8-2002

An evaluation of the psychometric properties of the Test of Dyslexia and Dysgraphia

Elizabeth A. Cox
University of Tennessee

To the Graduate Council:

I am submitting herewith a dissertation written by Elizabeth A. Cox entitled "An evaluation of the psychometric properties of the Test of Dyslexia and Dysgraphia." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

R. Steve McCallum, Major Professor

We have read this dissertation and recommend its acceptance:

Sherry M. Bell, Donald J. Dickinson, Richard S. Saudargas

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a dissertation written by Elizabeth Cox entitled "An Evaluation of the Psychometric Properties of the Test of Dyslexia and Dysgraphia." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

R. Steve McCallum, Major Professor

We have read this dissertation
and recommend its acceptance:

Sherry M. Bell

Donald J. Dickinson

Richard S. Saudargas

Accepted for the Council:

Interim Vice Provost and
Dean of The Graduate School

AN EVALUATION OF THE PSYCHOMETRIC PROPERTIES OF THE TEST OF DYSLEXIA & DYSGRAPHIA

A Dissertation

Presented for the

Doctor of Philosophy Degree

The University of Tennessee

Elizabeth A. Cox

August 2002

ACKNOWLEDGMENTS

I would like to express my gratitude to a wonderful committee: Dr. R. Steve McCallum, Dr. Sherry M. Bell, Dr. Don Dickinson, and Dr. Richard Saudargas. Your cooperation, support, and encouragement are very much appreciated. A special thank you to Dr. McCallum, my committee chair and academic advisor. I appreciate your guidance and support throughout my graduate program. Thank you for your many suggestions for this dissertation and your patience when my writing style was far from "tight." Thanks also to Charlotte Duncan for your editorial assistance.

I would like to thank the Anderson County School System. The teachers, administrators, support staff, and students at Claxon Elementary School and Norwood Middle School could not been more cooperative and enjoyable. Thanks to the research group that helped collect the data for this study: Maripat Gettlefinger, Shannon Sharpe, Christy Mayo, James Hawkins, and Susan Valentine. A special thank you to Maripat for completing your dissertation one step ahead of me and, therefore, making my path much smoother and more fun than it would have been on my own.

Finally, I would like to thank my family for your love and support and for giving me the invaluable gift of a sense of humor. It certainly came in handy throughout this project. Most important, I would like to thank St. Paul for including chapter 4, verses 6 and 7, in his letter to the Philippians; a great help during this and all challenging endeavors.

ABSTRACT

The Test of Dyslexia and Dysgraphia (TODD) was designed to provide a comprehensive assessment of dyslexia in a theoretically based and timely manner. It is based on the work of Padget, Knight, and Sawyer (1996) and Wolf (1999) and includes measures of intelligence, academic achievement, and basic cognitive processes believed to be related to reading. The TODD was administered to 105 students ranging in age from 5 to 13 years old. These children were randomly selected from two schools in a school district in East Tennessee. Each child was administered the entire TODD battery.

Measures of reliability and construct validity were obtained. Results suggest that the TODD has adequate reliability based on measures of internal consistency. Reliabilities ranged from .97 to .68 and are comparable to other similar assessment instruments. The first measure of construct validity was completed using age-to-raw score correlations. Correlations for each TODD subtest were significant at the .01 level and ranged from .38 to .80. Finally, exploratory factor analyses were conducted to determine the factor structure of the 8 subtests used to measure the basic cognitive processing variables. Data from the initial factor analysis and from the reliability analysis led to the decision to eliminate one subtest—Auditory Gestalt: Closure and to perform a 2nd exploratory factor analysis. This 2nd factor analysis yielded Two and Three Factor Models that seemed consistent with current reading research. Factor One of the Two Factor Model, called Auditory Processing, included: Memory of Symbols (.81), Phonological Awareness (.80), Word Memory (.77), Auditory Gestalt: Synthesis (.71) and Rapid Symbol Naming (.65). Factor Two, called Visual Processing/Speed, contained

Visual Processing: Closure (.94) and Visual Processing: Discrimination (.81). Visual Processing: Discrimination has a secondary loading of .46 on Factor One and Rapid Symbol Naming has a secondary loading of .59 on Factor Two. The Three Factor Model showed similar loadings but resulted in a separate Memory Factor defined by loadings of the Word Memory (.90), Memory for Symbols (.50), and Rapid Symbol Naming (.47) subtests on a 3rd factor. Results of this study suggest that the TODD shows promise for providing professionals with a tool that will enhance the assessment and diagnosis of dyslexia.

TABLE OF CONTENTS

1. INTRODUCTION....1

Purpose....1

The History of Dyslexia....1

Current Definitions of Dyslexia....9

Assessing Dyslexia: The IQ-Achievement Discrepancy Debate....15

From Research to Practice....23

Tennessee Meets the Challenge of Dyslexia....24

Standardized Assessment of Dyslexia....26

2. STATEMENT OF THE PROBLEM....30

3. RESEARCH QUESTIONS....33

4. METHODS....34

Participants....34

Instrument....34

Procedures....36

5. RESULTS....38

Research Question 1....38

Research Question 2....39

Research Question 3....40

6. DISCUSSION....45

Reliability: Internal Consistency....45

Validity: Relationship Between Chronological Age and Performance....48

Validity: TODD Factor Structure..50

Summary and Implications..57

Limitations and Suggestions for Further Research..59

REFERENCES..61

APPENDIX..71

VITA...85

LIST OF TABLES

Table 1. Definitions of Dyslexia/Specific Learning Disabilities................................72

Table 2. Descriptive Statistics of the TODD..75

Table 3. Reliability: Internal Consistency of TODD Subtests...................................76

Table 4. Construct Validity: Age-to-Raw-Score Correlations...................................77

Table 5. Correlation Coefficients for TODD Cognitive Processing Measures...........78

Table 6. Total Variance Explained, Initial Extraction Rotation.................................79

Table 7. Principle Components Analysis of Cognitive Processing Subtests:
Two-Factor Extraction...80

Table 8. Principle Components Analysis of Cognitive Processing Subtests:
Three-Factor Extractions...81

Table 9. Principle Components Analysis of Cognitive Processing Subtests:
Four-Factor Extraction..82

Table 10. Principle Components Analysis of Cognitive Processing Subtests:
Two-Factor Extraction (Auditory Gestalt: Closure Eliminated)...................83

Table 11. Principle Components Analysis of Cognitive Processing Subtests:
Three-Factor Extraction (Auditory Gestalt: Closure Eliminated).................84

1. INTRODUCTION

Purpose

The purpose of this research was to evaluate the psychometric properties of a newly developed test battery designed to diagnose dyslexia and dysgraphia. The first goal was to determine the reliability of each subtest. The second goal was to evaluate the test's construct validity. This was accomplished in two ways. Correlations were calculated between age and raw scores, and factor analyses were conducted to explore the factor structure of the subtests measuring the underlying cognitive processes believed to contribute to reading ability.

To date, there is no single instrument available to assess all of the academic, cognitive, and processing factors believed to represent a dyslexic profile (Padget, Knight, & Sawyer, 1996). Because of varying definitions of dyslexia and the use of diagnostic criteria that are primarily exclusionary in nature, there exists a great deal of confusion and variation in the way dyslexia is defined and measured in both clinical and research settings. The primary goal of this research was to advance the development of an assessment tool that is theoretically sound and offers a timely yet thorough evaluation of those variables reported in current research to be characteristic of dyslexia and dysgraphia.

The History of Dyslexia

In 1896, W. Pringle Morgan, a doctor in Sussex, England, wrote in the British Medical Journal, "Percy F., . . . aged 12, . . . has always been a bright and intelligent boy, quick at games, and in no way inferior to others his age. His great difficulty has been—

and is now—his inability to learn to read" (Morgan, 1896, cited in Shaywitz, 1996, p. 79). Now, more than 100 years later, children like Percy continue to be the impetus for much research and debate regarding the construct of dyslexia. Despite a century's worth of extensive research, experts remain much at odds regarding the best way to define, assess, and, ultimately, treat dyslexia.

According to Richardson (1992), "The word dyslexia is derived from both Latin and Greek. The Latin origin is dys (dis = difficult) + legere (to read); or Latin dys + Greek lexis (speech). Thus, dyslexia would mean difficulty with reading and speaking" (p. 40). A German ophthalmologist, Berlin, first used this term in 1887 to describe patients who had extreme reading difficulties due to cerebral disease. Like many in the medical profession at that time, Berlin grouped reading difficulties among many other aphasias (Richardson, 1992). Another ophthalmologist, James Hinshelwood, was an important figure in the history of reading difficulties. He used the term congenital word-blindness and was instrumental in making a distinction between individuals with pure difficulties in the area of reading from those with more global mental impairments (Hinshelwood, 1919, cited in Kamhi, 1992; Richardson, 1992).

Dr. Samuel T. Orton, a neuropathologist, was the first to report on reading difficulties in American literature (Orton, 1925, cited in Richardson, 1992). He also referred to these difficulties as word-blindness but preferred the term developmental instead of congenital due to his belief that environmental as well as hereditary factors were important (Orton, 1937, cited in Richardson, 1992). Like his colleagues in the medical profession, Dr. Orton included word-blindness with other aphasic disorders including: “(1) developmental alexia (word-blindness), (2) developmental word deafness (auditory aphasia), (3) special difficulty in writing (dysgraphia), (4) motor speech delay, and (5) stuttering” (Orton, 1937, cited in Richardson, 1992, p. 42).

Both Orton (1937, cited in Richardson, 1992) and Hinshelwood (1919, cited in Richardson, 1992) also referred to the term strephosymbolia (“twisted symbols”). This concept included the phenomenon of letter reversals in children with reading difficulties such as confusing “b” with “d” and “saw” with “was” (Doris, 1993; Rooney, 1995). Despite the vast accumulation of evidence to the contrary, many continue to relate the term “dyslexia” directly to strephosymbolia.

The next term developed to capture the essence of reading disability was minimal brain damage. This term was used to describe the wide range of behavioral and intellectual difficulties experienced by children after recovering from encephalitis, a disease that affects brain tissue. Subsequently, when children presented with similar difficulties in the absence of any such infection, it was assumed that undetectable neurological difficulties were present (Doris, 1993). The research of Alfred A. Strauss and Heinz Werner applied this concept to the learning problems of school-age children. They went on to make distinctions between children whose difficulties were related to damage to the central nervous system from those with more global deficits (Doris, 1993). Following in this tradition, W. M. Cruichshank and Samuel Kirk went a step further to advocate that the actual behavioral difficulties exhibited by children were of greater importance than etiology. The primary concern was the remediation of the symptomatology rather than discovering the neurological basis of the problem (Doris, 1993). Out of these perspectives came the first definition of learning disability:

> A learning disability refers to retardation, disorder, or delayed development in one or more processes of speech, language, reading, writing, arithmetic, or other school subjects resulting from a psychological handicap caused by possible cerebral dysfunction and/or emotional or behavioral disturbances. It is not the result of mental retardation, sensory deprivation, or cultural or instructional factors. (Kirk & Bateman, 1962/1963, p. 73 as cited in Doris, 1993, p. 103)

It was Kirk's preference that the focus move from mere neurological research to an emphasis on diagnosing, managing, and treating children with learning problems; and, for this reason, he favored the term learning disability as opposed to minimal brain damage (Doris, 1993). "In 1966, the United States Office of Education modified a formal definition of minimal brain dysfunction, producing a definition of learning disabilities based on the presence of achievement deficiencies in children with at least average intelligence" (Fletcher et al., 1994, p. 6; Satz & Fletcher, 1980). With this came the focus on behavioral symptoms that, in turn, led to an increased reliance upon psychological and educational testing rather than evaluations that were more medically oriented. This change also led to harsh scrutiny of the test instruments that were used to obtain this information (Doris, 1993). This discussion regarding the definition of the term learning disability was directly related to the construct of dyslexia because most researchers (Ackerman, Paal, Holloway, & Dykman, 1992; Lyon, 1995; Siegel, 1992; Stanovich, 1991) and formal guidelines (American Psychiatric Association, 1994; Individuals with Disabilities Education Act, 1997) included dyslexia as a sub-category of learning disabilities.

