-R is similarly able to
differentiate between normal children and a clinic-referred group has not been
investigated. In evaluating a diagnostically mixed sample of children, it is proposed that
the results of the present study will reflect the heterogeneous population that is typically
encountered in a children’s neuropsychology clinic. Indeed, it has recently been
demonstrated that the performance of normal versus brain impaired children on measures
of neuropsychological functioning is differentially influenced by age and education
(Reitan & Wolfson, 1995). Therefore, normative data which has been gathered from a
sample of normal children, may not be adequate in the evaluation of clinic-referred
children who exhibit impairments in one or more areas of neuropsychological
functioning. This further suggests a dissociation among neuropsychological test score
patterns, and developmental influences on normal versus brain impaired children. It
would therefore be instructive to know whether CWFT-R performance is sensitive to
developmental maturation in a heterogeneous clinic-referred sample. According to the
results of Martin (1982), normal children between the ages of 6 and 9 years demonstrated
significant differences in CWFT-R performance, which improved as a function of age.
Similarly, Pajurkova et al. (1976) found better CWFT performance in their 10-year-old participants in comparison to their 9-year-olds.

Furthermore, the precise abilities to which the test is sensitive are not clear. To date, the relation between WISC summary scores and performance on the CWFT-R has been examined in a relatively small sample, which has indicated that CWFT-R performance is differentially associated with WISC IQ scores. In delineating the cognitive abilities and skills that underlie performance on the CWFT-R, interpretation of test performance and the test’s clinical utility should be enhanced.

The primary objective of the present exploratory study then is to examine (i) the ability of the CWFT-R to differentiate between heterogeneous clinic-referred and normal children, (ii) the test’s sensitivity to developmental maturation and (iii) its construct dimensions, among a large sample of children referred for neuropsychological evaluation. Given the purpose of the current study and the findings of previous research on the WFT, the CWFT and the CWFT-R, the following hypotheses were formulated:

(i) *Diagnostic Utility of the CWFT-R*

The present work will assess the ability of the CWFT-R to differentiate between heterogeneous clinic-referred and normal children. The WFT, CWFT and CWFT-R have been shown to have diagnostic utility in adults and children with known or suspected cerebral dysfunction (Martin, 1982; Pajurkova, 1974; Pajurkova et al., 1976; Pendleton et al., 1985; Reitan, 1972; Reitan et al., 1988). It is therefore hypothesized that the CWFT-R will similarly distinguish between the 7- and 8-year olds of the present clinic-referred sample and Martin’s (1982) 7- and 8-year-old normal participants.
(ii) Developmental influences on CWFT-R performance

Consistent with previous research on the properties of the CWFT and CWFT-R, the degree to which performance on the CWFT-R is influenced by age will be assessed. In comparing the mean CWFT-R performance of the 6-, 7-, and 8-year-old groups, it is anticipated that the present study will confirm the results of Pajurkova et al. (1976) and Martin (1982) by finding that older children do significantly better on the CWFT-R than their younger counterparts. Predictions of age-related incremental improvements in performance are also predicated upon documented neurobiological changes which have been proposed to correspond with cognitive and behavioural development (For review, see Rourke et al., 1983; Janowsky & Carper, 1996) in addition to Piaget’s conceptualization of cognitive development during this period.

(iii) Construct dimensions of the CWFT-R

The CWFT-R was designed to measure the application of psycholinguistic skills in a problem-solving framework; thus, it is likely that CWFT-R performance would correlate with performance on other language-related and nonverbal problem-solving tasks. However, it is hypothesized that linguistic skills and nonverbal problem-solving ability differentially contribute to CWFT-R performance. Performance demands of the CWFT-R are complex, likely requiring both left and right hemispherical involvement. It is therefore proposed that intact problem-solving/concept formation abilities in addition to basic phonological processing and verbal ability are essential for success on this test.

Because Pajurkova (1974) found performance on the CWFT-R to be correlated most highly with VIQ in comparison to FSIQ and PIQ in both the learning disabled and normal groups, it is likely that a similar pattern of results will be obtained for the clinic-
referred children employed in the present work. More specifically, it is expected that performance on the CWFT-R will correlate most highly with the tests selected to reflect verbal comprehension/psycholinguistic skills (WISC/WISC-R Information, Similarities and Vocabulary) and phonological processing/auditory perceptual skills (Speech-Sounds Perception Test, Auditory Closure and Wide Range Achievement Test, Reading).

CWFT-R performance should correlate in a less robust fashion with measures of nonverbal concept formation/problem-solving abilities (Category Test, Tactual Performance Test and Matching Pictures) followed by tests of visuococonstruction/visual-spatial abilities (WISC/WISC-R Block Design, Object Assembly, Target Test). From among the WISC/WISC-R summary scores, CWFT-R performance is hypothesized to correlate most strongly with VIQ, less so with FSIQ and demonstrate the lowest association with PIQ.
CHAPTER II

METHOD

Subjects

Study participants were selected from an archival database of approximately 5000 children who had been assessed at a children's clinic in the Windsor-Detroit region, specializing in the assessment of neuropsychological functioning. Inclusionary criteria included referral to the children's neuropsychology clinic and assessment on a comprehensive neuropsychological battery of tests, which included the CWFT-R. Each participant was referred for evaluation because he or she demonstrated some degree of perceived impairment in perception, learning, language, information processing, and/or behaviour, thought to be due to cerebral dysfunction.

Neuropsychological data from 361 clinic-referred children was analyzed. These clinic-referred children represent a diagnostically mixed sample of English speaking, boys (n = 274) and girls (n = 87), aged 6 through 8 years inclusive who had been assessed between the years 1978 and 1986. The majority (i.e., 91.3%) of the clinic-referred children employed in the present work can be categorized into the five following diagnostic groups: (1) learning-disabled, (2) mentally retarded, (3) brain-injured, (4) emotionally disturbed, and (5) environmentally deprived. Diagnostic criteria for each of the five clinical groups are outlined in Table 1. The diagnostic characteristics of the 361 clinic-referred children are presented in Table 2.

The data of Martin's (1982) 7- and 8-year-old normal children (n = 40) were utilized as a comparison group. These children were originally selected from regular
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<tr>
<th>Category</th>
<th>Subgroup 00:</th>
<th>Subgroup 01:</th>
<th>Subgroup 02:</th>
<th>Subgroup 03:</th>
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<td>WISC FSIQ &gt; 85</td>
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<td>No clear evidence; questionable</td>
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<td>Suggestion of neurological dysfunction; no seizures</td>
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<td>Total</td>
<td>274</td>
<td>87</td>
<td>315</td>
<td>46</td>
<td>3</td>
</tr>
<tr>
<td>%</td>
<td>75.9</td>
<td>24.1</td>
<td>87.3</td>
<td>12.7</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>3</td>
<td>1.1</td>
<td>1.1</td>
<td>0.8</td>
</tr>
</tbody>
</table>
classrooms in the Windsor region and had no previous history of grade failures or learning difficulties. It was therefore assumed that these children were of average ability; however, no direct measure of their psychometric intelligence or academic achievement was obtained in the original study.

