A CLINICAL RATIONALE FOR ASSESSING RAPID, AUTOMATIC NAMING IN CHILDREN WITH LANGUAGE DISORDERS

Elisabeth H. Wiig, Ph.D.

Knowledge Research Institute

Arlington, Texas

Patricia Zureich, M. A.

and

Hei-Ning Helen Chan, M. S.

Psych Corp/Pearson

San Antonio, Texas

Published in Journal of Learning Disabilities, 2000, *33*, 359-374.

Elisabeth H. Wiig, Ph.D.

Knowledge Research Institute, Inc.

2131 Reflection Bay Drive

Arlington, Texas 76013

www. krii.com; ehwiig@krii.com; www.parietal.org.

Abstract

Three continuous rapid-naming tasks (Semel, Wiig, & Secord, 1995) were administered to 2,450 American-English speaking, academically-achieving subjects with normal language development and intellectual ability (ages 6 to 21 yrs.) (non-LD) and 136 subjects with primary language disorders (LD) (ages 6, 7, 9, 11, 12, 15-16) (LD). Naming time (in seconds) differed significantly ($p < .01$) between the groups for color naming (Task 1) at age 12,) (shape Naming) (Task 2 at age 6, and (Task 3) (color-shape Naming) at ages 6, 7, 9, and 12. Naming accuracy (percent correct) did not differ significantly ($p > .01$) between groups at the majority of the age levels compared. In the normative group, naming speed increased with age in a monotonic progression. The developmental trajectory in the LD group was essentially parallel, but elevated. The percentages of subjects, who failed the naming-time criteria for Task 3 (color-shape Naming), differed significantly in the two groups at all ages compared ($p < .05$). The findings indicate that the requirements for two-dimensional, continuous naming (Task 3 color-shape Naming) resulted in reduced naming speed (longer total times) and interference with fluency in language production in about one half of the clinical sample.

Background

Statement of Purposes

The purposes of this report are to present developmental patterns for three continuous, rapid-naming tasks (Semel, Wiig, & Secord, 1995), to discuss their uses as clinical tools, and give meaning to the use of criterion-referenced, rapid-naming tasks in clinical and educational practice. A rationale will be given for including one or more continuous, rapid-automatic naming tasks in the battery of diagnostic language tests administered by speech-language pathologists and psycho-educational specialists in schools.

Continuous, rapid naming of familiar competing stimuli has been shown to provide a clinical tool for probing brain mechanisms that underlie fluency in language production (Aine & Harter, 1984a,b; Posner, Walker, Friedrich, & Rafal, 1984; Stroop, 1935; Wolf & Segal, 1992). Failure to meet criteria for naming-speed, measured either by the total time needed to complete a given naming task or by response latency for single items, is interpreted to reflect lack of fluency or automaticity caused by interference and subtle dysnomia (Denckla & Rudel, 1976; Kinsbourne, Rufo, Gamzu, Palmer, & Berliner, 1991). Naming-speed deficits can be observed when a continuous naming task requires an individual to shift between perceptual fields, as in accessing color words (e.g., *red*) from lexical memory and inhibiting responses to non-matching colors used in printing the color words (e.g., blue) (Stroop, 1935). Deficits are also observed when the naming tasks require accessing words from different semantic fields, as in naming stimuli from two different semantic categories in lexical memory, such as alternating printed letters and numbers (Wolf, 1986, 1991), or repeated combinations of colors and shapes (Wiig, 1969).

There is extensive evidence from studies of children and adolescents with dyslexia that naming-speed deficits can be observed with a variety of single- and multi-dimensional stimuli presented for continuos naming (Denckla & Rudel, 1976a, b; Fawcett & Nicolson, 1994; Wolf,1986; Wolf & Obregon, 1992). Rapid automatic naming differentiates children with dyslexia from children with other forms of learning disabilities (Denckla & Rudel, 1976

a, b; Wolf, Bowers, & Biddle, in this volume), and naming deficits associated with dyslexia persist into adolescence and adulthood (Denckla & Rudel, 1976a; Korhonen, 1995; Wolff, Michel, & Ovrut, 1990). Children and adolescents with dyslexia also exhibited naming deficits on discrete-trials naming tasks with colors, digits, and letters (Fawcett & Nicolson, 1994). Their performance on the single-item naming tasks differed significantly from those of their age peers, but not from those of their reading-age controls. The latter findings suggest the presence of generalized deficits in speed of access to the lexicon that go beyond access to the alphanumeric stimuli that are automated in academic activities. These findings are relevant for the present study, which used stimuli (colors and shapes) that did not include letters or numbers.

Many students with language disorders lack accuracy and fluency on verbal association and other naming tasks, as well as in spontaneous language production (German, 1986, 1990, 1991). These deficits are interpreted to reflect word-finding difficulties (dysnomia) when the individual has adequate receptive vocabulary knowledge. There are few studies of continuous, rapid-naming abilities in children and adolescents with primary language disorders. Wiig, Semel, and Nystrom (1982) observed naming speed deficits for combinations of colors and shapes in smaller samples of children with primary language disorders, when naming-time measures were compared with those of age peers with normal language development. Similarly, there are few, if any, studies of continuous, rapid naming that use large, age-stratified normative samples to determine developmental patterns and establish clinical criteria for identifying rapid-naming deficits. This study investigates fluency and accuracy in the continuous, rapid naming of colors, shapes, and color-shape combinations in children and adolescents with primary language disorders. While it is recognized that about 60% of students with primary language disorders can be expected to experience reading disabilities (Bashir & Scavuzzo, 1992), the relationships among primary language disorders, rapid- naming deficits, and dyslexia are not considered here.

Several studies have investigated continuous, rapid-automatic naming skills in students with dyslexia (Denckla & Rudel, 1976; Kinsbourne, Rufo, Gamzu, Palmer, & Berliner, 1991; Korhonen, 1991; Wolf, 1986, 1991; Wolf & Obregon, 1992; Wolf & Segal, 1992). Among students with dyslexia, subtle dysnomia with deficits in naming speed for, among others, letters and numbers is a frequent and persistent characteristic, as are deficits in phonological awareness and non-word reading (Felton, Naylor, & Wood, 1990; Kinsbourne et al., 1991; Korhonen, 1991, 1995; Satz, Fletcher, Clark & Morris, 1981; Wolf, 1986, 1991; Wolf & Obregon, 1992; Wolf & Segal, 1992). Studies of students with dyslexia indicate that alphanumeric naming speed is a predictor of reading achievement, and that naming deficits contribute negatively to reading skills independently of deficits in phonological awareness, leading to a double-deficit theory of dyslexia (Bowers & Swanson, 1991; Felton & Brown, 1990; Korhonen, 1991, 1995; Spring & Perry, 1993; Wolf, 1991; Wolff, Michel, & Ovrut, 1990; Wolf & Segal, 1992). Furthermore, children with dyslexia can be differentiated into clinical groups in which deficits in naming speed and phonological processes can either exist independently or concomitantly (Wolf, Bowers, & Biddle, in this volume).

Models have been proposed to identify possible sources for the processing- and naming-speed deficits associated with dyslexia. Kail and Hall (1994) identify three possible causal factors. They are (a) a global speed-of-processing factor, involving all components; (b) a "local trends" factor, involving specific components; and (c) a task-strategy factor, reflecting properties inherent to stimuli and task formats. Wolf, Bowers, and Biddle (in this volume) present a stage-based model for visual naming. In this model, disruptions of fluency and automaticity in naming may occur at the levels of attentional processes, visual processing (bihemispheric), integration processes, or lexical processes (phonological and semantic access and retrieval). Comparison of the task requirements for rapid, automatic naming tests that show a predictive relationship with dyslexia indicates similarities, as well as differences, between these and the experimental tasks in this study. Fluency and speed in naming the colors, shapes, and color-shape combinations in the present measures depend upon adequate

attentional processes, visual processing, integration, and lexical processes, associated with semantic access and retrieval. The nature of the visual stimuli minimizes the demands for lexical processes associated with phonological access and retrieval. On the other hand, naming the stimulus combinations requires rapid, sequential shifts and flexibility in semantic access and retrieval of color and shape names.

This investigation uses large, age-stratified normative samples and smaller samples of students with diagnosed language disorders to explore and compare aspects of continuous, rapid-naming abilities. It addresses the need for inclusion of one or more rapid-naming tasks in the diagnostic assessment of language disorders and for clinical criteria for identifying deficits in continuous, rapid-naming speed and accuracy.

Factors in Dyslexia and Language Disorders

Dyslexia has commonly been considered to reflect deficits in aspects or components of phonological processing such as phonological awareness and processing, and short-term verbal memory (Ackerman, Dykman, & Gardner, 1990; Shankweiler, Crain, Katz, Fowler, Liberman, Brady, Thornton, Lundquist, Dreyer, Fletcher, Steubing, Shaywitz, & Shaywitz, 1995; Torgesen, 1988; Torgesen, Wagner, Simmons & Laughen, 1990). The same factors are also implicated as central to primary language disorders (Tallal, 1983; Tallal, Miller, Bedi, Byma, Wang, Nagarajan, Schreiner, Jenkins, & Merzenich, 1996). This view is supported by evidence from brain imaging studies that anatomical asymmetry of the auditory cortex, observed as primarily H-planar asymmetry, contributes to the prediction of deficits in phonological (phonemic) awareness (Leonard, Lombardino, Mercado, Browd, Breier, & Agee, 1996).