In the 1970s, another important shift occurred. Researchers began to suggest that phonological processing played a major role in a child's ability to successfully decode words. According to Shaywitz (1996):

> Early explanations of dyslexia, put forth in the 1920s, held that defects in the visual system were to blame for the reversals of letters and words thought to typify dyslexic reading. Eye training was often prescribed to overcome the alleged visual defects. Subsequent research has shown, however, that children with dyslexia are not unusually prone to reversing letters and words and that the cognitive deficit responsible for the disorder is related to the language system. In particular, dyslexia reflects a deficiency in the processing of the distinctive linguistic units, called phonemes, that make up all spoken and written words. (p. 78)

Since the 1970s, major strides have been made in uncovering the cognitive processes associated with reading difficulties and in showing the paramount importance of phonological awareness in the ability to decode words. No other factor has received more attention from reading experts than phonological processing. Researchers have demonstrated a strong relationship between reading and phonological awareness, the ability of phonological awareness to predict future reading success, and the ability to train young children in phonological skills as a means of increasing later reading success (Badian, 1998; Ball & Blachman, 1988 , 1991; Byrne, Fielding-Barnsley, 1991; Calfee, Lindamood, & Lindamood, 1993; Cunningham, 1990; Foorman, Francis, Shaywitz, Shaywitz, & Fletcher, 1997; Liberman, Shankweiler, Fischer, & Carter, 1974; Lundberg, Frost, & Petersen, 1988, Nicholson, 1997; Torgesen, Morgan, & Davis, 1992; Wagner & Torgesen, 1987). In a summary statement of the importance of phonological skills in the development of reading skills, Torgesen and Wagner stated (1998):

> These findings are extremely important in that they underline the fact that phonological skills are not simply correlates of word-reading difficulties, but they are, in fact, a proximal cause of these difficulties. Thus, they provide a means to identify, in a theoretically consistent way, children who are likely to develop reading disabilities, even before reading instruction begins. (p. 226)

In addition to the emphasis on phonological awareness, researchers have also investigated a more specific area of processing commonly referred to as rapid automatic naming (RAN, Blachman, 1984; Denckla, & Cutting, 1999; Geschwind, 1965, Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993; Wolf, 1997, 1999). This skill involves looking at either a continuous or discrete list of stimuli (e.g., numbers, letters, words, or objects) and naming the stimuli as rapidly as possible. Wolf, Miller, & Donnelly (2000) provided a description of the complex nature of RAN. They reported that the processes included in tasks of rapid naming are similar to those used for basic reading. They stated:

> Naming speed is conceptualized as the end product of an ensemble of both lower level perceptual, attentional, articulatory, and lexical retrieval processes and higher level cognitive and linguistic processes, each of which requires extremely

rapid rates of processing. This is particularly the case for alphanumeric stimuli that reach automatic-like levels of processing. (pp. 375-376)

Although evidence of the relationship of naming speed to reading ability is not new (Geschwind, 1965), its significance in predicting and diagnosing both currently existing and future reading difficulties has only recently been emphasized. The task of rapid automatic naming is now being included in major standardized diagnostic inventories (Wagner, Torgesen, & Rashotte, 1999; Woodcock, McGrew, & Mather 2001). Although there seems to be strong agreement regarding the importance of RAN (Blachman, 1984; Wagner et al., 1993; Wolf, 1997, 1999), there is some disagreement as to its classification. While many researchers consider it to be a measurement of phonological processing (Wagner et al., 1993), others view it as a skill somewhat independent of phonological processing (Wolf, 1997, 1999). Wolf is a leader in researching RAN as a separate skill and has coined the term double-deficit hypothesis to describe her research that indicated that children with reading difficulties fall into three categories: those with deficits in phonological processing only, those with deficits in rapid naming only, and those with a "double-deficit." She went on to emphasize the importance in this distinction as it related to successful remediation of reading difficulties (Wolf, 1997, 1999).

While the current trend in reading research is certainly to focus on phonological processing and RAN, there are also some researchers who continue to stress the importance of visual processing and believe that this area should not be ignored when defining dyslexia. Reddington and Cameron (1991) suggested that there are subtypes of dyslexia based on whether the deficit was in the area of phonological or visual processing. They reviewed several studies that supported a subgroup of subjects with primary deficits in the area of visual processing. Based on the study presented, the authors concluded that "neither visual perceptual nor vision variables . . . can be excluded from the assessment of dyslexia" (p. 192). Other studies considered eye movement research (Kennedy, 1993; Olson & Forsberg, 1993; Pollatsek, 1993), visual temporal processing (Lovegrove & Williams, 1993), and visuospatial perception (Stein, 1993) to be important factors to consider in defining reading disabilities.

Another group of researchers made a distinction between orthographic and phonologic dyslexia and encouraged researchers not to neglect the orthographic subtype (Roberts & Mather, 1997). Orthographic dyslexia has been defined as "the ability to represent the unique array of letters that defines a printed word, as well as general attributes of the writing system such as sequential dependencies, structural redundancies, and letter position frequencies" (Vellutino, Scanlon, & Tanzman, 1994, p. 314). Individuals with deficits described as orthographic had significantly more difficulty reading or spelling words that are phonetically irregular as they tend to spell words using a phonetic strategy. Having this grasp of phonetic coding but poor automaticity for irregular words is a distinguishing characteristic of orthographic dyslexia as compared to phonological dyslexia (Roberts & Mather, 1997).

As illustrated by the various and sometimes conflicting theories described above, there remain numerous unresolved issues regarding the definition of dyslexia. It is important for researchers to continue to work toward an accurate and thorough definition of this construct. Vague and inconsistent definitions of dyslexia lead to assessment procedures that are varied and theoretically unsound. Poor assessment procedures, in turn, impede the ability to provide data that will promote successful intervention.

Current Definitions of Dyslexia

Obtaining a clear, concise, practical, and interpretively useful definition of dyslexia is extremely important for both future research and for practical application. To date, there remains much confusion regarding the specific definition of dyslexia. The first point of clarification should be with the broad use of the term "dyslexia." It seems most researchers have used the terms "dyslexia," "reading disability," and "specific reading disability" interchangeably. Siegel (1999) specifically stated, "There is no difference in the terms dyslexia and reading disability" (p. 306). Torgesen and Wagner (1998) followed the term "reading difficulties" with "dyslexia" in parenthesis. If these terms are synonymous, then it would be helpful for researchers to choose one common term and use it consistently. If, indeed, these terms reflect different constructs, much more care is needed in providing objective definitions of these terms both in research and in clinical practice. For the purpose of the current study, the term "dyslexia" is used to represent a specific type of reading disorder and is not synonymous with the terms "reading difficulty" or "reading disorder."

These terms used by researchers are important because they illustrate the ambiguous way in which reading difficulties are defined. Of greater importance are the definitions used to diagnose the reading problems of today's school children and adopted by school personnel and by those in clinical practice. The definitions of reading disabilities used by state departments of education and in the Diagnostic and Statistical Manual of Mental Disorders, 4th edition, (DSM-IV, American Psychiatric Association, 1994) directly impact the classification of school children. These definitions are important because they determine whether children are included or excluded from receiving special education services based on their classification as learning disabled. Despite their importance, these definitions do not take into account the most current reading research described above regarding the nature of this complex disorder. In addition, these definitions are quite ambiguous.

Perhaps the most relevant definition of reading disability is provided by United States Department of Education in the Individuals with Disabilities Education Act of 1997 (IDEA-1997, Pub. L. No. 105-47). This definition includes reading disabilities and mentions dyslexia specifically, but is inclusive of all academic areas.

> "Specific learning disability" means a disorder in one or more basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in an imperfect ability to listen, speak, read, write, spell, or to do mathematical calculations. The term includes such conditions as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not apply to children who have learning problems that are

> primarily the result of visual, hearing, or motor disabilities, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage. (Jacob-Timm & Hartshorne, 1998, p. 109).

As can be seen in this definition, a reading disability is very loosely defined and is included with all other academic learning disabilities. This definition simply specifies that a child who has an "imperfect" ability to read and who does not have significant visual, hearing, motor, emotional, environmental, cultural, or economic deficits and who is not mentally retarded may be classified as reading disabled. It is then the decision of individual states to determine how they will define and measure learning disabilities. In addition, this definition provided by the U.S. Department of Education mentions the term dyslexia as simply inclusive (i.e., within the broad definition of specific learning disabilities) with no further clarification.

It is interesting to note that the current definition of specific learning disabilities includes only minimal semantic and grammatical changes from the United States Office of Education's 1977 definition that was incorporated in Public Law 94-142. Research over the past two decades has provided a great deal of clarification regarding reading disabilities, much of which remains to be reflected in current definitions. One of the earliest attempts to add clarification to the definition of specific learning disabilities occurred in 1976. At this time, the United States Office of Education offered the following definition of learning disabilities in attempt to be more objective:

> A specific learning disability may be found if a child has a severe discrepancy

> between achievement and intellectual ability in one or more of several areas: oral expression, written expression, listening comprehension or reading comprehension, basic reading skills, mathematics calculation, mathematics reasoning, or spelling. A "severe discrepancy" is defined to exist when achievement in one or more of the areas falls at or below 50% of the child's expected achievement level, when age and previous educational experiences are taken into consideration (USOE, 1976, p. 52405 as cited in Hammill, 1990).

This definition attempted to operationalize the diagnostic criteria but was met with a great deal of opposition and was changed. Critics charged that it was mathematically unsound, an infringement upon the rights of states, and forced the use of an ability-achievement discrepancy for the identification of children with learning disabilities (Hammill, 1990). The debate regarding the use of ability-achievement discrepancy formulas is extremely important and will be discussed later.

Another definition of reading disability comes from the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) of the American Psychiatric Association (1994); that definition describes reading disability separately from other learning disabilities (mathematics and written expression); however, the definitions are different in domain only. The criteria for each academic area are identical. A reading disability is defined as:

> A. Reading achievement, as measured by individually administered standardized tests of reading accuracy or comprehension, is substantially below that expected given the person's chronological age, measured intelligence, and age-

appropriate education.

B. The disturbance in Criteria A significantly interferes with academic achievement or activities of daily living which require reading skills.

C. If a sensory deficit is present, the reading difficulties are in excess of those usually associated with it. (American Psychiatric Association, p. 50)

This definition is quite similar to the Department of Education's definition. There is an emphasis on a discrepancy between ability and achievement and a reliance on exclusionary criteria. According to Kamhi (1992):

> The most serious problem is that exclusionary definitions provide a very limited description of the characteristics of the disorder (Catts, 1989; Kamhi & Catts, 1989; Thompson, 1984). Such definitions tell us more about what the disorder <u>is not</u>, rather than what it <u>is</u>. Because only the defining characteristic of the disorder is a difficulty learning to read, children must experience some academic failure before they can be identified as dyslexic. Exclusionary definitions thus do not encourage early identification of the problem. (p. 49)

The problem with these definitions goes beyond the fact that they are exclusionary. They are so broad that they minimize the value of the growing knowledge base that exists regarding reading disabilities. As noted above, the Department of Education's definition of specific learning disabilities, which includes reading disabilities, has not substantively changed in more than 20 years despite a drastic change in the way professionals are viewing reading difficulties. Typical exclusionist definitions require considerable interpretation and are interpreted differently from state to state. For example, a child may be learning disabled in one state but not in another. A specific definition of reading disabilities and dyslexia would be very helpful in eliminating such a problem.

Looking beyond these two broad, widely used definitions of specific learning disabilities there remains a great deal of variability and disagreement. As can be seen from the definitions presented in Table 1 (see Appendix for all tables), the definitions, though similar, are quite vague. Only the definition used by Lyon (1995) considered the role of phonological processing despite the fact that this concept has dominated the reading literature for more than a decade. Lyon gave several reasons why it is important to have a clear definition of dyslexia:

> A precise and inclusionary definition of dyslexia is sorely needed for at least three reasons. First, accurate identification of dyslexia requires that the key symptoms and characteristics be specified. Second, treatment of dyslexia, including early intervention and general teaching methods, must be based on an informed understanding of what difficulties impede reading development and reading mastery for children and adults with reading difficulties. Third, an operational definition is essential for research purposes. More specifically, to investigate the causes and consequences of dyslexia, to examine whether there are different types of reading problems, and to explore how dyslexia relates to other disorders, it is crucial to study individuals who meet well-specified selection criteria. (p. 3)

Many research studies begin with brief working definitions of dyslexia that are generally similar. For example, Shaywitz, Escobar, Shaywitz, Fletcher, and Makuch

(1992) defined dyslexia as "a neurologically based disorder in which there is an unexpected failure to read" (p. 145). Richardson (1992) said that, "Dyslexia means a specific language disorder that specifically involves reading and often an associated difficulty with the spoken word and/or writing" (p. 40). Lyon (1995) gave his working definition of dyslexia as "a specific language-based disorder of constitutional origin characterized by difficulties in single word decoding, usually reflecting insufficient phonological processing abilities" (p. 10). Siegel (1992) says that dyslexia is defined as "reading at a level that is significantly below expected reading level in the absence of exclusionary criteria, such as emotional problems, sensory deficits, neurological disease, and/or inadequate educational opportunity" (p. 618). Padget et al. (1996) concisely stated that "dyslexia is characterized as significant difficulty in reading and spelling individual words" (p. 51). Again, these definitions illustrate the need for a clarification and unity in the field regarding the definition of dyslexia. Two of the four brief, working definitions suggest the presence of a discrepancy between expected and actual reading ability while the other two do not. Currently, one of the most controversial issues regarding the definition of dyslexia is the use of ability-achievement discrepancies to define dyslexia. This controversy was one of the major reasons the United States Office of Education revised its 1976 definition as explained above. This dilemma is a clear example of the direct link between the definition of dyslexia and the assessment process used to diagnose it.