**Test Measures**

Neuropsychological tests were selected to reflect the following primary ability areas thought to influence performance on the CWFT-R: (i) verbal comprehension/psycholinguistic skills, (ii) phonological processing/auditory perceptual skills (iii) nonverbal concept formation/problem-solving skills, and (iv) visuoconstruction/visual-spatial abilities. The specific measures utilized in the current work were as follows: WISC/WISC-R Vocabulary, Information, Similarities, Block Design, Object Assembly, VIQ, PIQ and FSIQ from the Wechsler Intelligence Scale for Children (WISC; Wechsler, 1949) or the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974), Speech Sounds Perception Test (SSPT; Reitan & Davison, 1974), Auditory Closure Test (Kass, 1964), Reading subtest from the Wide Range Achievement Test, Reading (Jastak & Jastak, 1965) or Wide Range Achievement Test – Revised (Jastak & Wilkinson, 1984), Tactual Performance Test (TPT; total time; Reitan & Davison, 1974), Target Test (Reitan & Davison, 1974) Children’s Word-Finding Test (Revised; CWFT-R; Rourke & Fisk, 1976, Category Test (Reitan & Davison, 1974) and Matching Pictures Test (Reitan & Davison, 1974). A detailed description of these measures can be found in Appendix III.

The data were extracted from neuropsychological test files amassed over an 8-year period (1978-1986). During this time, the WRAT-R and WISC-R were adopted in
favor of the WRAT and WISC respectively, hence, a small portion of the clinic-referred children received a more recent edition of these measures. Upon closer inspection of the WISC data, these cases (n = 24) seem to have occurred in relative proportion to the total number of children from each age group (i.e., 2 out of 30 6-year-olds, 6 out of 104 7-year-olds, and 15 out of 227 8-year-olds) and should not, therefore, be of significant concern in the present work. Furthermore, research has demonstrated the comparability of WISC and WISC-R summary scores among a heterogeneous group of children with learning disabilities (Fisk & Rourke, 1987), further supporting the inclusion of these children in the present work. Similarly, scores obtained on each subtest of the WRAT-R have been shown to be significantly correlated with WRAT scores, demonstrating coefficients ranging from .91 to .99 (Jastak & Wilkinson, 1984). In addition, the majority of items in the WRAT-R were retained from the WRAT (Jastak & Wilkinson, 1984), further indicating the suitability of using the WRAT and WRAT-R interchangeably in the current work.

Procedure

Participants were administered an extended version of the Halstead-Reitan Neuropsychological Test Battery for Children, with auxiliary measures of neuropsychological functioning by trained technicians (for a description of the complete test battery, see Rourke et al., 1983.) However, only those tests thought to reflect abilities and skills related to performance on the CWFT-R were included for analysis in the present study. All tests were administered and scored according to standardized directions, and established normative data (i.e., Knights and Norwood, 1980) with one minor adjustment. The method by which the CWFT-R items were presented was slightly
modified from previous research where in the current study, the examiner read the
questions aloud as opposed to playing the tape-recording; differences in administration
time were found to be negligible. The rationale for this change in test administration was
an attempt to elicit a reasonably quick response to ensure the children’s understanding of
the connection between the sentences.
CHAPTER III

RESULTS

Data Screening

Prior to analyses, neuropsychological test scores for the 361 clinic-referred children were evaluated for accuracy of data entry, missing data, and univariate outliers through z-score transformations of individual test scores, based on each child's performance relative to the other children in his or her age group. A conservative criterion of scores in excess of 3.29 ($p < .001$) was adopted, yielding a total of 10 univariate outliers. Extreme scores were replaced by a value just greater than the next most extreme score on that variable within the corresponding age group. According to Tabachnick and Fidell (1996), this method enables the retention of cases considered part of the target population under evaluation by reducing their influence on data analyses. Following these adjustments, statistical analyses were performed on the test scores of the 361 participants through SPSS for Windows, version 10.0, and the Simple Interactive Statistical Analysis, Binomial (1997).

Data Analysis

(i) Diagnostic Utility

To evaluate the diagnostic utility of the CWFT-R, mean performance of the 7-and 8-year-old clinic-referred and normal groups were compared via the General Linear Model procedure for analysis of variance. Table 3 presents the results of these analyses, which yielded statistically significant differences in each of the comparisons between the clinic-referred and normal children; both the 7-year-old, $F(1, 123) = 38.27, p < .0001$. 

<table>
<thead>
<tr>
<th>Age</th>
<th>Clinic-Referred Children (Present Data)</th>
<th>Normal Children (Martin's Data)</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>7-year-olds</td>
<td>104</td>
<td>17.06</td>
<td>6.75</td>
</tr>
<tr>
<td>8-year-olds</td>
<td>227</td>
<td>23.78</td>
<td>8.47</td>
</tr>
</tbody>
</table>

**$p < .0001$  
*p < .001*
and the 8-year-old, $F(1, 246) = 11.67, p < .001$, clinic-referred children performed more poorly than their normal age-mates.

\textit{(ii) Developmental Influences}

Sensitivity of the CWFT-R to developmental maturation was examined through comparison of mean performance of the 6-, 7-, and 8-year-olds. Means and standard deviations of neuropsychological test scores for the entire sample of clinic-referred children are presented in Table 4. The analysis of variance (General Linear Model procedure) revealed significant age effects, $F(2, 358) = 39.85, p < .0001$. Neuman-Keuls comparisons indicated that there were significant differences between the 6- and 7-year-olds, the 6- and 8-year-olds, and the 7- and 8-year-olds.

\textit{(iii) Construct Dimensions}

To evaluate the construct dimensions of the CWFT-R, a Principal Components Factor Analysis with orthogonal rotation (Varimax procedure), and Kaiser normalization was performed on all individual test scores (i.e., not WISC summary scores). Acceptance of factors was based on a minimum eigenvalue of 1.00. In order to facilitate factor interpretation, Tactual Performance Test total time scores and Category Test total error scores were transformed such that higher scores reflect better performance.