Wolf (1991) and Wolf and Obregon (1992) proposed the alternative that an underlying, precise timing mechanism, shared by language and motor functions, may be deficient in many students with dyslexia. They considered the underlying timing deficits to be reflected in reduced continuous-naming speed and to be independent of phonological

processing deficits. They suggested a double-deficit hypothesis for dyslexia to accommodate a causal duality.

Wolf, Bowers, and Biddle (in this study) refine the early dual-deficit hypothesis of causal factors in dyslexia, based on the results of retrospective analyses of data from prior research. They present evidence to support the existence of clinical subgroups among dyslexic readers. The first, largest subgroup consisted of children with modest reading impairments in whom phonological deficits were more significant than naming- speed deficits, therefore a single deficit subgroup. A second, single-deficit subgroup was identified in which naming-speed deficits were more significant than phonological processing deficits. A third, double-deficit subgroup was identified in which both naming-speed and phonological-processing measures were significantly lowered. Children in the double-deficit subgroup performed worse than children with single deficits, either impaired phonological processes or serial naming deficits. The fact that the three groups could be differentiated indicates that deficits in naming speed and phonological processes can occur concomitantly or independently.

This study uses three continuous, rapid-naming tasks to explore the possibility that deficits in naming speed may also be prevalent among students with primary language disorders. These continuous naming tasks do not require rapid naming of alphanumeric symbols, a process that is considered to be highly automatic in nature (Lindsay & Jacoby, 1994). The present tasks use color and shape stimuli to elicit rapid naming in a process that is considered either to be controlled or less automatic in nature than digit and letter naming (Cohen, Dunbar, & McClelland, 1990; Lindsay & Jacoby, 1994). The study was not designed to support or refute single- or dual-deficit theories of contributing factors in primary language disorders. Rather, it was conducted to explore the clinical utility of using selected continuous, rapid-naming measures to identify the presence of interference with fluency in continuous naming.

The Stroop Test

The development of the continuous naming tasks used here was influenced by the early work by Stroop (1935) and the follow-up by others. Stroop (1935) was first to introduce continuous, rapid-automatic naming as a clinical, neuropsychological measure. He reported significant interference with naming speed when adults with neurological impairments were asked to perform a 50 item continuous, naming task in which color names were printed in incompatible colors (e.g., the word *red* printed in blue). Stroop's rapid, automatic naming test counterbalanced naming of (a) 50 printed color words with superimposed non-matching colors presented repeatedly, and (b) 50 solid color squares with the colors used in the printed visual stimuli, also presented repeatedly. The diagnostic Stroop color-word task requires inhibition of competing responses from different perceptual fields (colors and graphics), but from within the same semantic field (color names). MacLeod (1991) recently reviewed and integrated research that used the Stroop color-word test and reported consistent significant interference effects, reflected in increased total naming times (i.e., decreased naming rate or speed). MacLeod interpreted the interference effect to reflect a primitive type of response competition, and attributed it to a combination of relative speed-of-processing and response-competition factors.

The standard *Stroop Color-Word Test* (Stroop, 1935) has been used extensively in neuropsychological research and many variations have emerged (MacLeod, 1991). All variations have been found to be highly reliable, robust, and resistant to instructional manipulations. In other words, the skills involved in naming the Stroop color-word stimuli rapidly and accurately are not easily taught or improved with practice.

Causal Factors -- A series of studies, summarized by Garner (1974), explored possible causes for the Stroop interference effect. Several studies compared naming rates and found evidence of interference as a function of integration or non-integration of colors and printed words. In the integrated task, the competing colors and printed color words were presented simultaneously, as in showing the word *RED* printed in a blue color. In the non-integrated task, there were separate, alternating presentations of the competing colors and the printed

color words. When the competing colors were separated from the printed color words, there was less interference than on the standard, integrated color-word naming task. This suggests that dimensional integration is an important factor in causing the interference effect observed by Stroop. These findings influenced the design of the rapid-naming test used in this study in the direction that one of the three naming tasks, naming color-shape combinations, features integration of two dimensions.

Several theories have been proposed to explain how the Stroop interference effect arises. Seymour (1977) proposed that interference occurred at the level of conceptual encoding. It was thought to result from activation of two conceptual codes -- the color of the word and the color denoted by the word -- in semantic memory by incongruent color-word stimuli. The results of a recent study (Klopfer, 1996) of the degree of interference as a function of color-word similarity provides support for Seymour's conceptual encoding theory. That study reported a significant negative correlation between word-color similarity and the amount of Stroop interference. The Stroop interference effect generally diminished as the perceptual and semantic distance between a superimposed color and a printed color word decreased. As examples, the word PURPLE printed in yellow elicited half the interference (73 ms.) of PURPLE printed in blue (112 ms.). As examples of deviations from the general principle, the word ORANGE printed in blue elicited less interference than ORANGE printed in purple, even though the color-word similarities were judged to be similar. Cohen, Dunbar, and McClelland (1990) later showed that a wide range of response latency data could be simulated by a parallel distribution process (PDP). This supported a theory that interference may arise at many levels of processing and encoding, including at the conceptual, semantic levels. The view is now commonly held that "interference derives from a logjam at a limited-capacity response buffer," suggesting that the interference effects emerge in the response stages (McLeod, 1991, p. 182).

Evoked potential studies have shown that the activity associated with the Stroop interference effect occurs in the left hemisphere and that the left parietal and left frontal lobes

may be involved (Aine & Harter, 1984 a, b; Posner et al., 1984). These studies support the notion that continuous, rapid-naming tasks that require (a) accessing and inhibiting responses from different perceptual domains (e.g., colors vs. printed color names), or (b) accessing by shifting between different semantic fields (e.g., colors and shapes, or letters and numbers) can be used clinically to probe the degree of interference with automaticity or fluency in language production. The notion applies to the present investigation, because one of the three rapid, automatic naming tasks (color-shape naming) satisfies these requirements for creating an interference effect.

Developmental Patterns -- Developmental studies with the Stroop color-word task (Comalli, Wapner, & Werner, 1962) indicate that a normal interference effect can be measured in the early school years. This effect is at its maximum around grades 2 to 3, when automaticity in reading is relatively low or not yet established. There is also compelling evidence that children with reading disabilities, autism, childhood aphasia, and hyperactivity show a robust, significant Stroop interference effect indicative of left-hemisphere neurological impairments (Alwitt, 1966; Bryson, 1983; Cohen, Meier, & Schulze, 1983; DeHaas & Young, 1984). Gender comparisons indicate that girls in grade-school tend to name colors faster than boys, but that there is no gender difference in the degree of interference during integrated color-word naming (Dash & Dash, 1982). Unfortunately, the requirement for rapid reading of the color words on the *Stroop Color-Word Test* may result in spurious interference effects, when children with language disorders and reading disabilities, or adults with acquired aphasia or dyslexia, are evaluated. The continuous, rapid- naming tasks used in this study were designed to eliminate Stroop's requirement for accurate and rapid word reading by substituting familiar colors and geometric shapes as the visual stimuli.

Other Diagnostic Naming Tasks

Rapid, automatic naming (RAN) tasks, other than the Stroop test, (Denckla & Rudel, 1976; Semel, Wiig, & Secord, 1995; Wiig & Semel, 1980; Wolf, 1986; Wolf & Segal, 1992) are commonly used for diagnostic purposes by aphasiologists, neuropsychologists, and

psycho-educational specialists. There are also diagnostic naming tasks that measure the latency and accuracy of single, discrete responses (e.g., Goodglass & Kaplan, 1972) or the fluency of retrieval of words that begin with the same letter (e.g., Benton & Hamsher, 1977) or belong to the same semantic class (e.g., Semel, Wiig, & Secord, 1995). Among these naming tasks, performances on a modified version of the word fluency test (Benton & Hamsher, 1977) have been related to increased regional cerebral blood flow (Warkentin, Risberg, Nilsson, Karlson, & Graae, 1991).

Warkentin and associates asked 39 right-handed adults with normal neuropsychological profiles to say as many words as they could think of beginning with a specified letter that was changed every minute (e.g., F, A, S, …). The analyses indicated significantly higher flow values in the left anterior and inferior frontal areas together with lower values in the left central and anterior parietal areas during the test condition than during the resting period. The left frontal lobe has also been implicated in retrieval from memory, especially when the inferior and orbital sections are involved (Ojemann, 1983; Stuss & Benson, 1984). Ojemann demonstrated that electrical stimulation of the left anterior frontal lobe resulted in disruption of naming, reading, and sequencing orofacial movements. He postulated that the disruptions resulted from blockage of a precise timing mechanism involved in controlling decoding and encoding. Damage to the prefrontal areas is detrimental to planning and goal-directed behavior, indicating that the prefrontal cortex plays a central role in regulating cognitive and emotional behavior. The present study does not provide evidence of the cerebral regions involved in continuous, rapid naming. However, we hypothesize that prefrontal areas may be involved in controlling fluency and speed in naming the color-shape combinations used in one of the experimental tasks in this study.