Assessing Dyslexia: The IQ-Achievement Discrepancy Debate

Since at least the late 1800s, professionals have discussed an individual's difficulty learning to read in light of his or her adequate intellectual functioning as was evident in the case of Percy F. described above. When Dr. Pringle Morgan described such a discrepancy, it was not to illustrate that Percy met DSM-IV or Department of Education guidelines but simply to indicate that the reading difficulties were unexpected, due to his unimpaired cognitive abilities (Doris, 1993; & Shaywitz, 1996). Today, such a distinction is an integral part of the definitions of specific learning disabilities and has been used in both research and educational group classifications. Most all formal definitions of specific learning disabilities require a measured difference in intelligence quotient (IQ) score and academic achievement score. Because dyslexia is often considered a specific learning disability, it is oftentimes defined in this manner as well.

The work of Rutter and Yule (1975) included an analysis of the discrepancy between intelligence and reading achievement scores on a large sample of children in London and the Isle of Wight. The authors were assessing the validity of the concepts of reading retardation (a discrepancy between IQ and reading achievement) and reading backwardness (poor reading ability that is consistent with IQ) by analyzing the normal distribution of expected reading scores as predicted by IQ. They suggested that if reading scores are normally distributed, then it is likely that there is no difference in these two groups, whereas a "hump" at the lower end of the distribution would suggest that reading retardation is indeed a distinct syndrome. Their data did show such "a 'hump' at the lower end of the distribution" (p. 185). The authors recognized that the presence of the hump was not sufficient in suggesting an educationally meaningful distinction in these two groups; and, therefore, they continued the study in more detail. Out of approximately 2,300 children ages 9 to 11 from the Isle of Wight sample, the authors identified "86 children with specific reading retardation . . . [and] 79 children who displayed general reading backwardness alone" (p. 186). The authors did find some significant distinctions between these two groups including a significantly higher ratio of males in the reading retardation group and a higher percentage of organic brain disorder and "motor and praxic abnormalities" (p. 187) in the reading backwardness group. However, on measurements of speech and language development, both groups were quite similar with both being significantly below the control group of the general population. The reading retardation group was significantly below the reading backwardness group in the area of language complexity with all other language measures being statistically similar. Next, the authors investigated whether or not the educational prognosis was different for these two groups. The two groups were followed until the age of 14 at which time they were evaluated in the areas of reading, spelling, and mathematics. Results showed that "the reading retarded children made less progress in reading and spelling but more progress in arithmetic and mathematics" (p. 190). The authors' final conclusion was that reading backwardness and reading retardation are not synonymous, which supports the utility of a discrepancy model (Rutter & Yule, 1975).

Despite its intuitive appeal and the research of Rutter and Yule (1975), many researchers question the utility of a discrepancy model to distinguish between groups of poor readers (Fletcher et al., 1994; Lyon, 1996; Shaywitz, 1998; Siegal, 1992; Stanovich, 1991; Torgesen & Wagner, 1998). One major difference in these studies that oppose the discrepancy model and the study by Rutter and Yule is the more recent emphasis on phonological processing. Although Rutter and Yule did find their two groups (reading backwardness and reading retardation) to be quite similar in the area of "language," language was defined very broadly (i.e., speech onset, articulation, and language complexity). More recent research is focused on more specific aspects of language (particularly phonological processing and RAN) and academic achievement as a means of evaluating the usefulness of a discrepancy model.

In describing his opposition to a discrepancy requirement, Stanovich (1991) wrote:

> In short, we have been basing systems of educational classification in the area of reading disabilities on special claims of unique potential that are neither conceptually nor psychometrically justified . . . . The field plunged ahead into domains of educational practice and diagnosis without first setting itself on a firm foundation by unequivocally demonstrating the empirical differentiability that would establish validity for the construct of reading disability." (pp. 10, 12)

At the core of the discrepancy debate is the question of whether the cognitive processes of children with reading disabilities vary according to the presence or absence of a discrepancy between measured intellectual functioning and measured academic achievement. Since the 1970s research has strongly supported the notion that phonological processing is this primary deficit associated with poor reading ability in the vast majority of cases. Due to the strong link between phonological processing and reading ability, phonological processing is the major cognitive variable upon which this recent discrepancy research has been based (Fletcher et al., 1994; Lyon, 1996; Shaywitz, 1998; Siegal, 1992; Stanovich, 1991; Torgesen & Wagner, 1998).

Stanovich and Siegal have provided extensive data to address this topic (Siegal, 1992; Stanovich 1991; Stanovich & Siegel, 1994). In their research they differentiate dyslexic readers (those with an IQ-achievement discrepancy due to a specific difficulty in the area of phonological skills) and garden-variety poor readers (those with global processing deficits, and thus, more consistent IQ-achievement scores) in an effort to show that these groups are actually very similar in their cognitive processing abilities believed to be related to reading achievement. In a large meta-analytic study, they evaluated the rationale of the use of discrepancy criteria for distinguishing dyslexic versus garden-variety poor readers (Stanovich and Siegel, 1994). Their study consisted of a sample of more than 1,500 children between the ages of 7 and 16 years. These children were tested on a wide variety of skills, including intelligence, academic achievement, and various cognitive processing skills (phonological coding, orthographic coding, short-term memory, and working memory). Children were placed into three groups: (a) no discrepancy between aptitude and achievement and age-expected reading ability, (b) reading disabilities with an aptitude-achievement discrepancy, and (c) reading disabilities with no aptitude-achievement discrepancy. The study found "no support for the notion that there are critical differences between children with and children without an aptitude-achievement discrepancy in the phonological coding processes that are the proximal cause of their reading difficulties" (p. 40). Describing the study, Siegel (1992) stated:

> The distinction between these two groups of disabled readers does not appear to be a meaningful one in terms of the basic processes underlying reading. Of

> particular importance is the fact that these groups did not differ on measures of pseudoword reading, a critical measure of phonological processing. (p. 626)

In addition, Siegel stated that there were not significant differences between dyslexic readers and garden-variety poor readers in the area of short-term memory and only slight differences in the areas of working memory and syntax. Siegel suggested that "the assessment of learning disabilities should concentrate on specific academic skills and subskills, rather than on IQ scores, which have not been shown to yield useful information about an individual case" (p. 627).

Other researchers also question the validity of the IQ-achievement discrepancy as a means of identifying reading disabilities. In a study by Fletcher et al. (1994), the profile analysis of 199 children was investigated; the study included the following dependent variables: phoneme deletion, visual-spatial skills, verbal short-term memory, nonverbal short-term memory, speech production, vocabulary, rapid naming, visual-motor skills, and visual attention. The children were placed in the following groups: (a) reading impairment based on an ability-achievement discrepancy between standard scores, (b) reading impairment based on an ability-achievement discrepancy using a regression formula (i.e., one which takes into account regression to the mean), (c) reading impairment based on an ability-achievement discrepancy from both standard score and regression formulas, (d) reading impairment based on achievement scores below 90 with ability scores above 80, and (e) no reading impairment. Results of the profile analysis did support the importance of phonological awareness skills in the development of reading ability. Results also suggested that the factors that correlated with reading achievement were similar at all levels of ability and that the reading skills of impaired and nonimpaired readers represented a continuum for reading ability rather than distinct categories of impaired and nonimpaired readers. Based on these findings, the authors reported that:

> These results do not provide strong support for the validity of distinguishing children who meet the discrepancy and low achievement definitions of reading disability. In fact, both discrepancy and low achievement definitions appear valid. Each yielded groups of reading impaired children with cognitive profiles that were more similar to each other than different. (p. 18)

Torgesen and Wagner (1998) also expressed concern about the efficacy of the discrepancy model. They argue for a shift to an identification process based on weaknesses in phonological awareness and reading skills alone. This shift would likely change the composition of those receiving services to include more minority students and those from lower economic groups. They state:

> If the purpose of diagnostic procedures is to identify children with cognitive disabilities that make it difficult for them to learn to read (and who thus require special instruction), there is no scientific justification for traditional discrepancy-based (between IQ and reading level) formulas for identifying children with reading disabilities. (p. 230)

In addressing the confusion and variability related to the discrepancy model, Lyon (1996) suggestd a very practical argument against the use of this model. He stated:

> For the individual child, use of the discrepancy standard clearly promotes a wait-to-fail policy because a significant discrepancy between IQ and achievement

> generally cannot be detected until about age eight or nine. In fact, most school districts do not identify children with learning disabilities until a child is reading well below grade level, generally third or fourth grade. By this time the child has already experienced at least a few years of school failure and probably has experienced the common attendant problems of low self-esteem, diminished motivation, and inadequate acquisition of the academic material covered by his classmates during the previous few years. (p. 54)

In addition to these studies by leading reading researchers, Siegal (1992) provided a brief review of numerous studies that give further support to the notion that discrepant and nondiscrepant poor readers are more alike than different.

Although data are quickly accumulating that suggest an alternative diagnostic approach is needed, researchers are not forthcoming with viable alternatives. There are some suggestions, however. Fletcher et al. (1994) recommend researching the appropriateness of using listening comprehension as the benchmark upon which to compare reading skills. A second suggestion by this group was to simply use a low achievement definition. Just as mental retardation is defined by a cut-off score, reading impairments would be defined likewise. Siegel (1989) also supported the use of a simple criteria based on decoding deficits. Torgesen and Wagner (1998) suggested criteria based on phonological processing skills and word-reading skill level. They stated that the inclusion of the phonological skills criteria would allow for earlier identification of children who are at risk for later reading problems and would increase chances of successful intervention.

As is illustrated above, the field of reading research continues to be in need of a consistently defined set of criteria for classifying children with reading difficulties. The variability of definitions and lack of agreement among researchers on basic definitions of reading disability and dyslexia leads to perhaps even greater confusion and controversy among school psychologists and other clinicians trying to accurately assess and ultimately remediate the skill deficits in children who are struggling to learn to read. In the next section, a brief illustration of these difficulties is provided.

From Research to Practice

In the Texas Reading Report, Margaret Hill (1995) discussed the difficulty that a vague definition of dyslexia is causing in Texas schools. She reported:

> Texas defines dyslexia in exclusionary language. We know what it is not, but we do not know what it is. Therefore, it is not surprising to learn that in a recent random sample of 1/3 of the districts in Texas, over 140 different instruments were identified to help teachers and specialists identify what they think might be characteristics of a dyslexic learner." (p. 10)

Due to the unclear definition of dyslexia, there was no standardized method of assessment. Seven different instruments were being used to assess for intelligence. Four group and 3 individually administered achievement tests were being used. Three additional tests were being used to assess for more specific reading, writing, and language difficulties. Phonological awareness was being assessed but with 13 different instruments, few of which had recent publication dates. Thirteen instruments were being used to measure visual/auditory processing and 9 instruments were used to assess visual-motor integration skills. The author concluded that "it is clear that there is not one diagnostic instrument. As long as the definition for dyslexia is elusive, it will be impossible to precisely evaluate the condition some call dyslexia" (p. 13).