Table 5 presents the relationship between test measures through the use of partial correlations controlling for age. Several correlations reached statistical significance with notably high correlations among all of the verbal measures (e.g., CWFT-R, WISC/WISC-R Information, Vocabulary, Similarities etc.). Most of the correlations, however, did not account for more than 15% of the variance. Of note, the CWFT-R was significantly correlated ($p < .01$) with each of the test measures included in the current study. This is
Table 4. Means and Standard Deviations for the Clinic-Referred Children on Neuropsychological Measures.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Age</th>
<th></th>
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<th></th>
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</thead>
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<tr>
<td></td>
<td>6</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 30</td>
<td>n = 104</td>
<td>n = 227</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Auditory Closure</td>
<td>7.80</td>
<td>3.43</td>
<td>8.81</td>
<td>3.57</td>
</tr>
<tr>
<td>Category Test (Total Error Score)</td>
<td>22.20</td>
<td>10.92</td>
<td>19.21</td>
<td>9.46</td>
</tr>
<tr>
<td>CWFT-R</td>
<td>14.27</td>
<td>5.11</td>
<td>17.01</td>
<td>6.60</td>
</tr>
<tr>
<td>Matching Pictures</td>
<td>15.80</td>
<td>2.01</td>
<td>16.04</td>
<td>2.22</td>
</tr>
<tr>
<td>Speech-Sounds Perception Test</td>
<td>13.60</td>
<td>4.68</td>
<td>15.50</td>
<td>4.72</td>
</tr>
<tr>
<td>Tactual Performance Test (Total Time Score)</td>
<td>15.75</td>
<td>6.61</td>
<td>14.53</td>
<td>6.96</td>
</tr>
<tr>
<td>Target Test</td>
<td>10.87</td>
<td>3.40</td>
<td>10.93</td>
<td>3.75</td>
</tr>
<tr>
<td>WRAT/WRAT-R Reading</td>
<td>103.67</td>
<td>18.74</td>
<td>91.87</td>
<td>12.21</td>
</tr>
<tr>
<td>WISC/WISC-R Information</td>
<td>8.90</td>
<td>2.66</td>
<td>7.97</td>
<td>2.48</td>
</tr>
<tr>
<td>WISC/WISC-R Vocabulary</td>
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<td>2.53</td>
<td>10.88</td>
<td>2.52</td>
</tr>
<tr>
<td>WISC/WISC-R Block Design</td>
<td>11.70</td>
<td>2.76</td>
<td>10.77</td>
<td>2.72</td>
</tr>
<tr>
<td>WISC/WISC-R Object Assembly</td>
<td>11.43</td>
<td>3.00</td>
<td>10.88</td>
<td>2.82</td>
</tr>
<tr>
<td>WISC/WISC-R VIQ</td>
<td>104.10</td>
<td>10.61</td>
<td>95.64</td>
<td>10.98</td>
</tr>
<tr>
<td>WISC/WISC-R PIQ</td>
<td>110.60</td>
<td>13.36</td>
<td>104.55</td>
<td>11.77</td>
</tr>
<tr>
<td>WISC/WISC-R FSIQ</td>
<td>107.90</td>
<td>11.45</td>
<td>99.76</td>
<td>11.05</td>
</tr>
</tbody>
</table>

*a Subtest standard scores (mean = 10; sd = 3)

*b IQ/standardized scores (mean = 100; sd = 15)

*c Raw scores (# correct, except for Category Test and Tactual Performance Test)
Table 5. Age Controlled Partial Correlations between Neuropsychological Test Measures.

<table>
<thead>
<tr>
<th>Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CWFT-R</td>
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<td>.43**</td>
<td>.42**</td>
<td>.34**</td>
<td>.42**</td>
<td>.49**</td>
<td>.53**</td>
<td>.37**</td>
<td>.22**</td>
<td>.24**</td>
<td>.22**</td>
<td>.22**</td>
<td>.21**</td>
</tr>
<tr>
<td>2. AUDCLO</td>
<td>-</td>
<td>1.00</td>
<td>.51**</td>
<td>.49**</td>
<td>.30**</td>
<td>.33**</td>
<td>.32**</td>
<td>.21**</td>
<td>.13*</td>
<td>.13*</td>
<td>.20**</td>
<td>.23**</td>
<td>.06</td>
</tr>
<tr>
<td>3. READSS</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.65**</td>
<td>.42**</td>
<td>.37**</td>
<td>.37**</td>
<td>.19**</td>
<td>.08</td>
<td>.15**</td>
<td>.10</td>
<td>.23**</td>
<td>-.00</td>
</tr>
<tr>
<td>4. SSPER</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.30**</td>
<td>.19**</td>
<td>.24**</td>
<td>.17**</td>
<td>.10*</td>
<td>.23**</td>
<td>.20**</td>
<td>.20**</td>
<td>.05</td>
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<tr>
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<td>-</td>
<td>-</td>
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<td>.51**</td>
<td>.23**</td>
<td>.20**</td>
<td>.22**</td>
<td>.17**</td>
<td>.27**</td>
<td>.11*</td>
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<tr>
<td>6. SIMIL</td>
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<td>-</td>
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<td>.28**</td>
<td>.22**</td>
<td>.21**</td>
<td>.20**</td>
<td>.26**</td>
<td>.11*</td>
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<td>7. VOCAB</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.28**</td>
<td>.26**</td>
<td>.18**</td>
<td>.21**</td>
<td>.22**</td>
<td>.12*</td>
</tr>
<tr>
<td>8. BLKDES</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.53**</td>
<td>.36**</td>
<td>.22**</td>
<td>.24**</td>
<td>.29**</td>
</tr>
<tr>
<td>9. OBJASS</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.34**</td>
<td>.27**</td>
<td>.30**</td>
<td>.29**</td>
</tr>
<tr>
<td>10. TARGET</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.34**</td>
<td>.30**</td>
<td>.29**</td>
</tr>
<tr>
<td>11. CATTOT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.26**</td>
<td>.23**</td>
</tr>
<tr>
<td>12. MATPXT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.18**</td>
</tr>
<tr>
<td>13. TPT</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*p < .05; **p < .01

AUDCLO=Auditory Closure; SSPER=Speech-Sounds Perception Test; READSS=WRAT/WRAT-R Reading; INFO=WISC/WISC-R Information; SIMIL=WISC/WISC-R Similarities; VOCAB=WISC/WISC-R Similarities; BLKDES=WISC/WISC-R Block Design; OBJASS=WISC/WISC-R Object Assembly; TARGET=Target Test; CATTOT=Category Test; MATPXT=Matching Pictures Test; TPT=Tactual Performance Test.
not surprising given that each of the measures was carefully selected based on their hypothesized relationship to the CWFT-R. However, as predicted, the CWFT-R demonstrated the greatest association with the measures of verbal comprehension/psycholinguistic skills, and phonological processing/auditory perceptual skills.

Duplicating the methodology employed by Pajurkova (1974), Fisher’s z transformations were calculated to assess potential differences in obtained correlations between CWFT-R performance and WISC/WISC-R IQ scores in each of the three age groups. Pearson’s Product Moment Correlations and corresponding Fisher’s z scores for the 6-, 7-, and 8-year-old clinic-referred children are presented in Table 6. For all three age groups, CWFT-R performance was significantly correlated with WISC/WISC-R VIQ, FSIQ, and PIQ \((p < .05)\). The 6- and 8-year-old groups demonstrated a similar pattern of results, corresponding with the findings of Pajurkova (1974) in that CWFT-R correlated most strongly with VIQ, followed by FSIQ, and PIQ, respectively. A slightly different pattern of results was observed in the correlations between CWFT-R and WISC/WISC-R summary scores in the 7-year-old group; CWFT-R performance correlated most strongly with FSIQ, followed by VIQ, and PIQ, respectively. However, results of within group comparisons of the differences in correlations between CWFT-R and VIQ/FSIQ versus CWFT-R and PIQ did not reach commonly acceptable levels of statistical significance. Similarly, in performing between-group comparisons of the relative strength of the correlations between CWFT-R and WISC/WISC-R IQ scores, none of the correlations were found to be statistically different \((p > .05)\).
Table 6. Correlations and Fisher’s $z$ Tranformations of CWFT-R with VIQ, FSIQ, and PIQ for the Clinic-Refered Children.