Rapid, automatic-naming tasks measure the speed and accuracy of continuous naming responses. A summary of the RAN tests that form the background for this research is presented in Table 1. As shown, the content of the commonly used RAN tasks varies by the type and level of familiarity of stimuli and automaticity of responses.

(Insert Table 1 about here.)

Denckla and Rudel (1976) used common objects, letters, colors, and numbers in their research of rapid, automatic naming by students with and without dyslexia. Wolf (1986) introduced a continuous, rapid-automatic naming task with alternating visual stimuli (RAS) in the form of randomly sequenced letters and digits. This task requires knowledge and production of names that represent two different semantic fields (letters and numbers) and are highly automated in proficient readers.

Semel and Wiig (1980) and Wiig, Semel, and Nystrom (1982) used repeated colors, shapes, and color-shape combinations to explore continuous, rapid naming in children with normal language development and with diagnosed language disorders. The tasks were developed by Wiig (1969) for use with adults with acquired aphasia, who could not perform on the *Stroop Color-Word Test,* due to reduced ability to read. Early research with this RAN task indicated that naming time for all three tasks (naming colors, shapes, and color-shape combinations) decreased with age (Semel & Wiig, 1980). Furthermore, the color-shape naming task (Task 3) differentiated smaller samples of children with normal language development and academic achievement from children with language disorders (Semel & Wiig, 1980; Wiig, Semel, & Nystrom, 1982). Like the Wolf RAS task, the color-shape naming task (Task 3) requires production of names from two different semantic fields. Unlike the Wolf RAS task, performances on the tasks used in this study do not rely on knowledge and production of letters and numbers. These academic skills may not be acquired or automated in children with language disorders.

Continuous, rapid-naming tasks, that cause interference with automaticity or fluency in language production in persons with neurologically-based language disorders, appear to require rapid perceptual or conceptual shifts from one dimension or semantic field to another. The *Stroop Color-Word Test* (Stroop, 1935) requires naming of stimuli in competing dimensions, and reduced naming speed and accuracy are considered to signify interference with automaticity in language production. The *RAS* test (Wolf, 1986) also requires rapid

shifting between letter and digit names, and reduced naming speed is considered to reflect deficits in underlying timing mechanisms (Wolf, 1991; Wolf & Obregon, 1992).

One of the three tasks used in this study requires multi-dimensional naming with rapid, conceptual shifts. Task 3, Color-Shape Naming, elicits production of names for randomized color-shape combinations and requires attentional abilities related to focusing, sustaining, and alternating attention. Accessing responses requires accurate and rapid conceptual shifts between two dimensions and their associated semantic fields to maintain fluency. This multi-dimensional naming task was therefore expected to yield data to support its use as a measure to identify interference with fluency in language production in children and adolescents with primary language disorders.

Experimental Questions

This study was designed to obtain and compare developmental data for naming speed (in seconds) and accuracy of naming (in percent correct) on three different continuous, rapid naming tasks (Semel, Wiig, & Secord, 1995). Age-stratified samples of students with normal language development, academic achievement, and intellectual ability (non-LD), and with diagnosed language disorders, academic underachievement, and normal intellectual ability (LD) provided the data for the comparisons.

The study posed several experimental questions. The first concerned whether naming speed and accuracy would decrease significantly as a function of age in students with normal language development and in students with primary language disorders. The second question was whether or not the developmental progressions for naming speed and accuracy would follow similar trajectories in the two groups. The third concerned whether or not performance measures for speed and accuracy of naming on any of the three continuous naming tasks would differ significantly in the two groups at selected age levels. The final question was whether or not the failure rates (in percent) for naming speed or accuracy, as determined against criteria based on the normative sample distributions, would differ significantly in the two groups.

Methods

Subjects

The normative sample consisted of 2,450 students with normal language development (ages 6 through 21). There were 200 students (100 female and 100 male) at each one-year age level from 6 through 16 years and 250 students (125 female and 125 male) in the age range from 17 through 21 years. The nationally representative sample was stratified on age, gender (50% each), race/ethnicity (70.6% Caucasian, 15.4% African American, and 10.3% Hispanic), geographic region, and SES (19.2% with 11 years education or less; the remainder with 12 or more years of education) according to parent educational level based on the 1980 Census of Population (PC80-1-B1). Subjects in the normative sample attended regular classrooms. They achieved at or above grade level on norm-referenced academic-achievement tests (e.g., Stanford Achievement Test) in language-based subjects (e.g., reading comprehension and written language). Their intellectual ability quotients were within or above the normal range (between -1.0 and +1.5 SD of the mean) on group tests of intelligence (e.g., Slosson). The *Clinical Evaluation of Language Fundamentals - 3* (Semel, Wiig, & Secord, 1995) was administered to all subjects without language disorders. None of the normative subjects were diagnosed to exhibit language disorders, learning disabilities, or other disorders (e.g., sensory, perceptual, neuro-psychological, or emotional) that would require special education services. The sampling procedures for this group were designed to result in samples that would resemble the composition of regular classrooms in the public schools.

The clinical sample consisted of 136 students (74 males and 62 females) with diagnosed language disorders. In this group, 97 (71%) were Caucasian, 20 (15%) African American, and 19 (14%) Hispanic. The students were distributed unequally, but with similar gender ratios, across the ages 6 (n=31), 7 (n=15), 9 (n=31), 11 (n=15), 12 (n=30), and 15-16 (n=14) years. Subjects in the clinical sample were administered two or more standardized,

norm-referenced language tests (e.g., CELF-R, TOLD-I). All were administered the *Clinical Evaluation of Language Fundamentals - 3*.

Subjects in the clinical group were matched for age, gender and demography with subjects from the normative group (n = 136) to allow for controlled age-level comparisons. The CELF-3 mean composite and subtest score means for the matched clinical (LD) and normative (non-LD) groups are shown in Table 2. The mean composite scores for the clinical (LD) samples, broken down by age level, are shown in Table 3.

(Insert Tables 2 and 3 about here.)

The *WISC-III* was co-administered with the experimental tests and subjects received Full Scale IQ scores within the range from 85 to 115. Academic achievement tests were administered by psycho-educational specialists within the respective school settings. On intake, all subjects were diagnosed with a language disorder by using discrepancy formulae (e.g., intelligence scores at or above 85 and composite standard scores on tests of language and academic achievement at or below -1.5 SD of the mean). All subjects had hearing within the normal range and none had primary or uncorrected visual deficits. All students in the clinical group met Federal or State requirements for a diagnosis of language-learning disabilities and met eligibility criteria for direct language intervention in their school settings. At the time of the experimental testing all were enrolled in school-based language intervention programs.

All subjects in the normative and clinical samples were English-language dominant. Language dominance was determined by the parents, by the school district's educational placement, or by the subjects if they were 18 years or older.

Materials

The continuous-naming measures used in this study are part of the CELF-3 supplementary tasks (Word Associations, Listening to Paragraphs, and Rapid Automatic Naming). The CELF-3 contains eight diagnostic subtests *(Sentence Structure, Word Structure, Concepts and Directions, Formulated Sentences, Word Classes, Recalling*

Sentences, Sentence Assembly, and Semantic Relationships). The subtests are grouped in two diagnostic clusters for ages 6-8 and 9-21 years with three primarily receptive and three primarily expressive subtests in each..

The continuous-naming tasks used in this study have their theoretical grounding in the original work by Stroop (1935). The tasks share some design features with other rapid-naming tasks, but several features differ (see Table 1). The experimental test uses three separate continuous, timed naming tasks and are preceded by three familiarization trials.

Task 1, Color Naming, requires continuous, rapid naming of 36 circles of four, randomly repeated colors (blue, green, red, yellow). *Task 2, Shape Naming,* requires rapid naming of 36 instances of four, randomly repeated geometric shapes (circle, star, square, triangle). The color and shape naming tasks require continuous naming of stimuli from only one semantic field.

Task 3, Color-Shape Naming, requires continuous, rapid naming of 36 randomly repeated color and shape combinations. The combinations were created by superimposing the colors from Task 1 onto the geometric shapes from Task 2. The integrated task requires continuous production of conjoint responses from two different semantic fields. It involves executive functions that are related to focusing, sustaining and dividing attention.

The three experimental naming tasks were preceded by three untimed practice tasks, designed to establish adequacy in the ability to name the visual stimuli. The first practice task requires untimed naming of twelve circles in four repeated colors. The second requires untimed naming of twelve instances with four repeated geometric shapes. The third combines the colors and shapes used in the first two trials in twelve visual stimuli. Subjects were required to give accurate naming responses for all visual stimuli in the practice tasks in order to proceed to the experimental naming tasks.