Tennessee Meets the Challenge of Dyslexia

The title of this section was taken from the title of an article by Padget et al. (1996). The Tennessee Center for the Study and Treatment of Dyslexia has taken a significant step in creating a paradigm in which the numerous problems described above are minimized. A task force was created to "study the effects of dyslexia on the academic performance of K–12 students" (p. 52). The following points were acknowledged by this task force:

> (a) dyslexia affects a heterogeneous group; (b) there is probably a genetic component; (c) economic and educational impoverishment exacerbates, but does not cause dyslexia; (d) intelligence among persons with dyslexia ranges from low to high as does that of the general population; (e) dyslexia can be distinguished from other reading problems and that early appropriate intervention is critical. (p. 53)

The task force later enumerated the following recommendations:

> (1) reduce class size, particularly in early grades, to facilitate individualized instruction for those at risk of failure in reading and writing; (2) provide professional development programs to equip pre-K and K–12 teachers with strategies designed to address the full spectrum of reading problems, including dyslexia, as well as with informal assessment tools necessary for distinguishing

among the various types of language and reading problems; and (3) promote collaboration between regular education and special education teachers in assessing the effectiveness of teaching strategies implemented to remediate reading problems. (p. 53)

The authors realized that "before the work of this Center could commence, a definition of dyslexia that would effectively delineate the focus of its work was needed" (pp. 54-55). They took advantage of the vast amounts of solid research completed by experts across this country and beyond in formulating the following definition of dyslexia:

> Dyslexia is a learning-based disorder that is biological in origin and primarily interferes with the acquisition of print literacy (reading, writing, and spelling). Dyslexia is characterized by poor decoding and spelling abilities as well as deficits in phonological awareness and/or phonological manipulation. These primary characteristics may co-occur with spoken language difficulties and deficits in short-term memory. Secondary characteristics may include poor reading comprehension (due to decoding and memory difficulties) and poor written expression, as well as difficulty organizing information for study and retrieval. (p. 55)

In addition to this concise, theory-based definition of dyslexia, the authors also provided a "diagnostic profile of dyslexia" (p. 58) that delineates specific assessment data that are needed to obtain an accurate diagnosis. The profile describes relative performance levels of various cognitive and academic components. The first step in examining the diagnostic profile is determining whether Listening Comprehension, IQ or both are equal to or greater than a standard score of 90. The authors included intelligence level due to the requirements of many school systems and because there is some need to rule out general cognitive delay as the cause of reading failure. They do, however, also acknowledge research suggesting that using Listening Comprehension scores may be more valid. Second, Reading Comprehension scores should be lower than Listening Comprehension. Third, Word Recognition should be less than Reading Comprehension and 15 or more standard score points below Listening Comprehension and IQ. Fourth, Spelling skills should be lower than Word Recognition skills and also 15 standard score points below Listening Comprehension and IQ. Fifth, Word Attack skills should be less than Word Recognition. Sixth, Phonological Awareness Skills should be well below age expectations. The authors suggested use of both standardized assessment measures as well as criterion-referenced measures to obtain a full sampling of the child's abilities in all the above domains.

Standardized Assessment of Dyslexia

A review of current literature suggests that the definition of dyslexia provided by Padget et al. (1996) is the most comprehensive, concise, and interpretively useful definition currently being used to guide assessment procedures. This definition has, however, two significant limitations. First, the definition fails to include RAN in its dyslexic profile. As stated above, RAN is now considered to be an extremely important factor in diagnosing reading problems (Torgesen & Wagner, 1998; Wolf, 1997, 1999). It is deficient in many children with dyslexia and is likely lower than their IQ and Listening

Comprehension.

The second limitation is the number of different assessment instruments needed to assess all components necessary to diagnose dyslexia. The first components are intelligence and listening comprehension. There are many instruments currently available to complete an intellectual assessment. The most commonly used instrument is the Wechsler Intelligence Scale for Children–Third Edition (WISC–III, Wechsler, 1991). This instrument takes approximately 1½ hours to administer and provides minimal information that relates directly to reading ability. Likewise, the Stanford-Binet Intelligence Scale–Fourth Edition (SB–FE, Riverside Publishing, 1986) is a fairly lengthy assessment that provides minimal data that will be useful in determining areas of difficulty related to reading. Although these instruments provide a global assessment of a child's intellectual functioning, such information is superfluous for the purposes of diagnosing dyslexia. In addition, both instruments are quite expensive. Listening comprehension measures are not as prevalent. To obtain a measure of listening comprehension, a subtest from the Wechsler Individual Achievement Test (WIAT, Psychological Corporation, 1992) or a supplemental subtest from the Woodcock-Johnson Psychoeducational Battery–Third Edition (WJ–III, Woodcock et al., 2001) may be used.

The second component of the definition is reading comprehension. Almost all standardized, individually administered achievement tests contain a measure of reading comprehension, although the way this skill is measured varies. For example, on the WJ–III the examinee reads a passage and must fill in a missing word. On the WIAT after a passage is read, the examinee must answer questions asked by the examiner. On the

Peabody Individual Achievement Test–Revised (PIAT–R, Markwardt, 1989) the examinee reads a sentence and then selects one out of four pictures that the sentence is describing (Joshi, 1995). As slight variations in test procedures can significantly change the nature of the skill being measured, it is problematic to have such diverse methods to measure one skill. The third component is word recognition and involves reading single, independent words. This task is also included on the achievement tests listed above. As this task is more straightforward, there is less variability among the different tests. In addition to these comprehensive achievement tests, there are several other standardized tests used to measure reading skills specifically. Padget et al. (1996) suggested the use of the Woodcock Reading Mastery Test (Woodcock, 1987) and the Decoding Skills Tests (Richardson & Dibenedetto, 1985).

The fourth component of the profile is spelling. Again, spelling is measured on the majority of standardized achievement tests and is done so in a fairly consistent manner. Padget et al. (1996) also suggested the use of the Developmental Spelling Analysis (Ganske, 1993).

The fifth component is the ability to read pseudowords, a measure of phonemic awareness. This skill can be measured on the WJ–III but not on the WIAT. It is also a component of more recent tests used to measure phonological awareness, such as the Comprehensive Test of Phonological Processing (CTOPP, Wagner, et al., 1999).

The final component of the definition is phonological awareness. Padget et al. (1996) suggested the use of Tests of Awareness of Language Segments (Sawyer, 1987) and the Lindamood Auditory Conceptualization Test (Lindamood & Lindamood, 1979).

The CTOPP provides a comprehensive test of numerous measures of phonological processing but does not address academic such skills as basic reading, reading comprehension, spelling, or written expression.

This list of standardized test instruments required to assess all components of Padget et al.'s (1996) definition of dyslexia is quite extensive. Many of the instruments described above are more than 15 years old. Many are comprehensive tests with only a small portion of their subtests relevant to the definition of dyslexia. The WJ–III appears to be the only instrument available at this time that measures the components mentioned above. This instrument also includes many subtests that are not related to the assessment of reading skills. Due to the extensiveness of the WJ–III, it is a very expensive instrument. What is needed, therefore, is an instrument that provides a concise measure of all factors needed for a thorough assessment of dyslexia and one that is timely and cost-efficient.

2. STATEMENT OF THE PROBLEM

As can be seen from the discussion above, the definition of dyslexia and the diagnostic process are quite complicated, vague, and inconsistent. School psychologists are caught in a bind between state mandates and data-based research implications for best practices in their field. Padget et al. (1996) made an excellent effort to define dyslexia by consolidating reading research and requirements of state departments of education. However, they did not satisfactorily address in their profile the place of rapid automatic naming. In addition, they did not consider the implications of visual processing and visual memory in their definition. Another difficulty with their approach is the amount of time and number of different instruments that are involved in just the standardized portion of their evaluation process. They recommended the use of the following standardized instruments: WIAT, Woodcock Reading Mastery Test–Revised, Developmental Spelling Analysis, Decoding Skills Test, Test of Awareness of Language Segments, and Lindamood Auditory Conceptualization Test. In addition, they would likely require a standardized measurement of intelligence. Using this wide array of tests, each normed at different times and with different normative samples, decreases the psychometric quality of the data that is gathered as compared to collecting data with a single instrument and, thus, a single normative sample.

Shaywitz (1998) stated that "tests of reading, spelling, language, and cognitive abilities (for school-age children) represent a core battery for the diagnosis of dyslexia" (p. 310). Fuchs & Fuchs (1994) reported that assessments should be both reliable and valid, should not be too lengthy, have adequate floors and ceilings, and be related to the needs of the school district. At this time, these two suggestions are at odds. Currently, there is not an instrument available that can provide assessment data for reading, spelling, language, and cognitive abilities and do so in a reliable, valid, and, particularly, a timely and cost-efficient manner.

The conceptual model for the Test of Dyslexia and Dysgraphia (TODD) was modeled after the work of Padget et al. (1996), who clearly defined the construct of dyslexia, and Wolf (1999), who identified the importance of RAN. It provides a timely measurement of all the components mentioned above as needed to obtain a thorough diagnostic picture for determining a dyslexic pattern as well as measures to rule out difficulties with visual processing and visual memory. The TODD provides a brief measure of intelligence that, whether or not it is used in the actual determination of dyslexia, provides clinically useful information. It measures listening comprehension skills. Those adhering to a discrepancy formula have the option of using the IQ subtests, Listening Comprehension subtest, or both. Those opposed to a discrepancy formula can use this information as supplemental data; an estimate of general intellectual functioning and listening comprehension may be useful in treatment planning. There is also the option of simply not administering these subtests.

The TODD has several measures of phonological awareness. A student's ability to manipulate the basic units of a word is measured as well as their auditory processing ability. In addition, it includes measures of processing speed, rapid automatic naming, visual processing speed, and visual memory. The measures of visual processing and visual memory are useful in ruling out problems of a visual nature.

The TODD is a promising instrument that addresses the major factors related to reading disabilities. It is based on a sound theoretical definition of dyslexia that is inclusionary in nature, and it provides a thorough, yet timely assessment of those factors suggested by extensive research to be related to dyslexia. Despite its clinical appeal and face validity, unless the TODD has sound psychometric qualities, it will not be a useful instrument. For this reason, psychometric properties including its reliability and validity, should be established.

3. RESEARCH QUESTIONS

1. Is the reliability of the individual subtests of the TODD at an adequate level (i.e., > .80) as determined by internal consistency via Cronbach's alpha?
2. Is the construct validity of the TODD subtests supported by significant correlations between age and raw scores on individual subtests?
3. What is the most plausible factor structure of the TODD's basic cognitive processing subtests based on factor loading and current reading research?

4. METHODS

Participants

Participants in this research study were 105 students from an elementary and middle school in a rural county in East Tennessee. Students from kindergarten through sixth grade were randomly selected to participate from a large sample of children who returned signed permission slips. There were 50 males and 55 females in the study. Ages ranged from 67 through 159 months. Four children in the study received special education services. Six were identified with speech/language problems, 9 with reading disabilities, 3 with mathematics disabilities, and 3 with disabilities in written expression.

Instrument

The TODD is an individually administered test battery for children ages 5 to12 and designed to provide the information necessary for diagnosing dyslexia and dysgraphia. Its construction was based on models developed by Padget et al. (1996) and Wolf (1999) that provide a characteristic profile of children with dyslexia. Authors of the TODD suggest a profile such that intelligence and listening comprehension are approximately average (e.g, greater than 90 on a general IQ test), that reading comprehension and auditory processing are less than listening comprehension and IQ, that word recognition is equal to or less than reading comprehension and less than listening comprehension and IQ, that decoding is equal to or less than word recognition, and that phonemic awareness, rapid automatic naming, or both are well below age expectation. Also, in order to rule out reading problems due to the effects of visual-perceptual or visual processing problems, scores on tests of visual perception and visual memory should be obtained and should be in the average range.

The TODD is comprised of 13 individual subtests. Two subtests are used to obtain an estimate of the examinee's general level of cognitive functioning. These two subtests are Vocabulary, which assesses word knowledge, and Matrix Analogies, which assesses nonverbal reasoning.

Six of the subtests measure achievement in areas associated with reading and writing ability. These include: Letter-Word Calling, Reading Comprehension, Spelling, Written Composition, Listening Comprehension, and Decoding. Letter-Word Calling assesses sight recognition of letters and words. Reading Comprehension measures the ability to comprehend written passages read either silently or aloud. Spelling assesses a child's ability to spell both phonetically regular and irregular words in isolation. Basic grammar skills are also measured on the Spelling subtest. Listening Comprehension assesses the ability to comprehend meaningful information presented orally. Decoding measures the ability to phonetically decipher nonsense words, using their phonetic properties. Written Composition measures the ability to fluently and accurately engage in written expression.

Auditory perception and memory are assessed via the following four subtests: Phonological Awareness, Auditory Gestalt: Closure, Auditory Gestalt: Synthesis, and Word Memory. Phonological awareness measures the ability to manipulate the basic units of sound. Auditory Gestalt: Synthesis measures a child's ability to synthesize phonetically divided words presented orally, and Auditory Gestalt: Closure measures the ability to accurately process words presented orally when one or more sounds are omitted.

Word Memory assesses auditory memory, specifically, a child's ability to recall a list of unrelated words presented orally.

Rapid Symbol Naming is a measure of rapid automatic naming and assesses the speed and accuracy with which children can call letters and numbers from long-term memory. As described above, RAN is a complicated construct and consists of several cognitive tasks including processing speed, attention, articulation, and lexical retrieval (Wolf, Bower, & Biddle, 2000).

Visual perception and memory are assessed using three subtests. Visual processing is measured by assessing both visual processing speed and accuracy. Visual Processing: Discrimination measures the ability to visually discriminate similar stimuli accurately while Visual Processing: Closure measures the ability to visually "complete" a partial stimulus. Both of these tasks include time pressure and are, therefore, measures of processing speed. Memory for Symbols is a measure of visual memory; it measures a child's ability to remember a group of unrelated letters presented visually.