<table>
<thead>
<tr>
<th>Age</th>
<th>CWFT-R – VIQ</th>
<th></th>
<th>CWFT-R – FSIQ</th>
<th></th>
<th>CWFT-R – PIQ</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$r$</td>
<td>$z$</td>
<td>$r$</td>
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<td>7</td>
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<td>.65**</td>
<td>.77</td>
<td>.63**</td>
<td>.74</td>
<td>.45**</td>
<td>.48</td>
</tr>
</tbody>
</table>

**$p < .01$  
*p < .05*
The factor analysis based on partial correlations controlling for age generated three factors accounting for 55% of the total variance. Only those variables with factor loadings of .45 or greater were considered for the purposes of factor interpretation. These factors and their respective loadings are presented in Table 7. Factor 1 is defined by loadings from WISC/WISC-R Vocabulary, Similarities, CWFT-R and WISC/WISC-R Information, and is therefore considered a factor of general verbal skills and word knowledge. This factor accounted for 20% of the variance. Factor 2, with loadings from WISC/WISC-R Object Assembly, Target Test, WISC/WISC-R Block Design, Tactual Performance Test and Category Test, is thought to reflect a dimension of visual-spatial organization and nonverbal problem-solving skills, accounting for 19% of the variance. Factor 3, accounting for 17% of the variance, had loadings from the Speech-Sounds Perception Test, WRAT/WRAT-R Reading, and Auditory Closure Test, and is considered a factor of phonological processing skills.

To determine whether the relationship between neuropsychological measures differed as a function of age, separate factor analyses were conducted for the 7- and 8-year-old groups, and compared to the 3-factor solution in which age was controlled. A separate factor analysis; however, could not be performed on the 6-year-old data due to the insufficient sample size.

Correlations between the neuropsychological measures for the 6-, 7-, and 8-year-old participants are presented in Table 8, Table 9, and Table 10 respectively. It is clear from these analyses that the correlations between the CWFT-R and the other neuropsychological measures employed varies considerably between the three age
Table 7. Factor Analysis of Age-Corrected Neuropsychological Test Scores for the Clinic-Referred Children.

<table>
<thead>
<tr>
<th>Factor 1: general verbal skills/word knowledge</th>
<th>Factor 2: visual-spatial organization/nonverbal problem-solving</th>
<th>Factor 3: phonological processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure</td>
<td>Measure</td>
<td>Measure</td>
</tr>
<tr>
<td>WISC/WISC-R Vocabulary</td>
<td>WISC/WISC-R Object Assembly</td>
<td>Speech-Sounds Perception Test</td>
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<tr>
<td>.81</td>
<td>.70</td>
<td>.87</td>
</tr>
<tr>
<td>WISC/WISC-R Similarities</td>
<td>Target Test</td>
<td>WRAT-WRAT-R Reading</td>
</tr>
<tr>
<td>.76</td>
<td>.70</td>
<td>.78</td>
</tr>
<tr>
<td>CWFT-R</td>
<td>WISC/WISC-R Block Design</td>
<td>Auditory Closure Test</td>
</tr>
<tr>
<td>.68</td>
<td>.63</td>
<td>.69</td>
</tr>
<tr>
<td>WISC/WISC-R Information</td>
<td>Tactual Performance Test</td>
<td></td>
</tr>
<tr>
<td>.66</td>
<td>.62</td>
<td></td>
</tr>
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<td></td>
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<td></td>
<td>Matching Pictures Test</td>
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</tr>
<tr>
<td></td>
<td>.49</td>
<td></td>
</tr>
</tbody>
</table>

Factor loadings < .45 are not shown.
Table 8. Correlations between Neuropsychological Test Measures for 6-year-old Clinic-Referral Children.

<table>
<thead>
<tr>
<th>Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
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<tbody>
<tr>
<td>1. CWFT-R</td>
<td>1.00</td>
<td>.13</td>
<td>.28</td>
<td>.14</td>
<td>.26</td>
<td>.58**</td>
<td>.59**</td>
<td>.12</td>
<td>.19</td>
<td>.18</td>
<td>.45*</td>
<td>.30**</td>
<td>-.30</td>
</tr>
<tr>
<td>2. AUDCLO</td>
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<td>1.00</td>
<td>.40*</td>
<td>.57**</td>
<td>-.05</td>
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<td>-.18</td>
<td>.07</td>
<td>.05</td>
<td>-.14</td>
<td>.08</td>
<td>.12</td>
<td>-.45*</td>
</tr>
<tr>
<td>3. READSS</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.64**</td>
<td>.46*</td>
<td>.11</td>
<td>-.03</td>
<td>.01</td>
<td>.01</td>
<td>-.30</td>
<td>-.14</td>
<td>.13</td>
<td>-.48*</td>
</tr>
<tr>
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*p < .05; **p < .01

AUDCLO=Auditory Closure; SSPER=Speech-Sounds Perception Test; READSS=WRAT/WRAT-R Reading; INFO=WISC/WISC-R Information; SIMIL=WISC/WISC-R Similarities; VOCAB=WISC/WISC-R Similarities; BLKDES=WISC/WISC-R Block Design; OBJASS=WISC/WISC-R Object Assembly; TARGET=Target Test; CATTOT=Category Test; MATPXT=Matching Pictures Test; TPT=Factual Performance Test.
Table 9. Correlations between Neuropsychological Test Measures for 7-year-old Clinic-Referral Children.

<table>
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<tr>
<th>Measures</th>
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*p < .05; **p < .01

AUDCLO=Auditory Closure; SSPER=Speech-Sounds Perception Test; READSS=WRAT/WRAT-R Reading; INFO=WISC/WISC-R Information; SIMIL=WISC/WISC-R Similarities; VOCAB=WISC/WISC-R Similarities; BLKDES=WISC/WISC-R Block Design; OBJASS=WISC/WISC-R Object Assembly; TARGET=Target Test; CATTOT=Category Test; MATPXT=Matching Pictures Test; TPT=Tactual Performance Test.
Table 10. Correlations between Neuropsychological Test Measures for 8-year-old Clinic-Referred Children.