The visual stimuli in the practice and experimental tasks were highly differentiable, prototypical colors and shapes. The four colors (blue, green, red, yellow) are the landmark colors considered by Miller and Johnson-Laird (1976) to have unique psycho-physiological

bases that result in ease of naming. The color names have relatively high frequencies of occurrence, with estimated frequencies per million tokens ranging from 111.34 to 282.24. The geometric shapes (circle, star, square, triangle) have lower frequencies of occurrence, with estimated frequencies per million tokens ranging from 33.75 to 146.45. The names associated with all visual stimuli occur with similar frequencies in educational texts across grades 3 to 9 (Caroll, Davies, & Richman, 1971).

Procedures

The practice and experimental tasks were individually administered to all subjects in conjunction with the administration of the *Clinical Evaluation of Language Fundamentals - Third Edition* (CELF-3). All examiners were state licensed and/or ASHA certified speech-language pathologists. All used the standardized instructions for administration and scoring that are featured in the CELF-3 Examiner's Manual (Semel, Wiig, & Secord, 1995, pp. 82-84).

Performances on the experimental tasks were evaluated by measuring the total elapsed time to complete naming of the 36 visual stimuli in each task (measured in seconds) and the accuracy of naming them (expressed in percent). Each item in a task that was named accurately by color (e.g., *red*), shape (e.g., *circle*) or order (e.g., *red circle*) was credited one point as correct. Accurate self-corrections were also credited one point. Self corrections were therefore reflected only as increases in the time required to complete a given naming task. Total naming time (in seconds) and percent correct naming responses were used to (a) establish distributions by age for the normative sample and clinical groups; (b) compare distributions in age-level equivalent normative and clinical groups; and (c) establish the prevalence of significant deviations from the normative distributions.

Results

Naming One Dimension

For *Task 1, Color Naming,* the mean naming time for the normative sample (n = 2,450) decreased from 39.5 seconds at 6 years to 20.6 seconds at 17-21 years. The mean percentage of accuracy remained stable with a high of 99.8 and a low of 99.1 percent. In the clinical sample (n = 136), mean naming time decreased from 45.6 seconds at 6 years to 20.9 seconds at 15-16 years. Naming accuracy ranged from a high of 99.6 to a low of 90.3 percent (see Tables 4a and b). For Task 1, Color Naming, there was a significant difference in naming time ($p < .01$) between the two groups only at age 12.

(Insert Tables 4a and b about here.)

For *Task 2, Shape Naming* , the mean naming time for the normative sample (n=2,450) decreased from 57.7 seconds at 6 years to 24.0 seconds at 17-21 years . The mean percentage of accuracy remained stable with a high of 99.5 and a low of 95.9 %. In the clinical sample (n=136), naming time decreased from 74.4 seconds at 6 years to 28.6 seconds at 15-16 years. Accuracy ranged from a high of 98.2 to a low of 86.5 % (see Tables 5a and b). There were significant difference s between the two groups in naming times for Task 2, Shape Naming, at ages 6 and 9 ($p< .01$) and 12 ($p< .05$) and in naming accuracy at age 7 (< .05).

(Insert Tables 5a and b about here.)

Naming Two Dimensions

For *Task 3, Color-Shape Naming,* the mean naming time for the normative sample decreased from a mean of 114.7 seconds at age 6 years to 46.1 seconds at 17-21 years. Accuracy improved slightly with age and was generally high with a range from 98.5 to 85.1 %. In the clinical sample, mean naming time decreased from 162.5 seconds at age 6 years to 60.1 seconds at 15-16 years. Accuracy improved with age and was relatively high with a range from 94.1 to 76.1 % (Tables 6a and b). In both groups, the distribution of color-shape naming times (seconds) was left skewed across ages.

(Insert Tables 6a and b about here)

Analyses of variance (ANOVA), using general linear models procedures, were subsequently used to compare Color-Shape Naming time measures (RAN Item 3) in the normative sample (n = 2450) and the clinical group (n = 136) at ages 6, 7, 9, 11, 12, and 15-16. Table 7 gives a summary of the ANOVA results for these comparisons. The ANOVA indicated significant main effects for age and groups. There was also a significant age x group interaction effect. This indicates that naming times for the normal and clinical groups did not follow parallel paths across all age levels.

(Insert Table 7 about here.)

Application of Duncan's Multiple Range test and ANOVA procedures, which control the Type I comparison-wise error rate, for age-level differences in naming time in the normative group (n = 2450) yielded similar results. The normative means differed significantly by age in the range from 6 through 12 years, and between ages 13, 14, and 15 years. There were no significant differences between naming-time means for ages 12 and 13, or 15, 16, and 17 years.

In the clinical group (n = 136), Duncan's Multiple Range test and ANOVA procedures for age-level differences in naming time indicated that the means differed significantly between ages 6 and 7, and 9 and 11 years. There were no significant differences between means for ages 7 and 9 or 11, 12, 15 and 16 years. For Task 3, Color-Shape Naming, mean naming time for the normative group follows a monotonically decreasing curve. Naming times were longer in the clinical group, but decreases in mean naming time follow a similar trajectory with one exception at age 12 at which there was a reversal.

Subsequent ANOVA (general linear models) compared Color-Shape Naming times between the matched normative (n = 136) and LD subjects (n = 136) at seven age levels. Table 8 gives an overview of the ANOVA results for the comparisons by age level. The results indicate that the mean naming-time measures differed significantly in the matched groups at ages 6, 7, 9, 11, and 12 ($p<.01$). There were no significant differences at ages 15 and 16 ($p>.05$).

(Insert Table 8 about here.)

The mean accuracy measures (in percent) did not differ significantly ($p > .01$) between the matched LD ($n = 136$) and non-LD ($n = 136$) groups at most age levels. There were two exceptions at ages 7 and 9 where the mean accuracy measures were significantly higher in the non-LD than the LD group ($p < .01$). The combined findings suggest that the two-dimensional naming requirement (color-shape) created significant interference with fluency in continuous naming in the clinical samples in the age range from 6 to 12 years. This resulted in significantly slower naming speed (i.e., longer naming time) at all but the two upper age levels (ages 15 and 16).

Criterion Scores

Age-level criterion scores were determined only for *Task 3, Color-Shape Naming,* because this task best differentiated students with language disorders from students with normal language development. Two sets of age-based criterion scores resulted -- one for naming time in seconds and the other for naming accuracy in percent correct. The age criteria were determined by the distribution of scores in the normative sample ($n = 2{,}450$). The distributions of the accuracy (per cent correct) and time (seconds) measures were left-skewed across age levels, indicating that the majority of the normative subjects performed with a high degree of accuracy and speed. A combination of measures (mean, SD, mode, and median) and smoothing were used to determine criterion scores for naming time at each age level that identified about 16 percent of the normative sample. The FAIL criterion scores for naming times (seconds) were equivalent to measures at +1 SD of the normative-sample mean at each age level. The FAIL criterion scores for naming accuracy, expressed by the number of naming errors, were determined by accounting for the number of correct responses at each age level, whose accuracy measures were at or below -1 SD of the normative sample means.

FAIL Task 3, Color-Shape Naming

The FAIL criterion scores for naming time (seconds) and accuracy (number of errors) were used to identify subjects in the normative and clinical samples who failed to meet Task

3 (Color-Shape Naming) time or accuracy criteria. In the normative group (n = 2450) 375 students (15 percent) failed to meet Task 3 naming time criteria. This percentage reflects the fact that the cut-off (FAIL) scores were set to identify about 16 percent of the normative sample, a commonly used criterion. In the clinical group (n = 136) 65 students (48 percent) failed Task 3 naming time criteria. The percentages in the two groups at each age level that failed naming time and accuracy criteria are shown in Tables 9a and b.

(Insert Tables 9a and b about here.)

In the normative sample (n = 2450), the percentages that failed naming-time criteria for Task 3, Color-Shape Naming, ranged from a high of 23.0 to a low of 5.6 percent and decreased with age. In the clinical sample (n = 136), the percentages that failed naming time criteria ranged from a high of 58.1 to a low of 28.6 percent. Chi-square comparisons indicated significant differences ($p < .05$) between the two groups in the failure rates for naming time at all ages compared.

The percentages of students who failed the accuracy criteria for Task 3, Color-Shape Naming, ranged from 8.0 to 2.0 percent in the normative sample (n = 2450) and from 42.9 to 13.3 percent in the clinical sample (n = 136). The failure percentages for accuracy differed significantly in the two groups ($p <. .05$) at ages 6, 7, 9, 12, and 15-16. There was no significant difference at age 11 ($p > .05$).

In the clinical samples, the prevalence in percent of failing Task 3 (Color-Shape Naming) time criteria and obtaining composite standard scores below 85 (-1 SD) on CELF-3 were also explored. In the clinical group (n = 136), 65 (48 percent) failed age-level naming-time criteria for Task 3 (Color-Shape Naming). Of these 65 subjects, 3 percent obtained CELF-3 Total standard scores between 85 and 71 (between -1 and -2 SD below the mean), while 97 percent obtained total standard scores of 70 and below (- 2SD below the mean).