These subtests were administered to a group of approximately 30 school-age students with varying degrees of reading ability in an initial pilot study. Results of this pilot study were used to conduct an item analysis using item-to-total correlations for each subtest. Items were then arranged within each subtest in order of difficulty; redundant items were deleted.

Procedures

Permission slips were provided to each student at an elementary and middle school in a rural county in East Tennessee. Students were randomly selected from those with a signed permission form. Investigators or assistants tested each student individually. The test took approximately 1½ hours and was administered during school hours at a time deemed most appropriate by the students' teachers. Testing was conducted on school grounds in classrooms or offices according to privacy and availability.

The order in which each subtest was administered was the same for all subjects; however, the starting points were varied among all subtests. Starting points were equally divided among all TODD subtests and randomly assigned among subjects. Subtest scores for each student were calculated based on raw scores (number of items correct and completion times on speeded tasks). These raw scores were then used to evaluate various psychometric properties of the TODD in order to answer the research questions enumerated above.

5. RESULTS

All of the research questions presented above were created to assess the psychometric properties of the TODD. Adequate reliability and validity are paramount in determining the quality of this test. Descriptive statistics for each subtest, including means and standard deviations, are provided in Table 2. Data collected to address the first research question provided evidence of the reliability of each TODD subtest. Data collected to address the second research question provided evidence for the construct validity of the TODD through an analysis of age-to-raw score correlations. Data collected to address the third research question provided evidence for construct validity by determining the factor structure of the underlying cognitive processing subtests thought to be related to reading ability. The factor analysis of these TODD subtests is necessary to develop an understanding of their relationship to one another and to eventually aid in the interpretation of an individual's performance.

Research Question 1

Reliability coefficients were obtained to provide an index of psychometric quality. A reliability coefficient of .80 or higher was determined to be adequate, based on standards described by Bracken & McCallum (1998). Reliability was determined by Cronbach's alpha, a measure of the internal consistency of each subtest. Three subtests, Rapid Symbol Naming, Visual Processing: Discrimination, and Visual Processing: Closure, are timed items and were not amenable to this type of analysis and were not included. Results of the analysis of all other subtests are presented in Table 3.

Results suggest that the subtests designed to measure achievement in various academic areas have the strongest reliability. These areas include Spelling (.97), Letter-Word Calling (.96), Reading Comprehension (.95), Listening Comprehension (.92), and Decoding (.92). The two subtests that measure more general intellectual functioning have adequate internal consistency. They include Vocabulary (.87) and Matrix Analogies (.86). There is variability among the reliability coefficients of the subtests that measure basic cognitive processes believed to be related to reading ability. Of the processing measures, Phonological Awareness has the strongest reliability, a coefficient of .91, which is similar to the achievement measures. Memory for Symbols has an acceptable level with a coefficient of .86. Auditory Gestalt: Synthesis is just at the acceptable level (.80) while Auditory Gestalt: Closure is below the desired .80 level with a coefficient of .77. Word Memory has the poorest reliability of all subtests with a coefficient of .68; obviously this subtest needs to be improved.

Research Question 2

To answer the second research question, correlational data showing the relationship between age and the various TODD subtest scores were obtained. The subtests are designed to measure aspects of intelligence, academic achievement, and cognitive processing; these abilities are assumed to be acquired as a function of maturation and education (Berk, 2000; McGrew & Woodcock, 2001). Consequently, performance should improve with age. If results support a developmental progression within each subtest, then data are consistent with the notion that the TODD subtests are measuring the constructs they purport to measure. Pearson r correlation coefficients were obtained between chronological age and raw scores on each subtest; results of this analysis can be found in Table 4. All correlation coefficients are significant at the .01 level and 13 of the 15 are greater than .50. Coefficients ranged from .38 to .80.

While each TODD subtest shows considerable evidence of validity (i.e., all are significant at the .01 level of confidence), there is quite a bit of variability among the subtests. The following subtests have coefficients of .70 and higher: Visual Processing: Discrimination (.80), Visual Processing: Closure (.75), Vocabulary (.75), Letter-Word Calling (.75), Spelling (.71), Reading Comprehension (.70), and Rapid Symbol Naming (.70). Three subtests have coefficients that range from .60 - .70 and include Listening Comprehension (.69), Matrix Analogies (.65), and Memory for Symbols (.62). Four subtests have coefficients that ranged from .40 - .60 and include Phonological Awareness (.56), Auditory Gestalt: Synthesis (.54), Word Memory (.53), and Decoding (.48). There was one subtest with a validity coefficient below the .40 level. Auditory Gestalt: Closure had a coefficient of .38.

Research Question 3

The third research question was addressed by determining the factor structure of the subtests that measure basic cognitive processes believed to be related to reading ability. These subtests include Phonological Awareness, Auditory Gestalt: Closure, Auditory Gestalt: Synthesis, Word Memory, Memory for Symbols, Rapid Symbol Naming, Visual Processing: Discrimination and Visual Processing: Closure.

The relationship among the variables was assessed in two ways. Initially the relationships between each of the cognitive processing subtests were shown by a correlation matrix. Second, the factor structure of these subtests was assessed using a principle components exploratory factor analysis.

Correlation matrix. First, a correlation matrix was completed to show the relationship among the eight processing subtests. Results of this analysis can be found in Table 5. The correlation matrix suggests that there is a strong relationship among each of the processing subtests ($p < .01$), with coefficients ranging from .32 to .77. Rapid Symbol Naming has the strongest correlation to the other subtests while Auditory Gestalt: Closure has the weakest. Many of the correlations, 16 out of 28, were above .50.

Initial exploratory analysis. An exploratory factor analysis was conducted for the eight processing subtests. The extraction method was a principal components analysis followed by a varimax rotation. The analysis extracted one primary factor with an eigenvalue greater than 1 (4.766). This single factor accounted for 59.6% of the total variance. The second and third factors had eigenvalues that were less than 1 and only accounted for 9.8% and 9.7% of the variance respectively (see Table 6).

An analysis of the factor loadings on the large first factor yielded the following loadings: Rapid Symbol Naming - .87, Visual Processing: Discrimination - .85, Memory of Symbols - .82, Phonological Awareness - .81, Auditory Gestalt: Synthesis - .77, Visual Processing: Closure - .73, Word Memory - .70, and Auditory Gestalt: Closure - .57. As would be expected, given the significant correlation among these variables, each is strongly correlated to the single factor. Auditory Gestalt: Closure had the lowest correlation (.57) while Rapid Symbol Naming had the highest (.87).

In order to further explore the relationship among the TODD's processing variables, a varimax rotation with Kaiser normalization was conducted in order to explore two-, three-, and four-factor models. Further analysis was considered appropriate due to nature of the data. That is, because the subtests were designed to measure multiple aspects of cognitive processing related to reading, there is a need to explore additional factor structures to provide interpretive information. For many individuals, performance will not vary and a single factor will be consistent with their functioning. However, others may show variability according to a systematic conceptual scheme or model. The use of factor analytic strategies to explore various models can be helpful to identify those models.

Factor loadings are shown for the two-, three-, and four-factor models in Tables 7 through 9. In the Two-Factor Model (see Table 7) Factor One contains Memory for Symbols (.82), Word Memory (.80), Phonological Awareness (.79), Auditory Gestalt: Synthesis (.63), and Rapid Symbol Naming (.66). Visual Processing: Discrimination also has a secondary loading on Factor One of .51. Factor Two contains Visual Processing: Closure (.88), Visual Processing: Discrimination (.71), and Auditory Gestalt: Closure (.65). Factor Two also contains Rapid Symbol Naming and Auditory Gestalt: Synthesis with secondary loadings of .58 and .45, respectively.

For the Three-Factor Model (see Table 8), Factor One contains Memory for Symbols (.80), Word Memory, (.79), Phonological Awareness (.78), Rapid Symbol Naming (.63) and Auditory Gestalt: Synthesis (.61). Also included in Factor One is Visual Processing: Discrimination with a secondary loading of .47. Factor Two contains Visual Processing: Closure (.91) and Visual Processing: Discrimination (.80). Rapid Symbol Naming has a secondary loading of .57 on Factor Two. Factor Three contains

Auditory Gestalt: Closure (.93) and Auditory Gestalt: Synthesis, with a secondary loading of .49.

In the Four-Factor Model (see Table 9), the most salient finding is that Auditory Gestalt: Closure identifies a fourth factor with a single loading of .94. Factor One continues to contain Phonological Awareness (.83) and Auditory Gestalt: Synthesis (.77), which load only on this factor. Factor One also contains Memory for Symbols (.71) and Rapid Symbol Naming with a secondary loading of .50. Factor Two contains Visual Processing: Closure (.91), Visual Processing: Discrimination (.80), and Rapid Symbol Naming (.57). Factor Three contains Word Memory (.90), Memory for Symbols with a secondary loading of .43 and Rapid Symbol Naming with a tertiary loading of .41.

Final exploratory analysis with Auditory Gestalt: Closure eliminated. Although the factor structures described above have several characteristics consistent with a reasonable interpretation, they do not provide a totally satisfactory explanation. The poor psychometric properties of Auditory Gestalt: Closure (i.e., low reliability and low age-to-raw score correlation) and its tendency to load separately and unexpectedly led to a decision to exclude it and to repeat the factor analysis.

Although two-, three-, and four-factor models were explored in this second analysis, only the Two- and Three-Factor Models will be described, as they presented the most satisfactory explanations of the data. In the Two-Factor Model (see Table 10), Factor One contains Memory for Symbols (.81), Phonological Awareness (.80), Word Memory (.77), Auditory Gestalt: Synthesis (.71) and Rapid Symbol Naming (.65). Factor One also contains Visual Processing: Discrimination, with a secondary loading of .46.

Factor Two contains Visual Processing: Closure (.94) and Visual Processing: Discrimination (.81). It also contains Rapid Symbol Naming, with a secondary loading of .59.

In the Three-Factor Model (see Table 11), Factor One contains Auditory Gestalt: Synthesis (.85), Phonological Awareness (.79), and Memory for Symbols (.65). Rapid Symbol Naming has a secondary loading on this factor of .47. Factor Two is very similar to Factor Two described above. It contains Visual Processing: Closure (.92), Visual Processing: Discrimination (.80), and Rapid Symbol Naming (.58). Factor Three contains Word Memory (.90) and Memory for Symbols and Rapid Symbol Naming, with secondary loadings of .50 and .47, respectively.

6. DISCUSSION

The Test of Dyslexia and Dysgraphia is designed to provide a comprehensive assessment of the numerous skills required to diagnose dyslexia and dysgraphia. This particular study focused on the subtests necessary to diagnose dyslexia only. Assuring that the TODD has sound psychometric properties is an important phase of test development and is the goal of this study. Results will be used to provide evidence of the reliability and validity of the individual subtests of the TODD and of the test as a whole. Suggestions for improving this instrument are provided.

Reliability: Internal Consistency

The first area addressed was the reliability of the TODD subtests. Six of the TODD subtests had reliability coefficients of .90 or higher. These included Letter-Word Calling, Reading Comprehension, Spelling, Listening Comprehension, Decoding, and Phonological Awareness. It is interesting to note that all of these subtests, with the exception of Phonological Awareness, are measures of individual achievement. The two measures of intellectual functioning, Vocabulary and Matrix Analogies, have reliability coefficients of .87 and .86, respectively, while Memory for Symbols has a reliability coefficient of .86 and Auditory Gestalt: Synthesis has a reliability coefficient of .80. Subtests of Auditory Gestalt Closure (.77) and Word Memory (.68) yield reliability estimates below the recommended .80 criterion.

There are several factors that may contribute to the varying degrees of reliability among these subtests. Those subtests with reliability coefficients above the .90 level are also the subtests containing the greatest number of items, ranging from 26 to 50 for the academic subtests. Phonological Awareness is an exception, with an item total of 20. Likewise, the two subtests with the fewest items, Auditory Gestalt: Closure and Word Memory have the lowest reliability coefficients. Even so, there are some exceptions to this trend; item number alone is not sufficient to account for the variability.

The need to establish an adequate floor and ceiling for each subtest may have had a subtle negative effect on reliability. Reliability decreases when a subtest contains items that do not contribute to the scale variance (i.e., items that were either answered correctly by all subjects as needed to establish floors or missed by all subjects as needed to establish ceilings). Perhaps the subtest most negatively affected in this manner is Word Memory. This subtest contains only 16 items. The first two items were correctly answered by all subjects while the last two items were missed by all subjects. A combination of having few items initially and then having four additional items that produce no significant scale variance contributes to the low reliability score (.68).