<table>
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<tr>
<th>Measures</th>
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* p < .05; ** p < .01

AUDCLO=Auditory Closure; SSPER=Speech-Sounds Perception Test; READSS=WRAT/WRAT-R Reading; INFO=WISC/WISC-R Information; SIMIL=WISC/WISC-R Similarities; VOCAB=WISC/WISC-R Similarities; BLKDES=WISC/WISC-R Block Design; OBJASS=WISC/WISC-R Object Assembly; TARGET=Target Test; CATTOT=Category Test; MATPXT=Matching Pictures Test; TPT=Tactual Performance Test.
groups, particularly in comparing the 6-year-olds to both the 7- and 8-year-olds. It is noteworthy that unlike the performance of the 7- and 8-year-old groups, CWFT-R performance of the 6-year-old group was not significantly correlated with measures of phonological processing and auditory perceptual skills.

The factor analysis of the 7-year-old data, accounting for 56% of the variance, yielded the same three factors as those derived in the factor analysis which covaried the effects of age, although the relative variance accounted for by each factor differed slightly. On the other hand, the factor analysis of the 8-year-old data generated a 3-factor solution, accounting for 57% of the total variance, which differed substantially from the 7-year-old and age-controlled analyses. The results of the 8-year-old data, which are presented in Table 11, yielded unusual loadings on the third factor, rendering the solution unstable. This factor was defined by loadings from the Target Test, Category Test, Speech-Sounds Perception Test, and Matching Pictures Test. Two additional factor analyses were subsequently performed.

Data for the combined group of 7- and 8-year-olds without controlling for age effects was analyzed. The resulting 3-factor solution, which accounted for 56% of the variance, is presented in Table 12. Both the Block Design and Object Assembly subtests from the WISC/WISC-R loaded on the first factor, which otherwise consisted of verbal tasks, and the second factor, which was primarily visual-spatial/nonverbal problem-solving in nature. It is, however, noteworthy that these variables demonstrated the same or greater loadings on the second factor, which was considered reflective of visual-spatial organization and problem-solving abilities. The first factor was exclusively comprised of WISC/WISC-R subtests, with the exception of the CWFT-R, and may therefore be
Table 11. Factor Analysis of 8-year-old Neuropsychological Test Scores.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Measure</th>
<th>Measure</th>
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<td>WISC/WISC-R Vocabulary .79</td>
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<td>Target Test .68</td>
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<td>WISC/WISC-R Similarities .75</td>
<td>WISC/WISC-R Block Design .71</td>
<td>Category Test .61</td>
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<td>Tactual Performance .57 Test</td>
<td>Speech-Sounds Perception Test</td>
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<td>WRAT/WRAT-R Reading .71</td>
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Factor loadings < .45 are not shown.
Table 12. Non-Age-Controlled Factor Analysis of Neuropsychological Test Scores for the Combined Group of 7- and 8-year old Clinic-Referred Children.

<table>
<thead>
<tr>
<th>Factor 1</th>
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<tbody>
<tr>
<td>general intellectual abilities</td>
<td>visual-spatial organization/nonverbal problem-solving</td>
<td>phonological processing</td>
</tr>
<tr>
<td><strong>Measure</strong></td>
<td><strong>Measure</strong></td>
<td><strong>Measure</strong></td>
</tr>
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<td>Target Test</td>
<td>Speech-Sounds Perception Test</td>
</tr>
<tr>
<td>WISC/WISC-R Similarities</td>
<td>Tactual Performance Test</td>
<td>WRAT/WRAT-R Reading</td>
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<td>WISC/WISC-R Information</td>
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<td>WISC/WISC-R Block Design</td>
<td>WISC/WISC-R Block Design</td>
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</tr>
<tr>
<td>WISC/WISC-R Object Assembly</td>
<td>Matching Pictures Test</td>
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</tr>
</tbody>
</table>

Factor loadings < .45 are not shown.
considered a factor of general intellectual functioning, reflecting abilities of both a verbal and nonverbal nature.

An additional factor analysis was performed on the data of the entire group of clinic-referred children, also without covarying the effects of age. These results are presented in Table 13, which similarly reveals a 3-factor solution that accounted for 56% of the variance. The measures comprising the first factor, namely, WISC/WISC-R Vocabulary, Similarities, Information, Block Design, Object Assembly, and WRAT/WRAT-R Reading, were the same as those obtained in the combined group of 7- and 8-year-olds with the exception of the WRAT/WRAT-R Reading replacing the CWFT-R. Correspondingly, this factor is also hypothesized to reflect general intellectual functioning of a verbal and nonverbal nature. In this analysis; however, the CWFT-R loaded on a factor of phonological processing. It is important to note that in each of the non-age controlled analyses, at least two of the neuropsychological tests were found to contribute to two different factors, rendering the derived solutions more difficult to interpret, and less stable than the 3-factor solution in which age was covaried.

In sum, it appears that the most stable and reliable solution was obtained in the factor analysis which utilized partial correlations controlling for the effects of age. Based on the results of the factor analyses, it may be concluded that the relationship between the neuropsychological measures employed in the current work differ as a function of age.
Table 13. Non Age-Controlled Factor Analysis of Neuropsychological Test Scores for all Clinic-Refered Children.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Measure</th>
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<tbody>
<tr>
<td>WISC/WISC-R Vocabulary</td>
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Factor loadings < .45 are not shown.
CHAPTER IV

DISCUSSION

The present work was undertaken to examine the diagnostic utility and construct dimensions of the CWFT-R within a developmental framework among a sample of clinic-referred children. Based on the results of previous research efforts, the following hypotheses were formulated: (i) the CWFT-R was expected to distinguish between the 7- and 8-year-old clinic-referred children and Martin’s (1982) normal 7- and 8-year-old participants; (ii) CWFT-R performance was expected to demonstrate significant age effects in which older children would perform better than their younger counterparts, and (iii) CWFT-R performance was expected to demonstrate the greatest correlation with measures of verbal comprehension/psycholinguistic skills and phonological processing/auditory perceptual skills in comparison to measures of nonverbal concept formation/problem-solving abilities and visuoconstruction/visual-spatial abilities.

Correspondingly, in each age group, the CWFT-R was expected to demonstrate the greatest association with VIQ, followed by FSIQ, and PIQ respectively.

Diagnostic utility

As predicted, the CWFT-R differentiated between the current clinic-referred sample and Martin’s (1982) normal 7- and 8-year-olds. These findings are consistent with previous research on the CWFT (Pajurkova et al., 1976) and CWFT-R (Rourke & Fisk, 1976; Martin 1982); thus, it would seem that the CWFT-R has considerable diagnostic utility among a variety of clinical conditions. Accordingly, in examining the correlations between CWFT-R performance and WISC/WISC-R summary scores, although statistically significant, a considerable proportion of the variance in CWFT-R
performance is not accounted for by WISC/WISC-R summary scores. More specifically, the strongest association was observed between CWFT-R performance and VIQ scores in the 8-year-old group, which accounted for only 42% of the variance. These findings would seem to suggest that the test is sensitive to abilities beyond those reflected in WISC/WISC-R VIQ, FSIQ, or PIQ. The CWFT-R therefore not only distinguishes between normal and clinic-referred children, but also provides unique information with regards to the neuropsychological functioning of the child, that can be obtained in a relatively short period of time (i.e., the test takes approximately 20-30 minutes to administer).