Discussion

For the single-dimension naming tasks - Task 1, Color Naming and Task 2, Shape Naming - the mean naming time (in seconds) decreased monotonically and significantly with age in the large normative sample. The accuracy of naming was very high (above 95 percent) and stable across age levels on both single-dimension naming tasks. In the smaller clinical sample, naming time for the color and shape naming tasks decreased significantly between ages in a pattern similar to that in the normative groups. There were significant difference in naming time between the normative and the clinical groups for color (Task 1) at age 12 and shape (Task 2) at ages 6, 9, and 12.

Accuracy of naming was high for both color (Task 1) and shape (Task 2) naming (generally in the 90 percent range) and stable across ages. The majority of the single-dimension accuracy measures did not differ significantly ($p > .01$) in the normative (non-LD) and clinical age-level groups. One exception occurred for accuracy in naming shapes (Task 2) at age 7 ($p < .05$). Due to the lack of consistency in differentiating naming time and accuracy performances in the two groups across age levels, these measures were not subjected to further analyses.

For Task 3, Color-Shape Naming, which requires accessing of two dimensions, the naming time measures (in seconds) differed significantly at most ages in the normative and clinical groups. In the large normative sample, the mean naming time (in seconds) decreased monotonically with age. There were significant decreases in naming time between age levels in the range from 6 through 12 years, and between 13 and 15 years. There were no significant differences between age levels beyond age 15. Naming accuracy was high in the normative groups (generally in the 90 percent range) and increased slightly across ages.

In the clinical sample, mean naming times were significantly longer than in the normative sample at all but the two upper age levels (ages 15 and 16). Naming time decreased in a pattern similar to that of the normative sample with one deviation at age 12, where there was a reversal in the trend associated with an increase in the mean and standard deviation. The significant decreases in naming time across age levels occurred between ages

6 and 7 and 9 and 11 years. Naming accuracy was moderate to high in the clinical group (between 76 and 94 percent) and increased slightly across ages. Accuracy of naming did not differ significantly in the normative and clinical groups at ages 6, 11, 12, and 15-16. There were two exceptions at ages 7 and 9, where the clinical groups were significantly less accurate than the normative groups.

These findings concur with many of the observations from rapid automatic naming studies of students with dyslexia (Denckla & Rudel, 1976a, b; Wolf, 1986; Wolf & Obregon, 1992). Among similarities in studies of students with dyslexia and this study of students with primary language disorders are that measures of accuracy for the continuous naming of single- or multi-dimensional stimuli do not seem to differentiate consistently and reliably among clinical (language disordered vs. non-language disordered) or educational groups (dyslexic vs. non-dyslexic). Naming speed or latency measures for letters, numbers, and alternating letters and numbers, however, consistently differentiate students with dyslexia from their academically achieving age-peers. In a similar vein, the color-shape naming speed measures in this study differentiated students with primary language disorders from their normal age-peers at the majority of the age levels compared.

Another similarity exists in the observations that continuous naming speed measures decrease significantly with age among non-dyslexic and non-language disordered students. The present study contributes to these observations by showing that the developmental trajectory for color-shape naming-time means (Task 3) decreased monotonically in the non-LD group from about 115 sec. at age 6 to about 47 sec. at ages 15 and up. The naming-time trajectory was similar in the LD group, in spite of a reversal at age 12, but elevated with a mean decrease from about 163 sec. at age 6 to about 60 sec. at ages 15-16. The mean color-shape naming time at age 6 was about 1.42 times slower and at age 15-16 about 1.30 times slower in the LD than in the non-LD group. The mean color-shape naming measures (sec.) in the two groups in this study do not allow for calculating a critical "slowing" factor for speed of processing, similar to that determined for adults with closed-head injury of approximately

1.54 (Ferraro, 1996). Future studies should address questions related to the degree of interference with naming fluency or "slowing" that can be expected among students with primary language disorders across age levels and as a function of degree of severity.

There are some important differences between the rapid naming measures for students with primary language disorders and those obtained by using color and alphanumeric naming tasks with children, adolescents, and adults with dyslexia (Fawcett & Nicolson, 1994; Felton, Naylor, & Wood, 1990; Korhonen, 1995; Wolff, Michel, & Ovrut, 1990). First, the color-shape naming times in this study did not differentiate between LD and non-LD students at ages 15 and 16. The reasons for the lack of discrimination by naming speed at ages 15-16 may well be that the color-shape combination stimuli loose diagnostic sensitivity in adolescence. This contrasts with findings that rapid, automatic-naming time measures for letters and numbers maintain diagnostic sensitivity for individuals with dyslexia through adolescence and young adulthood (Felton, Naylor, & Wood, 1990; Korhonen, 1995).

A second difference is that naming time for single-dimension stimuli (colors or shapes) did not differentiate the LD and normative non-LD groups in this study. In contrast, studies of students with dyslexia report that rapid naming time for colors differentiated students with and without dyslexia, but with similar intellectual abilities (Fawcett & Nicolson, 1994; Felton, Naylor, & Wood, 1990; Korhonen, 1995; Wolff, Michel, & Ovrut, 1990). This difference may be explored in future studies by grouping students with primary language disorders by whether or not they exhibit concomitant dyslexia and by co-varying or controlling for intelligence.

The percentages of subjects who failed the diagnostic naming-time criteria (in seconds) for Task 3 (Color-Shape Naming) differed significantly in the two groups. In the normative sample 15 percent overall failed the established naming-time criteria. This finding meets expectations, since the PASS/FAIL cut-off scores for Task 3 (Color-Shape Naming) were determined at + 1 SD of the mean for naming time (sec.). The FAIL percentages in the normative sample were distributed fairly equally across ages between 6 and 15-16 years

(between 15 and 23 percent). In the clinical sample, 48 percent overall failed the established naming-time criteria for Task 3. As in the normative sample, the FAIL percentages were distributed fairly equally across ages between 6 and 12 years, but they were larger and ranged between 40 and 58 percent. Based on chi-square analyses, the FAIL percentages were significantly larger for Task 3 naming time all age levels compared in the clinical than in the normative group ($p < .05$). The possibility that those subjects who failed the naming time criteria for color-shape combinations may also exhibit dyslexia should be explored in future studies. In view of the similarity between the percentages that failed color-shape naming-time criteria in this study (between 58 and 40 percent) and the prevalence of dyslexia (about 60 percent) in children with primary language disorders (Bashir and Scavuzzo, 1992) such comparisons appear relevant.

The percentages of subjects who failed the established criteria for accuracy of naming (in percent) for Task 3 (Color-Shape Naming) were relatively low in the normative sample, ranging from 2 to 8 percent. In the clinical sample, failure rates for accuracy ranged from 13 to 43 percent and varied widely between ages. The failure rates for naming accuracy were significantly larger in the clinical than in the normative group at all but one age level compared (age 11 years)**.**

These results support prior observations that total naming time measures (in seconds), such as the ones obtained by RAN Task 3, Color-Shape Naming, identify a substantial proportion of students with language disorders (from 58 to 40 percent, depending on age). The total naming-time measures differentiated subjects with primary language disorders from their age peers with normal language development and academic achievement at all but the upper age levels (ages 15-16). We infer that the task requirements for continuous, rapid naming of the color-shape combinations (i.e., two-dimensional naming) caused the interference with fluency in language production that resulted in the differentiation.

In the group of 65 subjects with primary language disorders, who failed the naming-time criteria for Task 3 (Color-Shape Naming), only 3 percent obtained CELF-3 Total

language scores between 85 and 71. The majority (97 percent) obtained CELF-3 Total Language standard scores at or below 70. This placed their overall performances in the severe language deficit range, suggesting a relationship between the severity of a primary language disorder and rapid-naming deficits for color-shape combinations. The rapid color-shape naming (Task 3) may identify processing speed and interference factors that may be associated with involvement of the prefrontal aspects of the left hemisphere in planning and controlling language production. Future studies should explore the distributions of cerebral-blood flow during rapid color, shape, and color-shape naming by using methods similar to those used by Warkentin and his associates (1991) to test these hypotheses.

Two different models have been proposed to account for naming-time deficits on continuous alternating stimulus tasks in clinical groups of students with dyslexia (Kinsbourne et al., 1991; Satz et al., 1981). They are the developmental lag and the deficit model. The developmental lag model postulates that observed differences in naming time or accuracy measures reflect a lag in the rate of development and that students with dyslexia will eventually catch up with their peers. A deficit model, on the other hand, postulates that the observed performance differences in continuous naming speed or accuracy reflect deficits in underlying neuro-psychological processes, important for the development of the skills probed. It would assert that students with difficulties will not catch up to their peers by age 16 years (Kinsbourne et al., 1991; Satz et al., 1981).

In this study, the mean naming-time measures of students with language disorders did not differ significantly ($p > 0.01$) from the naming-time measures of their peers in the normative group at age 15-16. The present findings therefore appear to support a developmental lag mode. It is important to remember, however, that this was not a longitudinal study. Acceptance of the developmental lag model, rather than of a deficit model, would depend on whether individual students with rapid color-shape naming deficits in the middle-school years would eventually catch up with their peers without naming deficits. In a similar vein, the distinctions between the two models could be tested by

evaluating whether rapid-naming deficits can be ameliorated or reversed by medical intervention with prescriptions used for conditions such as attention deficit disorders or depression. It seems relevant to investigate which neuro-psychological processes or cortical systems might be involved in controlling normal fluency in persons without language disorders or dyslexia and in persons with primary language disorders and concurrent naming speed deficits. It also appears important to investigate if the single- and double-deficit models supported by research of causal and predictive factors in dyslexia (Wolf, Bowers, & Biddle, in this volume) might find parallels in the classification of children with primary language disorders. A combination of tests and measures that determine speed of auditory processing, phonological awareness, semantic access, and speed of retrieval in a well-defined group of children with primary language disorders could provide the supportive evidence.