An examination of the reliability coefficients of the WJ–III (McGrew & Woodcock, 2001) was conducted as a basis of comparison. This test was selected due to its extensive normative sample and because it has subtests that closely resemble some of those on the TODD. When looking at the entire WJ–III battery, reliability coefficients ranged from .74 to .97. For those subtests that are most similar to the tasks on the various TODD subtests, the reliability coefficients ranged from .80 to .97. A comparison suggests that the TODD's reliabilities on achievement measures (Letter-Word Calling, Reading Comprehension, Spelling, Listening Comprehension, and Decoding) are comparable to similar WJ-III subtests, with TODD reliabilities being slightly higher. It should be noted that the reliability coefficients used for the WJ–III comparison are median reliabilities for their entire normative sample, which covers a very broad age range and contains 8,818 subjects from across the United States. The TODD reliability coefficient for Phonological Awareness is also slightly higher than the WJ–III's Sound Awareness subtest. These two subtests measure similar constructs even though their methodology is very different. This favorable comparison to the WJ–III is particularly encouraging when considering the TODD's relatively small sample size, which would likely weaken its reliability.

When comparing the other cognitive processing subtests (Sound Awareness to Phonological Awareness, Sound Blending to Auditory Gestalt: Synthesis, and Incomplete Words to Auditory Gestalt: Closure), the WJ–III has stronger reliabilities. An explanation for this could be the larger number of items on the WJ–III subtests; the methodology for each of the compared subtests is almost identical. The Memory for Words subtest on the WJ–III has a reliability coefficient of .80 and is the lowest coefficient of the WJ–III subtests in this comparison. Likewise, Word Memory is the TODD's least reliable subtest. The Memory for Words subtest has three items at each level of difficulty for the WJ–III, while the TODD's Word Memory test has two items at each difficulty level. Due to the poor reliability of Word Memory (.68), consideration should be given for adding one item at each difficulty level, which would likely improve its reliability.

Overall, the TODD's internal consistency is adequate to strong. Perhaps reliability coefficients will increase when data are collected on a much larger normative sample. There are two subtests with inadequate reliabilities, Auditory Gestalt: Closure (.77) and Word Memory (.68). Auditory Gestalt: Closure may not be viable for psychometric and theoretical reasons. Word Memory is used in many other instruments and is considered a theoretically sound measure. For this reason, consideration should be given to saving it by increasing the total item number across difficulty level.

Validity: Relationship Between Chronological Age and Performance

The second psychometric evaluation of the TODD compared the age of the subjects to the raw scores they received. Each of the TODD subtests contains items related to achievement or cognitive functioning, and one would expect a developmental progression throughout the age range of the sample (5 to 12 years). Others have used this strategy. McGrew and Woodcock (2001) provide these data as support for the validity of the WJ–III tests and cluster areas. Similarly, on the CTOPP, age-to-raw score comparisons were used by Wagner et al. (1999).

The age-to-raw score correlations for the individual TODD subtests ranged from .38 to .80. Vocabulary, Letter-Word Calling, Reading Comprehension, Spelling, Rapid Symbol Naming, Visual Processing: Discrimination, and Visual Processing: Closure produced validity coefficients of .70 or higher, indicating a strong correlation between subjects' ages and the raw scores they obtained on these subtests. Matrix Analogies, Listening Comprehension, and Memory for Symbols had validity coefficients greater than .60.

Decoding yielded a validity coefficient of .48; Phonological Awareness, Auditory Gestalt: Synthesis, and Word Memory produced coefficients of .56, .54, and .53, respectively. Decoding, although considered a measure of achievement, requires the examinee to pronounce nonsense words based on phonology. Although a developmental trend is present, the correlation may be affected by students' knowledge of phonics and the extent to which they have been required to sound out words in their curriculum. Fifth- and sixth-grade students likely spend little or no time during the school day focusing on phonics and sounding out sight words. However, this skill is likely practiced quite often in the lower grades. This difference in focus may impact the developmental nature of this task. The other three subtests, Phonological Awareness, Auditory Gestalt: Synthesis, and Word Memory are cognitive processing skills and, while related to a child's development, would not be expected to show as strong a relationship to age as achievement in basic academic areas, such as reading and spelling.

The subtest with the lowest age-to-raw score correlation is Auditory Gestalt: Closure. As discussed above, this subtest produced a low internal consistency coefficient (.38). On this subtest, subjects are required to listen to a word with one or more sounds of the word omitted. The subject then states the intended word. While one would expect a developmental trend, there are other factors that are likely involved in this task. Attention and auditory processing skills will likely affect performance. In addition, this task requires a child to guess when unsure of words. Most younger children seemed to enjoy this task and guessed at words without reservation. Older children did not seem to enjoy the task, and several were unwilling to make guesses.

CTOPP subtests resemble many of the TODD subtests. CTOPP subtests' coefficients ranged from .26 to .68 while the TODD subtests ranged from .38 to .80. By comparison, the TODD achievement and intelligence subtests yielded correlations that are stronger than those of the CTOPP; the TODD cognitive processing subtest coefficients are comparable to those from the CTOPP. The magnitude of the TODD's coefficients support the construct validity of this instrument.

Validity: TODD Factor Structure

The final research question explored the nature of the relationships among the cognitive processing subtests from the TODD using zero-order correlations and a principle components analysis. Data from the correlation matrix (see Table 5) show strong overlap between variables. For comparative purposes, a correlation matrix for similar subtests on the WJ–III shows relationships ranging from .09 to .49 while the TODD cognitive processing subtests' relationships range from .32 to .77. The TODD subtests were chosen because of their relationship to reading ability; and, therefore, a high degree of correlation was expected. The homogeneity of the sample may have maximized the relationship of these variables as well as the wide age range and use of raw scores. The TODD sample consisted of 105 students from only two different schools is one county. Their educational background is very similar. In addition, in this pilot test, the sample was randomly selected and, as a result, only 9 of the subjects were reported to have reading disabilities with only 4 of the subjects receiving special education services. Because the majority of the sample is experiencing success in learning to read, their scores may have been more similar.

The TODD was designed to assess several constructs related to cognitive processing. It is important to investigate the relationships among these cognitive processing variables for two reasons. First, the factors should relate to one another in a way that is consistent with what they purport to measure (i.e., subtests thought to measure similar constructs should be highly correlated) and that is somewhat consistent with reading research and other valid instruments; if so, the test's construct validity is supported. Second, gaining a clearer understanding of how the processing subtests relate to one another will aid in test interpretation and intervention strategies.

An initial factor analysis provided a factor structure that was difficult to reconcile with current research. That is, the Auditory Gestalt: Closure subtest loaded in unexpected ways. In the Two-Factor Model, it loaded with Rapid Symbol Naming and the two visual processing subtests, but the Auditory Gestalt: Closure task clearly has no visual component. For the Three- and Four-Factor Models, it loaded by itself to form the third or fourth factor, respectively, with other subtests having secondary loadings on these factors. According to a logical analysis of task demands and based on previous research with similar subtests, Auditory Gestalt: Closure would be expected to load on an Auditory Processing factor. Because of its unanticipated loading, low reliability, and a low age-to-raw score correlation, it was excluded from a second exploratory factor analysis. Two-, three-, and four-factor models were considered. The Two- and Three-Factor Models provide the best fits for the data according to current reading research and can be found in Tables 10 and 11, respectively.

<u>Two-Factor Model.</u> The Two-Factor Model (Table 10) contains Memory for Symbols (.81), Phonological Awareness (.80), Word Memory (.77), Auditory Gestalt: Synthesis (.71) and Rapid Symbol Naming (.65) on Factor One and Visual Processing:

Closure (.94) and Visual Processing: Discrimination (.81) on Factor Two. Visual Processing: Discrimination has a secondary loading of .46 on Factor One and Rapid Symbol Naming has a secondary loading of .59 on Factor Two. This model defines two constructs that could be called Auditory Processing and Visual Processing/Speed. Somewhat unexpectedly, this solution shows Memory for Symbols loading solely on the Auditory Gestalt Factor rather than the Visual Processing Factor and Visual Processing: Discrimination having a dual loading on both factors.

This Two-Factor Model seems to be a good fit when considering the most prevalent research regarding reading skill. The importance of auditory processing or phonological processing in the development of reading skills is supported by current literature. A study by Wagner et al. (1993) illustrates that tasks found in the TODD's Auditory Processing Factor are related to the auditory processing measures used in their study (e.g., phoneme segmentation and blending, memory for digits and memory for sentences, and naming digits and naming letters). These skills are related to the TODD subtests of Phonological Awareness, Auditory Gestalt: Synthesis, Word Memory, and Rapid Symbol Naming, all of which are part of the Auditory Processing Factor.

The fact that Rapid Symbol Naming has a double loading seems appropriate, given the debate regarding this construct. As mentioned above, Wagner et al. (1993) suggest that RAN is a component of Auditory Processing or Phonological Awareness. However, there are other researchers who view it as an independent construct (Blachman, 1984; Denckla & Cutting, 1999; Wolf, 1997). Denckla and Cutting (1999) described a study designed to identify "what 'goes into' RAN" (p. 34). Like the current study, the sample was not comprised of poor readers. Results suggested that RAN "was in large part accounted for by processing speed" (p. 34). Their study suggested that RAN is a measure of processing speed while the work of Torgesen et al. (1992) supports RAN as a measure of auditory processing. These two studies support Rapid Symbol Naming's double loading on both the Auditory Processing and Visual Processing/Speed Factors.

The studies described above support the inclusion of Phonological Awareness, Auditory Gestalt: Synthesis, Rapid Symbol Naming, and Word Memory as part of an Auditory Processing Factor. There are two additional subtests that load on this factor, but less robustly. The subtest of Memory for Symbols was designed to measure visual memory of letters in sequence and requires subjects to look briefly at an unrelated string of letters and then pick that string of letters from a choice of four similar strings. It was expected that it might load on the Visual Processing/Speed Factor because it appears to be a visual task. However, in the Two-Factor Model, Memory for Symbols loaded strongly with the other Auditory Processing variables (.81). Visual Processing: Discrimination showed a weaker, secondary loading on the Auditory Processing Factor. This task required the examinee to look at a group of four letter strings and then select the one string that is different from the other three as rapidly as possible. This task was expected to load heavily on the Visual Processing/Speed Factor and does (.81). The secondary loading on the Auditory Processing Factor was unexpected. Stone and Brady (1995) discussed the process of phonologically coding information during short-term memory tasks. They suggested that any memory tasks that could be coded phonologically, such as a sequence of letters, are similar. It is likely that this type of verbal mediation was used on Memory for Symbols, which could explain the relationship between this task and the other Auditory Processing variables. Similarly, verbal mediation was also likely used to aid students in completing the Visual Processing: Discrimination subtest.

The second factor, Visual Processing/Speed contained the two visual processing tasks and a secondary loading for the Rapid Symbol Naming task. This factor is quite similar to the WJ–III factor of Processing Speed, which also contained two visual processing tasks and a rapid naming task. Current reading research de-emphasizes the importance of visual processing in reading acquisition and emphasizes phonological processing and RAN. However, there are some researchers who continue to emphasize the importance of this construct. Watson & Willows (1993) provided an overview of the history of visual processing's role in reading research. The authors stated that,

> despite longstanding disagreement as to the function of visual processing deficits in reading disabilities, a subgroup manifesting deficits in some aspect of visual perception, visual memory, or visual-spatial-motor skills, has repeatedly emerged in both clinical and statistical classification research. (p. 304)

Although these authors acknowledged that there are limitations in the research cited, they urge researchers to continue considering visual processing deficits as having a unique role in the diagnosis of reading disabilities. This Visual Processing/Speed factor suggested that visual processing may indeed make an independent contribution to the definition of reading disabilities.

Three-Factor Model. The Principle Components Analysis also yielded a Three-

Factor Model that varied only slightly from the Two-Factor Model. In this model, Factor One continues to represent Auditory Processing and contains Auditory Gestalt: Synthesis (.85), Phonological Awareness (.79), and Memory for Symbols (.65). Rapid Symbol Naming had a secondary loading on this factor of .47. Factor Two, Visual Processing/Speed, contained Visual Processing: Closure (.92), Visual Processing: Discrimination (.80), and Rapid Symbol Naming (.58). Factor Three appeared to be a Memory Factor and contained Word Memory (.90), Memory for Symbols with a secondary loading of .50, and a tertiary loading for Rapid Symbol Naming of .47.

As described above, the unexpected loading of Memory for Symbols on the Auditory Processing Factor can best be explained by its reliance on phonological coding and verbal mediation. The Visual Processing/Speed factor contained the three speeded tasks, all requiring visual attention, effective scanning, and rapid responding; all would be expected to load together, given their common content and the loading pattern of similar subtests (see McGrew & Woodcock, 2001). The Rapid Symbol Naming task contains a visual component but differs from the other two visual processing tasks in that responses are spoken rather than written. Hence, its loading on this factor is less robust. The third factor appeared to be a Memory Factor. It contains Word Memory and Memory for Symbols, each involving short-term memory. This factor also contains Rapid Symbol Naming, which has a retrieval component that is related to long-term memory.