It should, however, be borne in mind that although participant inclusion criteria were intentionally broad in an effort to be representative of the diagnostically heterogeneous population that would present to a children's neuropsychological service, more than half (i.e., 53%) of the sample was ultimately diagnosed as learning disabled. It therefore comes as no surprise that the CWFT-R differentiated between the clinic-referred and normal children in the present work, as it has been previously established that the test is sensitive to the presence of learning disabilities.

*Sensitivity to Developmental Influences and Ability Components of the CWFT-R*

Consistent with current hypotheses and the findings of Pajurkova et al. (1976), and Martin (1982), results of the present study indicated that the CWFT-R is highly sensitive to developmental maturation. Scores on the test were found to differ significantly for each of the three age groups, where older children demonstrated the most adept performance in comparison to their younger counterparts. In contrast to the findings of Pajurkova (1974), correlations between CWFT-R and WISC/WISC-R
summary scores were not statistically different for clinic-referred children within the three different age groups employed in the present work. It is, however, important to note that differences between the strength of the correlations for CWFT and VIQ were only present in her comparisons between her normal 9-year-old group and her clinical 9- and 10-year-old groups. Therefore, in her comparisons of correlations for CWFT and VIQ between her 9- and 10-year-old learning disabled children, she failed to find significant differences. The present sample was also comprised of a large proportion of children diagnosed with learning disability. Thus, based on the findings of Pajurkova, the current sample of clinic-referred children would not be expected to demonstrate significant differences in the degree to which CWFT-R performance correlates with WISC/WISC-R summary scores in each of the three age groups.

The present 6- and 8-year-old groups demonstrated the same pattern of results as those reported by Pajurkova (1974) where CWFT-R performance was found to have the strongest correlation with VIQ, followed by FSIQ, and PIQ, respectively. CWFT-R performance of the current 7-year-old group correlated most strongly with FSIQ followed by VIQ, and PIQ, respectively. However, the relative difference between the correlations with VIQ and FSIQ were negligible (i.e., CWFT-R-VIQ: \( r = .59 \); CWFT-R-FSIQ: \( r = .61 \)). Although the results of Pajurkova’s (1974) learning disabled and normal groups demonstrated a similar trend as the results obtained in the present 6- and 8-year-old groups, none of the correlations between CWFT performance and WISC IQ scores were statistically significant in her learning disabled group. Curiously, in contrast to the findings of Pajurkova, the present research found significant correlations between CWFT-R and all three WISC/WISC-R summary scores in each of the three age groups,
even though the majority of children were diagnosed as learning disabled. Perhaps, the absence of significant correlations reported by Pajurkova relates to her considerably smaller sample, which may have a limiting effect on statistical power. Taken together, these findings suggest that the skills to which the CWFT-R is sensitive are primarily verbal in nature, irrespective of age. They also indicate that among diagnostically heterogeneous children aged 6 through 8 years inclusive, the CWFT-R is associated with WISC/WISC-R summary scores in a similar fashion.

Level of developmental acquisition had a profound effect on the relationship between neuropsychological measures and the CWFT-R. Indeed, the most reliable factor structure was derived from the analysis in which the effects of age were controlled, where the CWFT-R loaded on a factor of general verbal ability and word knowledge. Clearly, the factor structure of the various verbal and nonverbal/visual-spatial measures employed is not invariant across the ages 6 through 8 years. Thus, depending on the specific developmental level of the child, the interrelations between various neuropsychological ability areas were found to vary.

Interestingly, statistically significant correlations between CWFT-R and each of the other neuropsychological measures employed were found, with the exception of the 6-year-old group. Evidently, among the 6-year-old clinic-referred children, performance on the CWFT-R was not related to measures of phonological processing. Apart from the significantly smaller sample size, converging evidence seems to indicate that developmental maturation during middle childhood has a profound effect on cognitive processes. In the case of CWFT-R performance, it appears that in a group of 6-year-old clinic-referred children, whose verbal skills are presumably less developed than children
7 or 8 years of age, phonological processing skills are relatively independent of the abilities being measured. It may be concluded that the task is inherently more difficult and less rote for these youngsters in comparison to their older counterparts, whose performance on the task correlates with measures of verbal knowledge, general verbal proficiency and phonological processing. The current findings also correspond with Piaget's theory of cognitive development, which asserts that acquisition of concrete operations between the ages of 7 and 8 years is marked by the emergence of reasoning and problem-solving abilities. One would therefore expect to see older children perform better than their younger counterparts on tests that require any form of problem-solving ability.

The results of the present work provide compelling evidence that the ability components of the CWFT-R cannot be adequately described by a uniform set of skills, although clearly general verbal ability and nonverbal problem-solving seem to be the primary ability domains underlying performance on the test. Thus, from the present findings it would appear that the CWFT-R is sensitive to both verbal and nonverbal skills, which is consistent with the intentions of its authors. This sensitivity to both verbal and nonverbal abilities likely contributed to the present finding of the test's ability to differentiate between normal controls and a diagnostically heterogeneous sample, particularly in considering the range of impairments that might be manifested in a clinically mixed group. Therefore, unlike many of the tests used in the assessment of children's linguistic functioning, which tend to measure rather specific components of language, the CWFT-R appears to be measuring a range of verbal and nonverbal abilities. That said, it is nevertheless interesting to note that the results from each of the analyses
conducted in the present work (i.e., correlations, factor analyses, Fisher's $z$
transformations) consistently demonstrated that the CWFT-R is most related to verbal
skills and abilities.

Despite the fact that the CWFT-R was shown to be primarily verbal in each of the
non-age-controlled factor analyses, all but the 7-year-old data yielded factors that were
different from those generated from the factor analysis in which the effects of age were
covaried. This variable structure across the three ages further suggests that
developmental influences have a significant effect on cognition and the association
between neuropsychological abilities during these formative years of middle childhood.
Alternatively, potential methodological limitations which may have influenced the
different factor structures obtained, should be addressed. Peculiarities specific to the
independent factor analyses may be explained by the reduced sample size, which is
known to have an adverse impact on solutions derived through factor analysis
(Tabachnick & Fidell, 1996). However, this alone cannot adequately explain the unusual
factor solution obtained in the 8-year-old data ($n=227$) which was not similarly observed
in the 7-year-old data ($n=104$). Quite possibly, on its own, the 8-year-old data may have
been unsuitable for factor analysis, due to great variability in test scores, which when
combined with the entire sample, had less of an influence on statistical analyses. This
does not, however, likely account for the results of the non-age-controlled analyses in
which all (6-, 7- and 8-year olds) or a majority (7- and 8-year-olds) of the 361 children
were included. Because the test scores of the present sample have been shown to consist
of a range of performance levels which vary according to age, collapsing this data into a
single group, without covarying the effects of age, is an untrustworthy and unsuitable
method of data analysis. The resulting solution would therefore be expected to be flawed with limited meaning.