In combination, the findings suggest that failing CELF-3 RAN Task 3 (Color-Shape Naming) time criteria may indicate the presence of factors that contribute to interference with fluency in continuous, automatic language production. This study does not allow for a determination of whether or not the interference effect may have been caused by reduced speed-of-processing and response-competition or "log jamming" (McLeod, 1991), underlying timing mechanism deficits (Wolf, 1991; Wolf, Bowers, & Biddle, in this volume; Wolf & Obregon, 1992), or dysfunction of interactive or regional brain mechanisms and systems (Aine & Harter, 1984a, b; Warkentin et al., 1991).

From a clinical perspective, one rationale for administering the present continuous naming tasks would be to identify whether a naming deficit and interference with fluency in language production might be a contributing factor in a diagnosed, primary language disorder. The present findings suggest that in clinical use, Task 1 (Color Naming) and Task 2 (Shape Naming) would best serve as control measures. Task 3 (Color-Shape Naming) would serve to identify naming-speed deficits and interference with fluency in language production, if performances on the control tasks met naming time and accuracy criteria for normalcy. It would be important for clinical and educational interpretations to co-administer one or more

rapid, automatic-naming tasks that use alphanumeric stimuli and have been found to predict dyslexia. The RAS naming task (Wolf, 1986) appears well suited for co-administration for clinical and educational diagnostic purposes. Wolf, Bowers, and Biddle (in this volume) suggest that rapid naming tasks should be included in diagnostic reading assessments in Kinder-garten and the early grades. It would also be of diagnostic value to explore relationships among the measures that are obtained by administering the CELF-3 RAN task (Semel, Wiig & Secord, 1995) and the RAS naming task (Wolf, 1986).

Clinical interpretation of the CELF-3 RAN results will depend on whether naming speed is significantly reduced (i.e., slower) on all three tasks, or on Task 3 (Color-Shape Naming) only. If the total naming times (in seconds) for all three tasks are significantly slowed and exceed a point at + 1 SD above the mean for age level, it would suggest a more pervasive slowing in language production that may be associated with cognitive limitations or with neurogenic disorders of speech (e.g., dysarthria or apraxia). In those cases, Task 3 may be invalid as a measure for identifying deficits in the fluency of language production, characterized by interference with fluency for only the two-dimensional naming of color-shape combinations. Interference with fluency in two-dimensional naming only may reflect deficits associated with reduced executive functions.

The clinician or educator may want to administer norm- or criterion-referenced tests of word finding and analyze a spontaneous language sample for additional evidence of word-finding difficulties (German, 1986, 1990, 1991), if the total naming time exceeds the established criteria for CELF-3 RAN Task 3 (Color-Shape Naming). Speech-language pathologists should explore the level of automaticity in continuous naming of alternating letters and numbers (Wolf, 1986) and fluency in oral reading concurrently with diagnostic language tests to identify characteristics commonly associated with dyslexia.

There is evidence that repetitive training of word naming will improve naming accuracy and time per word. Levy, Abello, and Lysynchuk (1997). observed that gains in word-naming accuracy transferred to reading the trained words in context. There were

general gains in reading comprehension with repeated readings of stories, but the gains were not directly related to ease of word recognition that resulted directly from word training. The implications for language intervention are not to train rote automaticity or fluency in naming shapes, colors, or words out of context. Rather, the clinician should help students develop strategies for increasing naming accuracy and speed. The work by German (1986, 1990, 1991), Levy et al. (1997), and Wolf and Segal (1992) provide relevant recommendations for this intervention. A broader scope for intervention to improve retrieval, automaticity, and vocabulary can be found in the RAVE-O curriculum (Wolf, Miller, & Donnelley, 1996). The curriculum encompasses phonological training and provides opportunities for word recognition and lexical retrieval practice within a broader semantic context of developing word knowledge and reading text.

Acknowledgements

The authors gratefully acknowledge the many contributions by professional colleagues, especially by those who were involved in the standardization of CELF-3 (Semel, Wiig, & Secord, 1995). This research was supported by The Psychological Corporation by providing access to CELF-3 standardization data.

References

Ackerman, P. T., Dykman, R. A., & Gardner, M. Y. (1990). Counting rate, naming rate, phonological sensitivity, and memory span: Major factors in dyslexia. *Journal of Learning Disabilities*, *23*, 325-327.

Aine, C. J., & Harter, M. R. (1984a). Event-related potentials to Stroop stimuli: Color and word processing. *Annals of the New York Academy of Sciences*, *425*, 152-153.

Aine, C. J., & Harter, M. R. (1984b). Hemispheric differences in event-related potentials to Stroop stimuli: Attention and color-word processing. *Annals of the New York Academy of Sciences*, *425*, 154-156.

Alwitt, L. F. (1966). Attention in a visual task among non-readers and readers. *Perceptual and Motor Skills*, *23*, 361-362.

Bashir, A. S., & Scavuzzo, A. (1992). Children with learning disabilities: Natural history and academic success. *Journal of Learning Disabilities*, 25, 53-65.

Benton, A. L. & Hamsher, K. (1977). *Multilingual aphasia examination*. Iowa City: University of Iowa.

Bowers, P. G., & Swanson, L. B. (1991). Naming speed deficits in reading disability: Multiple measures of a singular process. *Journal of Experimental Child Psychology*, *51*, 195-219.

Bryson, S. E. (1983). Interference effects in autistic children: Evidence for the comprehension of single stimuli. *Journal of Abnormal Psychology*, *92*, 250-254.

Cohen, J. D., Dunbar, K., & McClelland, J. L. (1990). On the control of automatic processes: A parallel distributed processing account of the Stroop effect. *Psychological Review*, *97*, 332-361.

Cohen, J. D., Meier, E., & Schulze, V. (1983). Spontaneous reading in aphasics (Stroop Test). *Der Nervenarzt*, *54*, 299-303.

Comalli, P. E., Jr., Wapner, S., & Werner, H. (1962). Interference effects of Stroop color-word test in childhood, adulthood, and aging. *Journal of Genetic Psychology*, *100*, 47-53.

Carroll, J. B., Davies, P., & Richman, B. (1971). *The American heritage word frequency book.* Boston, MA: Houghton Mifflin.

Dash, J., & Dash, A. S. (1982). Cognitive developmental studies of the Stroop phenomena: Cross-sectional and longitudinal data. *Indian Psychologist*, *I*, 24-33.

DeHaas, P. A., & Young, R. D. (1984). Attention styles of hyperactive and normal girls. *Journal of Abnormal Child Psychology*, 12, 531-545.

Denckla, M. B., & Rudel, R. G. (1976). Rapid "automatized" naming (R.A.N.): Dyslexia differentiated from other learning disabilities. *Neuropsychologia*, *14*, 471.

Fawcett, A. J., & Nicolson, R. I. (1994). Naming speed in children with dyslexia. *Journal of Learning Disabilities*, 27, 641-646.

Felton, R., & Brown, L. S. (1990). Phonological processes as predictors of specific reading skills in children at risk for reading failure. *Reading and Writing: An Interdisciplinary Journal*, *2*, 39-59.

Felton, R. H., Naylor, C. E., & Wood, F. B. (1990) Neuropsychological profile of adult dyslexics. *Brain and Language*, 39, 485-497.

Ferraro, F. R. (1996). Cognitive slowing in closed-head injury. *Brain and Cognition*, 32, 429-440.

Garner, W. R. (1974). *The processing of information and structure*. Hillsdale, NJ: Erlbaum.

German, D. J. (1986). *National College of Education test of word finding*. Austin, TX: Pro-Ed.

German, D. J. (1990). *National College of Education test of adolescent/adult*

word finding. Austin, TX: Pro-Ed.

German, D. J. (1991). *Test of word finding in discourse*. Austin, TX: Pro-Ed.

Goodglass, H., & Kaplan, E. (1972). *Boston diagnostic aphasia examination*. Philadelphia, PA: Lea & Febirger.

Hammill, D. D., & Newcomer, P. (1988). *Test of language development - 2. Intermediate.* Austin, TX: PRO-ED.

Kail, R., & Hall, L. K. (1994). Processing speed, naming speed, and reading. *Developmental Psychology, 30*, 949-954.

Kinsbourne, M., Rufo, D. T., Gamzu, E., Palmer, R. L., & Berliner, A. K. (1991). Neuropsychological deficits in adults with dyslexia. *Developmental Medicine and Child Neurology*, *33*, 763-775.

Korhonen, T. T. (1991). Neuropsychological stability and prognosis of subgroups of children with learning disabilities. *Journal of Learning Disabilities*, *24*, 48- 57.