Of particular interest in the Three-Factor Model, Rapid Symbol Naming had a triple loading on Auditory Processing, Visual Processing/Speed and Memory. Recent research continues to emphasize the importance of this subtest in defining and predicting reading disabilities (Torgesen et al., 1992; Torgesen & Wagner, 1998; Wolf, 1997, 1999). In a recent article, Wolf, Bowers et al. (2000) described the complexity of this task. They reported that "visual naming represents a demanding array of attentional, perceptual, conceptual, memory, lexical, and articulatory processes" (p. 393). Processing speed became a factor when visual naming was in the form of a continuous naming speed task. In response to researchers that classify RAN within the broad category of phonological awareness, the authors stated that the complexity of the underlying structure of RAN and the extent of the processing speed requirements "make naming speed a different cognitive task from phonology" (p. 393). This explanation of the complexity of RAN helps to explain why the Rapid Symbol Naming subtest has moderate factor loadings on all three factors in the Three-Factor Model.

A comparison of the Two-Factor Model and the Three-Factor Model suggested that they are similar. Both models contained two factors that could be called Auditory Processing and Visual Processing/Speed. One difference in these two models is that the subtest of Rapid Symbol Naming shifted from having a primary loading on Auditory Processing in the Two-Factor Model to a primary loading on Visual Processing/Speed when a third factor was extracted. In each model, Rapid Symbol Naming's secondary loading remained fairly robust (.59 and .47 respectively). Also, when a third factor was extracted, Visual Processing: Discrimination no longer had a secondary loading on the Auditory Processing Factor.

The Three-Factor Model included a third factor that could be called Memory. In this case, Word Memory shifted from the Auditory Processing Factor to the Memory

Factor and did not have a secondary loading on the other two factors. The Memory Factor also contained fairly robust secondary loadings for Memory for Symbols (.50) and Rapid Symbol Naming (.47).

Although both models have merit, the Three-Factor Model may provide the most parsimonious yet thorough explanation of the subtests due to the inclusion of a separate Memory Factor. The Auditory Processing, Visual Processing/Speed, and Memory Factors provided a concise and theoretically sound grouping of the cognitive processing subtests. These three factors are consistent with factors identified on other standardized instruments, including the WJ–III and CTOPP. These instruments, which have been described above as being similar to the TODD, support the inclusion of the Memory Factor. In addition, the Stanford-Binet Intelligence Scale and the Universal Nonverbal Intelligence Test (UNIT, Bracken & McCallum, 1998) also have a separate memory factor and provide further support for Three-Factor Model. In addition, the complex nature of RAN is described more clearly in the Three-Factor Model, which illustrates its reliance upon auditory processing, speed, and memory. The major limitation of this model is the loading of Word Memory solely on the Memory Factor while Memory for Symbols has a dual loading on Auditory Processing and Memory. Current research would suggest this same dual loading would be expected for Word Memory. When the recommended changes are made to improve the reliability of the Word Memory subtest, its factor loadings should be reexamined.

Summary and Implications

Overall, the psychometric properties of the TODD appear to be quite sound. It has adequate reliability in the area of internal consistency and is comparable to other instruments with much broader normative samples. Likewise, its construct validity was supported by two different analyses. First, the raw scores on each TODD subtest did correlate significantly with the age of the subjects. Second, exploratory factor analysis yielded a factor structure that is consistent with current reading research.

There is currently a great deal of emphasis on the importance of reading and much debate regarding the best way to diagnose reading disabilities. There is little confidence in the widespread use of a discrepancy formula to determine who does or does not have a reading impairment and, subsequently, who does and does not qualify for services to address reading difficulties. There is a great need for an instrument that does not rely solely on a discrepancy formula and that does consider the important strides made in reading research regarding the various cognitive variables related to reading performance. This instrument should be comprehensive yet timely. It must be both reliable and valid.

The exploratory factor analysis completed on the TODD's cognitive processing variables suggested a strong relationship among each of these subtests. Further analysis yielded two- and three-factor structures that are consistent with current reading research, therefore supporting the construct validity of this aspect of the test with two caveats. First, TODD authors should consider either eliminating the Auditory Gestalt: Closure subtest because of psychometric limitations or strengthening it. For this reason, special attention to this subtest is recommended. It may be useful to carefully examine the subtest and perhaps add more items to increase its length. Second, the subtest of Word Memory also yielded a reliability coefficient below the acceptable level. However, this subtest seems theoretically sound and desirable; it (or a similar one) is common to many test batteries. It is recommended that consideration be given to adding items at each level of difficulty in order to improve the reliability of this subtest.

For the most part, the instrument appears to have adequate reliability and validity. Assuming future research continues to support the validity of the TODD, its use will allow examiners to follow the TODD's comprehensive formula based on the research of Padget et al. (1996) and Wolf (1997, 1999) for determining a diagnosis of dyslexia. Using this formula, the following questions can be answered, which could lead to a diagnosis of dyslexia: Are Listening Comprehension or IQ subtests equal to or greater than 90? Second, is Reading Comprehension lower than Listening Comprehension? Third, is Letter-Word Calling less than Reading Comprehension and 15 or more points below Listening Comprehension or IQ? Fourth, is the Spelling subtest lower than Letter-Word Calling and also 15 points below Listening Comprehension and IQ? Fifth, is Decoding less than Letter-Word Calling? Sixth, are processing abilities such as phonological awareness, RAN, or auditory processing well below age expectations? Use of this "formula" provides an alternative to the discrepancy model of defining reading disabilities and offers a theoretically sound manner in which to provide a thorough assessment of the controversial and oftentimes misunderstood construct of dyslexia.

Limitations and Suggestions for Further Research

Many of the limitations of this study are directly related to its status as an experimental test and the limited data associated with it. One limitation of this study is the nature of the sample. First of all, the sample size is small, especially given the nature of the research questions addressed. Second, the sample of students in this study came from two different schools in one county in East Tennessee. In the future, a much broader study should be conducted. Sample sizes should be large enough to allow for comparisons between age groups rather than considering all age levels as a single unit. Comparisons should also be made between groups of children with and without reading disabilities. These data could allow for the use of other, more sophisticated data analyses (e.g., confirmatory analysis). The current data do not allow for reliability measures for the speeded tasks. Test-retest measures would be appropriate for determining the reliability of these subtests but were not completed in the pilot study.

Also, no concurrent validity data are available between the TODD and related tests, such as the WJ–III and CTOPP. These three tests have much in common. Future studies should include a direct comparison between the TODD and these instruments.

Finally, the results of this study suggest that the TODD has promise in offering a new dimension in dyslexia assessment and research. Although the current results provide limited support for its reliability and validity, these results should be considered tentative until further research and "fine-tuning" occur.

REFERENCES

References

Ackerman, P. T. Paal, N. P., Holloway, C., & Dykman, R. A. (1992). Test selection efficacy in the diagnostic confirmation and sub-typing of children with dyslexia. Learning Disabilities Research and Practice, 7, 199–202.

American Psychiatric Association. (1994). Diagnostic and Statistical Manual of Mental Disorders (4th ed.). Washington DC: American Psychiatric Press.

Badian, N. A. (1998). A validation of the role of preschool phonological and orthographic skills in the prediction of reading. Journal of Learning Disabilities, 31, 472–481.

Ball, E. W., & Blachman, B. A. (1988). Phoneme segmentation training: Effects on reading readiness. Annals of Dyslexia, 38, 208–225.

Ball, E. W., & Blachman, B. A. (1991). Does phoneme awareness training in kindergarten make a difference in early word recognition and developmental spelling. Reading Research Quarterly, 26, 49–66.

Berk, L. E. (2000). Child development, (5th ed.). Boston: Allyn and Bacon.

Blachman, B. A. (1984). Relationship of rapid naming ability and language analysis skills to kindergarten and first-grade reading achievement. Journal of Educational Psychology, 76, 610–622.

Bracken, B. A., & McCallum, R. S. (1998). Universal Nonverbal Intelligence Test. Chicago: Riverside Publishing.

Byrne, B., & Fielding-Barnsley, R. (1991). Evaluation of a program to teach phonemic awareness to young children. Journal of Educational Psychology, 83, 451–455.

Calfee, R., Lindamood P., & Lindamood, C. (1993). Acoustic-phonetic skills and reading: Kindergarten through twelfth grade. Journal of Educational Psychology, 64, 293–298.

Catts, H. (1989). Defining dyslexia as a developmental language disorder. Annals of Dyslexia, 39, 50–67.

Cunningham, A. E. (1990). Explicit instruction in phoneme awareness. Journal of Experimental Child Psychology, 50, 429–494.

Denckla, M. B. & Cutting, L. E. (1999). History and significance of rapid automatized naming. Annals of Dyslexia, 49, 29–42.

Doris, J. L. (1993). Defining learning disabilities: A history of the search for consensus. In G. R. Lyon, D. B. Gray, J. F. Kavanaugh, & N. A. Krasnegor (Eds.), Better understanding learning disabilities (pp. 97–115). Baltimore: Paul H. Brookes.

Fletcher, J. M., Shaywitz, S. E., Shankweiler, D. P., Katz, L., Liberman, I. Y., Stuebing, K. K., Francis, D. J., Fowler, A. E., & Shwaywitz, B. E. (1994). Cognitive profiles of reading disability: Comparisons of discrepancy and low achievement definitions. Journal of Educational Psychology, 86, 6–23.

Foorman, B. R., Francis, D. J., Shaywitz, S. E., Shaywitz, B. A., & Fletcher, J. M. (1997) The case for early intervention. In B. A. Blachman (Ed.), Foundations of reading acquisition and dyslexia–Implications for early intervention. (pp. 243–264). Mahwah, NJ: Lawrence Erlbaum Associates.

Fuchs, L. S. & Fuchs, D. (1994). Academic assessment and instrumentation. In S. Vaughn & C. S. Bos (Eds.), Research issues in learning disabilities (pp. 233–245).

New York: Springer-Verlag.

Ganske, K. (1993). Developmental Spelling Analysis. Barboursville, VA: author.

Geschwind, N. (1965). Disconnection syndrome in animals and man (Parts I and II). Brain, 88, 237–294, 585–644.

Hammill, D. D. (1990). On defining learning disabilities: An emerging consensus. Journal of Learning Disabilities, 23, 74–84.

Hill, M. H. (1995). What is dyslexia? Is there a test for dyslexia? Texas Reading Report, 18, 2 , 11–13.

Individuals with Disabilities Education Act, 1997, Pub. L. No. 105–47, (1997).

Jacob–Timm, S. & Hartshorne, T. S. (1998). Ethics and law for school psychologists, (3rd Ed.). NY: John Wiley & Sons.

Joshi, R. M. (1995). Assessing and Reading Spelling Skills. School Psychology Review, 24, 361–375.

Kahmi, A. G. (1992). Response to historical perspectives: A developmental language perspective. Journal of Learning Disabilities, 25, 48–52.

Kamhi, A., & Catts, H. (1989). Reading disabilities: Terminology, definitions, and subtyping issues. In A. Kamhi & H. Catts (Eds.), Reading disabilities: A developmental language perspective (pp. 35–67). Austin, TX: PRO-ED.

Kennedy, A. (1993). Eye movement control and visual display units. In D. M. Willows, R. S. Kruk, & E. Corcos (Eds.), Visual processes in reading and reading disabilities (pp. 215–236). Hillsdale, NJ: Lawrence Erlbaum Associates.

Liberman, I. Y., Shankweiler, D., Fischer, F. W., & Carter, B. (1974). Explicit syllable and phoneme segmentation in the young child. Journal of Experimental Child Psychology, 18, 201–212.

Lindamood, C. H., & Lindamood, P. C. (1979). Lindamood Auditory Conceptualization Test. Chicago: Riverside Publishing.

Lovegrove, W. J., & Williams, M. C. (1993). Visual temporal processing deficits in specific reading disability. In D. M. Willows, R. S. Kruk, & E. Corcos (Eds.), Visual processes in reading and reading disabilities (pp. 311–330). Hillsdale, NJ: Lawrence Erlbaum Associates.

Lundberg, I., Frost, J., & Petersen, O. (1988). Effects of an extensive program for stimulating phonological awareness in preschool children. Reading Research Quarterly, 23, 263–284.

Lyon, G. R. (1995). Toward a definition of dyslexia. Annals of Dyslexia, 45, 3–27.