An additional methodological limitation of the present work relates to the significant correlations between the CWFT-R and each of the other measures included in statistical analyses. Despite the fact that when age was covaried a seemingly reliable and valuable factor solution was generated, including such a restricted range of ability domains may have omitted other potential sources of variance. Conceivably, if more variables had been included in the present analyses, a greater number of factors would have been obtained, which may or may not have influenced the relationship between the CWFT-R and the measures of verbal and nonverbal functioning.

Summary and Future Directions

In sum, based on the current findings, it would seem that in clinic-referred children 6 through 8 years inclusive, the CWFT-R is particularly sensitive to general verbal abilities. Although less prominent, CWFT-R performance was also found to correlate with measures of nonverbal problem-solving, indicating that the test is assessing some element of both verbal and nonverbal functioning, consistent with the authors' initial intentions in constructing the instrument. It has also been demonstrated that the test is highly influenced by developmental maturation, a fundamental consideration in the neuropsychological assessment of children. In finding that the test differentiates between the performance of three different age groups and between a diagnostically mixed and normal group of children, the present findings serve to further corroborate earlier research demonstrating the clinical utility of the CWFT-R within the context of a comprehensive neuropsychological examination. Consonant with the findings of
Pajurkova (1974), the CWFT-R was found to provide information concerning children’s skills and abilities beyond those measured by a standardized test of psychometric intelligence. Given the unique contributions of the test and the brevity with which it may be administered, the present research demonstrated that the CWFT-R is a valuable adjunct to standardized neuropsychological test batteries in use with children.

Although the present work did not address the differential pattern of CWFT-R performance among the various diagnostic groups, future research may wish to examine the degree to which the CWFT-R distinguishes between children with varying neuropsychological and/or learning impairments. Such an endeavour would also provide validating evidence for the three factors derived in the present research.

Current results indicate that the CWFT-R differentiates between diagnostically heterogeneous children and healthy controls; however, the percentage of children within each of the non-learning disabled groups was comparatively small, warranting the use of a greater and more diverse sample. It is further recommended that future investigations employ a more varied range of ability domains, such as motor, sensory-perceptual, memory and/or attentional measures, which would likely provide a more comprehensive, and perhaps clearer picture of the differential relationship between the skills measured by the CWFT-R and other neuropsychological tests.
APPENDIX I

CHILDREN'S WORD-FINDING TEST (REVISED): INSTRUCTIONS

WE ARE GOING TO PLAY A WORD GAME. HERE IS WHAT WE'LL DO. I HAVE A WORD THAT DOES NOT MEAN ANYTHING. THE WORD IS 'GROBNICK.' I WOULD LIKE YOU TO TRY AND FIND A WORD THAT YOU KNOW THAT COULD REPLACE THE WORD, GROBNICK, IN THE SENTENCES THAT YOU WILL HEAR. EACH TIME THERE WILL BE A GROUP OF FIVE SENTENCES WHICH WILL DESCRIBE THE WORD THAT YOU ARE LOOKING FOR. LISTEN CAREFULLY. AND AFTER EACH SENTENCE TELL ME WHAT GROBNICK MEANS.

FOR EXAMPLE: (WINDOW)

SENTENCE 1. YOU CAN SEE THROUGH A GROBNICK. WHAT DOES GROBNICK MEAN?
SENTENCE 2. YOU CAN BREAK GROBNICK VERY EASILY. WHAT IS A GROBNICK?
SENTENCE 3. THERE ARE MANY GROBNICKS IN EVERY HOUSE. WHAT ARE GRONBICKS?
SENTENCE 4. WE USUALLY KEEP GROBNICKS CLOSED DURING WINTER TO KEEP THE ROOMS WARM.
SENTENCE 5. PEOPLE USUALLY PUT CURTAINS OVER THEIR GROBNICKS.

DO YOU UNDERSTAND HOW TO PLAY THIS GAME? OKAY, NOW LET'S TRY ANOTHER GROUP OF SENTENCES.

(TEACHER)

SENTENCE 1. THE GROBNICK IS ALWAYS OLDER THAN YOU.
SENTENCE 2. THE GROBNICK CAN BE A MAN OR A WOMAN.
SENTENCE 3. YOU CAN LEARN THINGS FROM A GROBNICK.
SENTENCE 4. THERE ARE MANY GROBNICKS IN EVERY SCHOOL.
SENTENCE 5. THE GROBNICK GIVES YOU HOMEWORK.

When the child makes a correct guess in these examples, say O.K. and continue with the next sentence. When the guess is incorrect, but fits the sentence well, ask what other word could replace grobnick. When a guess is obviously wrong, point out the inconsistency before you proceed to the next sentence. Whether or not the child successfully guesses the correct response by the end of the five-sentence trial, review the
sentences providing the correct response in each case. It is important that the child demonstrates some understanding of the concept underlying this test prior to Item 1 on the actual test (The child should guess at least 1 of the 2 examples. If not, the test should not be administered.)

After the second example is completed, review instructions as necessary and proceed with test items. During the test, do not give any explicit feedback regarding the correctness of the child's answers.

Administer all sentences of all items. Score one point for each correct response (Maximum 65).
APPENDIX II

CHILDREN’S WORD-FINDING TEST (REVISED): ITEMS

Item 1. (BLACKBOARD)
1. Every classroom has at least one grobnick.
2. Grobnicks usually hang on the wall.
3. The teacher writes on the grobnick.
4. Grobnicks can be green or black.
5. You write on a grobnick with chalk.

Item 2. (MONTH)
1. January is a very cold grobnick.
2. People usually pay their rent every grobnick.
3. Most people go for vacations during summer grobnicks.
4. There are 12 grobnicks in a year.
5. Some grobnicks have 30 days.

Item 3. (MIRROR)
1. Some people believe that breaking a grobnick brings bad luck for seven years.
2. A grobnick reflects light.
3. A grobnick has a shiny surface.
4. A grobnick has a smooth surface.
5. You can see yourself in a grobnick.

Item 4. (EYES)
1. Everyone has two grobnicks.
2. Grobnicks are usually brown or blue.
3. Sunglasses help keep the sun out of our grobnicks.
4. When you go to sleep you close your grobnicks.
5. We see with our grobnicks.

Item 5. (CLOUD)
1. Grobnick is usually suspended high in the air.
2. Sometimes you can’t see the sun because of grobnicks.
3. Grobnick can be dark or white.
4. You cannot touch a grobnick.
5. Airplanes often fly above grobnicks.
Item 6. (VACATIONS)
1. Grobnicks are supposed to be fun.
2. The summer months are the most frequent time for grobnicks.
3. Employers grant grobnicks to their employees.
4. Many people spend their grobnicks travelling.
5. Grobnicks are a time often spent away from home.