Korhonen, T. T. (1995). The persistence of rapid naming problems in children with reading disabilities: A nine-year follow-up. *Journal of Learning Disabilities*, *28*, 232-239.

Klopfer, D. S. (1996). Stroop interference and color-word similarity. *Psychological Science*, *7*, (3), 150-157.

Leonard, C. M., Lombardino, L. J., Mercado, L. R., Browd, S. R., Breier, J. I., & Agee, O. F. (1996). Cerebral asymmetry and cognitive development in children: A magnetic resonance imaging study. *Psychological Science,* *7*, 89- 94.

Levy, B. A., Abello, B., & Lysynchuk, L. (1997). Transfer from word training to reading in context: Gains in reading fluency and comprehension. *Language Disability Quarterly*, 20, 173-188.

Lindsay, D. S., & Jacoby, L. L. (1994). Stroop process dissociations: The

relationship between facilitation and interference. *Journal of Experimental Psychology: Human Perception and Performance*, 20, 219-234.

MacLeod, C. M. (1991). Half a century of research of the Stroop effect: An integrative review. *Psychological Bulletin*, *109*, 163-203.

Miller, G. A., & Johnson-Laird, P. N. (1976). *Language and perception*. Cambridge, MA: Harvard University Press.

Ojemann, G. A. (1983). The intrahemispheric organization of human language derived from electrical stimulation techniques. TINS 184-189.

Posner, M. I., Walker, J. A., Friedrich, F. J., & Rafal, R. D. (1984). Effects of parietal injury on covert orienting of attention. *Journal of Neuroscience*, *4*, 1863-1874.

Psychological Corporation (1996).*Stanford academic achievement tests - 9th ed*. San Antonio, TX: Psychological Corp.

Satz, P., Fletcher, J. M., Clark, W., & Morris, R. (1981). Lag, deficit, rate, and delay constructs in specific learning disabilities. In A. Ansara, N. Geschwind, A. Galaburda, M. Albert, & N. Cartell (Eds.), *Sex differences in dyslexia* (pp. 129-150). Towson, MD: The Orton Dyslexia Society.

Semel, E. M., & Wiig, E. H. (1980). *Clinical evaluation of language functions*. Columbus, OH: Merrill.

Semel, E. M., Wiig, E. H., & Secord, W. A. (1989). *Clinical evaluation of language fundamentals - Revised*. San Antonio, TX: Psychological Corp.

Semel, E. M., Wiig, E. H., & Secord, W. A. (1995). *Clinical evaluation of language fundamentals - 3*. San Antonio, TX: The Psychological Corporation.

Seymour, P. H. (1977). Conceptual encoding and locus of the Stroop effect. *Quarterly Journal of Experimental Psychology*, *29*, 245-265.

Shankweiler, D., Crain, S., Katz, L. Fowler, A. E., Liberman, A. M., Brady, S. A., Thornton, R., Lundquist, E., Dreyer, L., Fletcher, J. M., Steubing, K. K., Shaywitz, S. E., & Shaywitz, B. A. (1995). Cognitive profiles of reading-disabled children: Comparison of language skills in phonology, morphology, and syntax. *Psychological Science, 6*, 149-156.

Spring, C., & Perry, L. (1983). Naming speed and serial recall in poor and adequate readers. *Contemporary Educational Psychology, 8*, 141-145.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Psychological Monographs, 50*, 38-48.

Stuss, D. T., & Benson, D. F. (1984). Neuropsychological studies of the frontal lobes. Psychological Bulletin, 95, 3-28.

Tallal, P. (1983). A precise timing mechanism may underlie a common speech perception and production area in the peri-Sylvian cortex of the dominant hemisphere. *The Behavioral and Brain Science*s, *6*, 219-220.

Tallal, P., Miller, S. L., Bedi, G., Byma, G., Wang, X., Nagarajan, S., Schreiner, C., Jenkins, W., & Merzenich, M. (1996). Language comprehension in language-learning impaired children improved with acoustically modified speech. Science, 271, 81-84.

Torgesen, J. K. (1988). Studies of children with learning disabilities who perform poorly on memory span tasks. *Journal of Learning Disabilities, 21*, 605-612.

Torgesen, J. K., Wagner, R. K., Simmons, K., & Laughon, P. (1990). Identifying phonological coding problems in disabled readers: Naming, counting, or span measures? *Learning Disability Quarterly, 13*, 236-243.

Warkentin, S., Risberg, J., Nilsson, A., Karlson, S., & Graae, E. (1991). Cortical activity during speech production: A study of regional cerebral blood flow in normal subjects performing a word fluency task. In S.

Warkentin (ed.), *Brain dysfunction in psychosis*. Departments of Psychiatry and Psychogeriatrics, University Hospital and Department of Psychology, University of Lund, Sweden.

Wechsler, D. (1991). *Wechsler intelligence scale for children - III*. San Antonio, TX: Psychological Corp.

Wiig, E. H. (1969). A test of rapid automatic naming of colors, forms, and color- form combinations. Working paper. Residential Aphasia Rehabilitation Program, The University of Michigan , Ann Arbor, Michigan.

Wiig, E. H., Semel, E. M., & Nystrom, L. (1982). Comparison of rapid naming abilities in language-learning disabled and academically achieving eight-year-olds. *Language, Speech, and Hearing Services in Schools*, *13*, 11-23.

Wolf, M. (1986). Rapid alternating stimulus naming in the developmental dyslexias. *Brain and Language, 27*, 360-379.

Wolf, M. (1991). Naming speed and reading: The contribution of the cognitive neurosciences. *Reading Research Quarterly, 26*, 123-141.

Wolf, M., Miller, L., & Donnelley, K. (1996). The RAVE-O manual: Curriculum for the development of retrieval, automaticity, vocabulary, elaboration, and orthography. Manual for NICHD Project #1R55HD/OD30970-01A1.

Wolf, M., & Obregon, M. (1992). Early naming deficits, developmental dyslexia, and a specific deficit hypothesis. *Brain and Language, 42*, 219-247.

Wolf, M., & Segal, D. (1992). Word finding and reading in the developmental dyslexias. *Topics in Language Disorders, 12*, 51-65.

Wolff, P., Michel, G., & Ovrut, M. (1990). Rate variables and automatized naming in developmental dyslexia. *Brain and Language*, *39*, 556-575.

Journal: Journal of Learning Disabilities, Vol. 33, No. 4.

Article: A Clinical Rationale for Assessing Rapid Automatic Naming in Children with Language Disorders.

Authors: Wiig et al.

Table 1. Variations in commonly used continuous naming tasks.

Source	**RAN/Single-Item Tasks**	**Diagnostic Measures**
Stroop Color-Word Test (Stroop, 1935)	Continuous naming of common colors on solid squares, and printed color words printed in non-matching colors	Interference effect for incongruent Color-Word combinations, measured by total naming time (sec.) and accuracy
Rapid, Automatic Naming (Denckla & Rudel, 1976)	Continuous naming of common objects, letters, colors, and numbers (50 items)	Naming speed and accuracy, measured by total naming time (sec.) and accuracy
Rapid Alternating Stimuli (Wolf, 1986)	Continuous naming of randomly sequenced letters and digits (50 items)	Naming speed and accuracy, measured by total naming time (sec.) and accuracy
Rapid, Automatic Naming (CELF; CELF-3) (Wiig, 1969; Semel & Wiig, 1980; Semel, Wiig, & Secord, 1995)	Continuous naming of colors (36 items), geometric shapes (36 items), and color-shape combinations (36 items)	Task 3 Color-Shape Naming speed, measured by total naming time (sec.) and accuracy (%) compared to age-level criteria.

Table 2. Means and standard deviations for CELF-3 Composite and subtest standard scores for matched subjects with and without language disorders (LD).

Variable (n)	LD (n = 136) Mean (SD)	Non-LD (n = 136) Mean (SD)
CELF-3 Composites		
Language Total	78.57 (17.50)	98.9 (14.8)
Receptive	81.07 (17.28)	98.8 (15.3)
Expressive	78.59 (18.35)	100.0 (14.9)
CELF-3 Subtests		
Sentence Structure*	7.84 (3.0)	9.8 (2.7)
Word Structure*	8.22 (3.2)	10.8 (2.8)
Concepts and Directions	7.06 (2.8)	10.0 (3.1)
Formulated Sentences	6.91 (2.6)	9.7 (2.9)
Word Classes	7.43 (2.7)	9.8 (2.8)
Recalling Sentences	6.40 (2. 9)	10.0 (2.9)
Sentence Assembly	7.51 (3.0)	9.9 (3.1)
Semantic Relationships	7.13 (2.4)	9.5 (2.9)
Supplementary		
Word Associations	7.35 (2. 7)	9.8 (3.0)
Listening to Paragraphs	7.13 (3.0)	9.6 (3.1)

* Only children ages 6 through 8 (n = 77 per group) were given these subtests

Table 3. Means and standard deviations for CELF-3 Composite standard scores by age level for subjects with language disorders (LD).

Age Levels (n)	**Composites**	**Mean SS**	**SD**
Age 6 (n = 31)	Total	84.97	14.24
	Receptive	87.16	13.61
	Expressive	85.10	15.35
Age 7 (n = 15)	Total	84.33	14.09
	Receptive	88.27	12.32
	Expressive	82.73	15.73
Age 9 (n = 31)	Total	76.35	16.44
	Receptive	78.97	15.44
	Expressive	76.48	17.88
Age 11 (n = 15)	Total	76.20	21.07
	Receptive	80.53	21.57
	Expressive	74.33	22.35
Age 12 (n = 30)	Total	77.03	18.26
	Receptive	79.07	19.08
	Expressive	77.60	17.96
Age 15-16 (n = 14)	Total	68.93	18.63
	Receptive	69.36	17.47
	Expressive	71.01	20.62

Table 4a. Means and standard deviations of time measures (in seconds) for RAN Task 1 Color Naming.

Normative Sample (N=2,450)				**Clinical Sample (n=136)**			
		Time (seconds)			**Time (seconds)**		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**p-value**
6	200	39.49	15.95	31	45.60	11.65	0.0652
7	200	34.73	12.25	15	36.79	6.45	0.5361
8	200	31.09	11.33	None			
9	200	28.54	8.62	31	32.31	10.79	0.0344
10	200	27.24	8.36	None			
11	200	26.43	17.43	15	27.27	10.00	0.8547
12	200	22.58	7.29	30	31.13	12.80	0.0011
13	200	23.20	15.09	None			
14	200	21.01	11.79	None			
15-16	400	21.89	23.73	14	20.86	4.99	0.5664
17-21	250	20.62	16.66	None			

Table 4b. Means and standard deviations of accuracy (in percent) for RAN Task 1, Color Naming.

Normative Sample (N= 2,450)				**Clinical Sample (N= 136)**			
		Accuracy (%)			**Accuracy (%)**		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**p-value**
6	200	99.13	0.85	31	97.12	3.24	0.2566
7	200	99.16	0.90	15	90.28	9.53	0.2319
8	200	99.42	0.54	None			
9	200	99.19	0.81	31	98.75	0.74	0.3245
10	200	99.26	0.71	None			
11	200	99.42	0.58	15	99.63	0.35	0.6151
12	200	99.48	0.70	30	99.35	0.50	0.7203
13	200	99.65	0.45	None			
14	200	99.67	0.53	None			
15-16	400	99.74	0.38	14	99.01	0.63	0.1472
17-21	250	99.83	0.30	None			

Table 5a. Means and standard deviations of time (in seconds) for RAN Task 2, Shape Naming.

Normative Sample (N = 2,450)				**Clinical Sample (N = 136)**			
		Time (seconds)			**Time (seconds)**		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**p-value**
6	200	57.71	26.56	31	74.42	31.26	0.0034
7	200	48.41	17.69	15	55.64	15.01	0.1380
8	200	42.85	15.45	None			
9	200	36.91	11.15	31	48.59	23.17	0.0122
10	200	34.47	10.20	None			
11	200	31.59	11.21	15	41.67	23.73	0.1245
12	200	28.02	7.43	30	52.37	20.10	0.0346
13	200	28.18	10.10	None			
14	200	25.45	8.37	None			
15-16	400	25.05	21.00	14	28.64	7.74	0.1369
17-21	250	23.98	8.16	None			

Table 5b. Means and standard deviations of accuracy (in percent) for RAN Task 2, Shape Naming.

Normative Sample (N = 2,450)				**Clinical Sample (N = 136)**			
		Accuracy (%)			**Accuracy (%)**		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**p-value**
6	200	95.94	2.69	31	91.36	4.29	0.0603
7	200	97.24	1.85	15	86.51	5.82	0.0276
8	200	97.78	1.55	None			
9	200	98.52	1.38	31	95.98	2.32	0.0469
10	200	98.80	1.05	None			
11	200	98.71	0.95	15	97.41	1.39	0.0758
12	200	99.27	0.75	30	98.06	1.56	0.1393
13	200	99.36	0.55	None			
14	200	99.47	0.51	None			
15-16	400	99.41	0.79	14	98.21	1.28	0.232
17-21	250	99.54	0.51	None			

Table 6a. Means and standard deviations of time (in seconds) for RAN Task 3, Color-Shape Naming.

Normative Sample (N = 2,450)				**Clinical Sample (N = 136)**		
		Time (seconds)			**Time (seconds)**	
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
6	200	114.67	44.02	31	162.48	59.04
7	200	95.52	30.90	15	127.36	47.89
8	200	84.70	27.83	None		
9	200	76.37	19.82	31	98.76	29.45
10	200	69.48	17.63	None		
11	200	64.22	18.19	15	77.73	32.88
12	200	57.02	14.82	30	81.60	38.78
13	200	55.34	15.09	None		
14	200	52.22	18.51	None		
15-16	400	47.80	22.69	14	60.14	17.64
17-21	250	46.06	12.22			

Table 6b. Means and standard deviations of accuracy (in percent) for RAN Task 3, Color-Shape Naming.

Normative Sample (N = 2,450)				**Clinical Sample (N = 136)**		
		Accuracy (%)			**Accuracy (%)**	
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
6	200	85.14	7.63	31	76.13	10.98
7	200	92.73	4.44	15	78.57	6.31
8	200	92.78	4.79	None		
9	200	95.88	3.44	31	89.37	4.54
10	200	95.31	4.56	None		
11	200	95.99	3.14	15	94.07	3.72
12	200	97.45	1.69	30	93.70	3.97
13	200	97.89	1.63	None		
14	200	97.57	2.22	None		
15-16	400	98.50	0.91	14	87.30	6.79
17-21	250	98.44	1.28	None		

Table 7. ANOVA for RAN Task 3 Naming Time (Sec.) for the normative (n = 2450) and clinical (n = 136) groups

Source	DF	Sum of Squares	Mean Square	F-Value	P-Value
Model	13	1011357.56	77796.74	101.98	0.0001
Error	1491	1137467.56	762.89		
Corrected	1504	2148825.11			
		Type I			
Age	6	913722.69	152287.11	199.62	0.0001
Group	1	80965.91	80965.91	106.13	0.0001
AgexGroup	6	16668.97	2778.16	3.64	0.0014
		Type III			
Age	6	368610.02	61435.00	80.53	0.0001
Group	1	47980.13	47980.13	62.89	0.0001
AgexGroup	6	16668.97	2778.16	3.64	0.0014

Table 8. ANOVA for RAN Task 3 Naming Time for Matched non-LD and LD Samples by Age Level

Source	DF	Sum of Squares	Mean Square	F-Value	P-Value
Age 6					
Model	1	50837.60	50837.60	24.13	0.0001
Error	213	448795.72	2107.02		
Total	214	499633.32			
Age 7					
Model	1	13222.74	13222.74	12.70	0.0005
Error	203	211288.90	1040.83		
Total	204	224511.64			
Age 9					0.0001
Model	1	12690.94	12690.94	28.10	
Error	226	102077.53	451.67		
Total	227	114768.47			
Age 11					
Model	1	2548.05	2548.05	6.70	0.0103
Error	213	80957.25	380.08		
Total	214	83505.30			
Age 12					
Model	1	15750.67	15750.67	41.04	0.0001
Error	227	87117.12	383.78		
Total	228	102867.79			
Age 15					
Model	1	2333.33	2333.33	2.83	0.0938
Error	204	167917.10	823.12		
Total	205	170250.43			
Age 16					
Model	1	251.54	251.54	1.31	0.2534
Error	205	39313.93	191.78		
Total	206	39565.48			

Table 9a. Percentages FAILED based on time (in seconds) criteria for RAN Task 3, Color - Shape Naming.

Normative Sample (N = 2450)			**Clinical Sample (N = 136)**		
		Time (seconds)		**Time (seconds)**	
Age	**n**	**Percent Fail**	**n**	**Percent Fail**	**p-value**
6	200	14.5	31	41.9	0.001
7	200	18.5	15	40.0	0.005
8	200	13.5	None		
9	200	23.0	31	58.1	0.001
10	200	22.5	None		
11	200	22.0	15	46.7	0.030
12	200	16.5	30	56.7	0.001
13	200	19.5	None		
14	200	15.0	None		
15-16	400	7.8	14	28.6	0.006
17-21	250	5.6	None		

Table 9b. Percentages FAILED based on accuracy (in percent) criteria for RAN Task 3, Color-Shape Naming.

Normative Sample (n = 2450)			**Clinical Sample (n = 136)**		
		Accuracy (%)		**Accuracy (%)**	
Age	**n**	**Percent Fail**	**n**	**Percent Fail**	**p-value**
6	200	8.0	31	22.6	0.011
7	200	2.0	15	20.0	0.001
8	200	8.0	None		
9	200	5.0	31	19.4	0.003
10	200	7.5	None		
11	200	5.0	15	13.3	0.175
12	200	5.0	30	20.0	0.003
13	200	6.5	None		
14	200	7.5	None		
15-16	400	4.0	14	42.9	0.001
17-21	250	4.4	None		