Item 7. (FIRE)
1. Grobnick is a very useful thing.
2. When not controlled, grobnick can be a very harmful thing.
3. Grobnick is used to keep us warm.
4. The first grobnick known to man was probably caused by lightning.
5. Children who play with matches often cause grobnicks.

Item 8. (PENCIL)
1. Grobnicks are used in school.
2. With most grobnicks you can do something with one end and undo it with the other.
3. You often have to sharpen a grobnick.
4. Grobnicks are commonly used for writing.
5. Grobnicks are not recommended for writing cheques.

Item 9. (SCHOOL)
1. A grobnick is a building with a special purpose.
2. Grobnicks are usually large.
3. You can learn things in a grobnick.
4. There are many rooms in a grobnick.
5. There are many teachers in a grobnick.

Item 10. (BALL)
1. There are many games you can play with a grobnick.
2. A grobnick can be hard or soft.
3. A grobnick is usually round.
4. Some grobnicks are smaller than your hand.
5. You can throw, kick or catch a grobnick.
Item 11. (CATS)
1. Most grobnicks have long tails.
2. Grobnicks of a certain breed have very short tails.
3. Grobnicks can climb trees.
4. Birds are afraid of grobnicks.
5. Grobnicks are said to have nine lives.

Item 12. (CANDY)
1. Most children like grobnick
2. Grobnick is usually very inexpensive.
3. You are not supposed to eat grobnick before dinner.
4. Grobnick is usually sweet.
5. Grobnick may cause cavities.

Item 13. (SUN)
1. Without the grobnick we would not live very long.
2. The grobnick is very big.
3. The grobnick is very far away.
4. We cannot see the grobnick at night.
5. The grobnick is hot and bright.
APPENDIX III

DESCRIPTION OF NEUROPSYCHOLOGICAL MEASURES

(i) Tests of verbal comprehension/psycholinguistic skills:

WISC/WISC-R Vocabulary (Wechsler, 1965, 1949)

WISC/WISC-R Information (Wechsler, 1965, 1949)

WISC/WISC-R Similarities (Wechsler, 1965, 1949)
Requires the test-taker to identify the most essential semantically common characteristics of each word pair. Score: number correct. Task requirements: verbal abstraction. Stimulus: spoken question. Response: spoken definition.

(ii) Tests of phonological processing/auditory perceptual skills:

Auditory Closure Test (Kass, 1964)
The test-taker is required to blend 23 progressively longer chains of sound elements into words. Score: number correct. Task requirements: auditory perception, phonological awareness. Stimulus: tape-recorded sound elements. Response: spoken word.

Wide Range Achievement Test, Reading (Jastak & Jastak, 1949) and Wide Range Achievement Test- Revised, Reading (Jastak & Wilkinson, 1985)
Requires the test-taker to read aloud a list of words of increasing difficulty. Score: number correct. Task requirements: recognition and association between printed and spoken word (sound-symbol relationship). Stimulus: printed list of words. Response: spoken word.

Speech-Sounds Perception Test (Reitan & Davison, 1974)
Requires the test-taker to identify from among 4 possible options, the written word that corresponds with the nonsense word presented via tape-recorder. Score: number correct. Task requirements: phonological processing, auditory perception. Stimulus: tape-recorded nonsense words. Response: underline word.

1 Description of neuropsychological measures was adapted from Rourke, Bakker, Fisk & Strang (1983). Child Neuropsychology An introduction to theory, research and clinical practice. New York: Guilford Press.
(iii) Tests of visuoconstruction/visual-spatial skills:

WISC/WISC-R Block Design (Wechsler, 1965, 1949)
Involves the arrangement of coloured blocks to form designs which match those presented on a printed card. Score: total score for speed and accuracy of block placement. Task requirements: visual-spatial organization, psychomotor speed, and synthesis of parts to whole. Stimulus: printed geometric design. Response: manipulation and arrangement of blocks.

WISC/WISC-R Object Assembly (Wechsler, 1965, 1949)
Involves the arrangement of pieces to form a picture. Score: total score for speed and accuracy of assembly. Task requirements: visual-spatial organization, psychomotor speed, and synthesis of parts to whole. Stimulus: disarranged parts of picture. Response: manipulation and arrangement of parts.

Target Test (Reitan & Davison, 1974)
Following a brief delay, the test-taker is required to replicate visual-spatial configurations of increasing complexity, demonstrated (through tapping) by the examiner. Score: number correct. Task Requirements: visual perception, visual-spatial skills, and attention. Stimulus: tapped out pattern. Response: line drawings of reproduced visual-spatial patterns.

(iv) Tests of nonverbal problem-solving/concept formation abilities:

Category Test (Reitan & Davison, 1974)
Involves the presentation of a visual pattern on a screen attached to four response levers denoted by the colours red, blue, yellow, and green. The test-taker must depress one of the four answer buttons to indicate his or her answer. A bell or buzzer is sounded to signal correct and incorrect responses, respectively. The test is divided into 5 subtests, each consisting of a uniform principle. The final subtest is a summary of previously viewed items and does not require the child to discern the underlying concept. The principles tested are colour, quantity, oddity, and colour prominence. Score: number of errors. Task requirements: concept formation, appreciation of verbal feedback, hypothesis generation and testing. Stimulus: patterns. Response: button depression.

Matching Pictures (Reitan & Davison, 1974)
The test-taker is required to match pictures at the top of the page with their appropriate match at the bottom of the page to form various category pairings. Score: number correct. Task Requirements: abstraction, concept formation. Stimulus: pictures. Response: identification of pairings.

Tactual Performance Test (Reitan & Davison, 1974)
While blindfolded, the test taker is required to place 6 differently shaped wooden blocks into their proper spaces on an upright board. The test is administered in three trials: first using only the dominant hand, followed by the non-dominant hand and then both hands simultaneously. After the blindfold is removed, the test-taker is asked to draw
as many shapes as he or she can recall in their relative position on the board. *Score:* time to complete each trial; number of blocks correctly placed within time limit; number of blocks correctly recalled; number of blocks placed in their correct position (for the purposes of the present work, only the time score was analyzed, however, additional measures are typically derived). *Task Requirements:* tactile perception, problem-solving, *Stimulus:* wooden blocks and board. *Response:* placement of blocks and written diagram of board.
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VITA AUCTORIS

Rosemary Susan Waxman (nee Schorr) was born on March 22, 1971 in Toronto, Ontario. She attended Concordia University in Montreal, Quebec, where she was conferred the degree of Bachelor of Arts (Honours) in Psychology in June 1994. Following graduation, Rosemary moved to Edmonton, Alberta and was employed as a Psychometrist at the University of Alberta Hospital, Keegan Psychological Services, and the Canadian Study of Health and Aging II. Rosemary returned to Toronto in the summer of 1997 where she worked as a Research Assistant at the Rotman Research Institute of Baycrest Centre for Geriatric Care. In September 1998, Rosemary commenced graduate studies in clinical neuropsychology at the University of Windsor.