Lyon, G. R. (1996). Learning disabilities. In K. L. Freiberg (Ed.), Annual editions: Educating exceptional children (pp. 49–71). Guilford, CT: Dushkin/McGraw Hill.

Markwardt, F. C. (1989). Peabody Individual Achievement Test–Revised. Circle Pines, MN: American Guidance Service.

McGrew, K. S., & Woodcock, R. W. (2001) Woodcock-Johnson III technical manual. Chicago: Riverside Publishing.

Nicholson, T. (1997). Closing the gap on reading failure: Social background, phonemic awareness, and learning to read. In B. A. Blachman (Ed.), Foundations of reading acquisition and dyslexia – Implications for early intervention. (pp. 381–407). Mahwah, NJ: Lawrence Erlbaum Associates.

Olson, R. K., & Forsberg, H. (1993). Disabled and normal readers' eye movements in reading and nonreading tasks. In D. M. Willows, R. S. Kruk, & E. Corcos (Eds.), Visual processes in reading and reading disabilities (pp. 377–392). Hillsdale, NJ: Lawrence Erlbaum Associates.

Padget, S. Y., Knight, D. F., & Sawyer, D. J. (1996). Tennessee meets the challenge of dyslexia. Annals of Dyslexia, 46, 51–72.

Pollatsek, A. (1993). Eye movements in reading. In D. M. Willows, R. S. Kruk, & E. Corcos (Eds.), Visual processes in reading and reading disabilities (pp. 191–214). Hillsdale, NJ: Lawrence Erlbaum Associates.

Reddington, J. M., & Cameron, K. D. (1991). Visual and auditory information processing in dyslexia: The possibility of subtypes. International Journal of Disability, Development, and Education, 38, 171–203.

Richardson, E. & Dibenedetto, B. (1985). Decoding Skills Test. Los Angeles: Western Psychological Services.

Richardson, S. O. (1992). Historical perspectives on dyslexia. Journal of Learning Disabilities, 25, 40–47.

Roberts, R., & Mather, N. (1997). Orthographic Dyslexia: The neglected subtype. Learning Disabilities Research and Practice, 12, 236–250.

Rooney, K. J. (1995). Dyslexia revisited: History, educational philosophy, and clinical assessment applications. Intervention in School and Clinic, 31, 6–15.

Rutter, M., & Yule, W. (1975). The concept of specific reading retardation. Journal of Child Psychology and Psychiatry, 16, 181–197.

Satz & Fletcher. (1980). Minimal brain dysfunction: An appraisal of research concepts and methods. In H. E. Rie & E. D. Rie (Eds.), Handbook of minimal brain dysfunctions: A critical review (pp. 669–714). New York: Wiley.

Sawyer, D. J. (1987). Test of Awareness of Language Segments. Austin, TX: PRO-ED.

Shaywitz, S. E. (1996). Dyslexia. Scientific American, 275, 78–84.

Shaywitz, S. E. (1998). Dyslexia. The New England Journal of Medicine, 338, 307–312.

Shaywitz, S. E., Escobar, M. D., Shaywitz, B. A., Fletcher, J. M., & Makuch, R. (1992). Evidence that dyslexia may represent that lower tail of a normal distribution of reading disability. New England Journal of Medicine, 326, 145–150.

Siegel, L. S. (1989). IQ is irrelevant to the definition of learning disabilities. Journal of Learning Disabilities, 22, 469–478.

Siegel, L. S. (1992). An evaluation of the discrepancy definition of dyslexia. Journal of Learning Disabilities, 25, 618–629.

Siegel, L. S. (1999). Issues in the definition and diagnosis of learning disabilities: A perspective on Guckenberger v. Boston University. Journal of Learning Disabilities, 32, 304–319.

Stanovich, K. E. (1991). Discrepancy definitions and reading ability: Has intelligence led us astray? Reading Research Quarterly, 26, 7–29.

Stanovich, K. E., & Siegal, L. S. (1994). Phenotypic performance profile of children with reading disability: A regression-based test of the phonological core variable difference model. Journal of Educational Psychology, 86, 24–53.

Stein, J. F. (1993). Visuospatial perception in disabled readers. In D. M. Willows, R. S. Kruk, & E. Corcos (Eds.), Visual processes in reading and reading disabilities (pp. 331–346). Hillsdale, NJ: Lawrence Erlbaum Associates.

Stone, B., & Brady, S. (1995). Evidence for phonological processing deficits in less-skilled readers. Annals of Dyslexia, 45, 51–77.

Thompson, M. (1984). Developmental dyslexia: Its nature, assessment, and remediation. London: Arnold Press.

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). Stanford-Binet Intelligence Scale: 4th ed. Chicago: Riverside Publishing Company.

Torgesen, J. K., Morgan, S. T., & Davis, C. (1992). Effects of two types of phonological awareness training on word learning in kindergarten children. Journal of Educational Psychology, 84, 364–370.

Torgesen, J. K & Wagner, R. K. (1998). Alternative diagnostic approach for specific developmental reading disabilities. Learning Disabilities Research and Practice, 13, 220–232.

Vellutino, F. R., Scanlon, D. M., & Tanzman, M. S. (1994). Components of reading ability: Issues and problems in operationalizing word identification, phonological coding, and orthographic coding. In G. R. Lyon (Ed.), Frames of reference for the assessment of learning disabilities: New views on measurement issues (pp. 279–232).

Baltimore: Brookes.

Wagner, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. Psychological Bulletin, 101, 192–212.

Wagner, R. K., Torgesen, J. K., Laughon, P., Simmons, K., & Rashotte, C. A. (1993). Development of young readers' phonological processing abilities. Journal of Educational Psychology, 85, 83–103.

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1999). Comprehensive Test of Phonological Processing. Austin, TX: PRO-ED.

Watson, C., & Willows, D. M. (1993). Evidence for a visual-processing-deficit subtype among disabled readers. In D. M. Willows, R. S. Kruk, & E. Corcos (Eds.), Visual processes in reading and reading disabilities (pp. 287–310). Hillsdale, NJ: Lawrence Erlbaum Associates.

Wechsler Individual Achievement Test. (1992). New York: The Psychological Corporation.

Wechsler, D. (1991). Wechsler Intelligence Scale for Children–Third Edition. New York: The Psychological Corporation.

Wolf, M. (1997). A provisional, integrative account of phonological and naming-speed deficits in dyslexia: Implications for diagnosis and intervention. In B. A. Blachman (Ed.), Foundations of reading acquisition and dyslexia - Implications for early intervention. (pp. 67–92). Mahwah, NJ: Lawrence Erlbaum Associates.

Wolf, M. (1999). What time may tell: Towards a new conceptualization of developmental dyslexia. Annals of Dyslexia, 49, 3–28.

Wolf, M., Bowers, P. G., & Biddle, K. (2000). Naming-speed processes, timing, and reading: A conceptual review. Journal of Learning Disabilities, 33, 387–407.

Wolf, M., Miller, L., & Donnelly, K. (2000). Retrieval, automaticity, vocabulary, elaboration, orthography (RAVE-O): A comprehensive, fluency-based reading intervention program. Journal of Learning Disabilities, 33, 375–386.

Woodcock, R. W. (1987). Woodcock Reading Mastery Tests (rev. ed.). Circle Pines, MN: American Guidance Service.

Woodcock, R. W., McGrew, K. S., Mather, N. (2001). Woodcock-Johnson, Third Edition, Tests of Cognitive Abilities and Tests of Achievement. Chicago, IL: Riverside Publishing.

APPENDIX

Table 1

Definitions of Dyslexia/Specific Learning Disabilities

National Joint Committee on Learning Disabilities: Learning disabilities is a general term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities. These disorders are intrinsic to the individual, presumed to be due to central nervous dysfunction and may occur across the life span. Problems with self-regulatory behaviors, social perception, and social interaction may exist with learning disabilities but do not by themselves constitute a learning disability. Although a learning disability may occur concomitantly with other handicapping conditions (for example, sensory impairment, mental retardation, serious emotional disturbance) or with extrinsic influences (such as cultural differences, insufficient or inappropriate instruction), they are not the result of those conditions or influences. (Hammill, Leigh, McNutt, & Larsen, 1981; cited in Hammill, 1990, p. 77).

The Learning Disabilities Association of America: Specific Learning Disabilities is a chronic condition of presumed neurological origin which selectively interferes with the development, integration, and/or demonstration of verbal and/or nonverbal abilities. Specific Learning Disabilities exist as a distinct handicapping condition and varies in its manifestations and in degree of severity. Throughout life, the condition can affect self-esteem, education, vocation, socialization, and/or

Table 1 (continued)

daily living activities. (ACLD, 1986, p. 15; cited in Hammill, 1990, p. 78)

Council for Exceptional Children/Division for Children With Learning Disabilities: A child with learning disabilities is one with adequate mental ability, sensory processes, and emotional stability who has specific deficits in perceptual, integrative, or expressive processes which impair learning efficiency. This includes children who have central nervous system dysfunction which is expressed primarily in impaired efficiency. (Siegel & Gold, p. 14; cited in Hammill, 1990, p. 76)

G. Reid Lyon's Working Definition: Dyslexia is one of several distinct learning disabilities. It is a specific language-based disorder of constitutional origin characterized by difficulties in single word decoding, usually reflecting insufficient phonological processing. These difficulties in single word decoding are often unexpected in relation to age and other cognitive and academic abilities; they are not the result of generalized developmental disability or sensory impairment. Dyslexia is manifest by variable difficulty with different forms of language, often including, in addition to problems with reading, a conspicuous problem with acquiring proficiency in writing and spelling. (The Orton Dyslexia Society Research Committee, 1994, p. 9, cited in Lyon, 1995)

Table 1 (continued)

<u>The World Federation of Neurology:</u> Specific developmental dyslexia is a disorder manifested by difficulty learning to read, despite conventional instruction, adequate intelligence, and sociocultural opportunity. It is dependent upon fundamental cognitive disabilties which are frequently constitutional in origin. (Kamhi, 1992, p. 49)

Table 2

Descriptive Statistics of the TODD

Subtest	Mean	Standard Deviation
Vocabulary	14.11	4.30
Matrix Analogies	13.61	4.24
Letter-Word Calling	29.28	11.51
Reading Comprehension	20.76	10.44
Spelling	24.69	13.25
Listening Comprehension	17.92	7.12
Decoding	14.13	5.82
Phonological Awareness	14.71	4.81
Auditory Gestalt: Closure	7.70	3.44
Auditory Gestalt: Synthesis	10.70	3.50
Word Memory	7.11	1.98
Visual Processing: Discrimination*	20.91	4.57
Visual Processing: Closure*	17.10	6.33
Rapid Symbol Naming*	268.52	11.54
Memory for Symbols	14.55	4.21

Note. *Data represents means and standard deviations for only the accuracy portion of these subtests.

Table 3

Reliability: Internal Consistency of TODD Subtests

	Reliability coefficients
Spelling	.97
Letter-Word Calling	.96
Reading Comprehension	.95
Listening Comprehension	.92
Decoding	.92
Phonological Awareness	.91
Vocabulary	.87
Matrix Analogies	.86
Memory For Symbols	.86
Auditory Gestalt: Synthesis	.80
Auditory Gestalt: Closure	.77
Word Memory	.68

Table 4

Construct Validity: Age-to-Raw Score Correlations

	Correlation coefficient
Visual Processing: Discrimination	.80*
Vocabulary	.75*
Letter-Word Calling	.75*
Visual Processing: Closure	.75*
Spelling	.71*
Rapid Symbol Naming	.70*
Reading Comprehension	.70*
Listening Comprehension	.69*
Matrix Analogies	.65*
Memory for Symbols	.62*
Phonological Awareness	.56*
Auditory Gestalt: Synthesis	.54*
Word Memory	.53*
Decoding	.48*
Auditory Gestalt: Closure	.38*

*$p < .01$.

Table 5

Correlation Coefficients for TODD Cognitive Processing Measures

	PAware	AGClos	AGSyn	WMem	MFSym	RSName	VPDis	VPClo
PAware	1.00							
AGClos	.40*	1.00						
AGSyn	.66*	.50*	1.00					
WMem	.52*	.32*	.48*	1.00				
MFSym	.71*	.40*	.61*	.58*	1.00			
RSName	.69*	.47*	.58*	.57*	.71*	1.00		
VPDis	.60*	.37*	.54*	.56*	.61*	.75*	1.00	
VPClo	.45*	.37*	.48*	.34*	.46*	.61*	.77*	1.00

Note. PAware = Phonological Awareness; AGClos = Auditory Gestalt: Closure; AGSyn = Auditory Gestalt: Synthesis; WMem = Word Memory; MFSym = Memory for Symbols; RSName = Rapid Symbol Naming; VPDis = Visual Processing: Discrimination; VPClo = Visual Processing: Closure.

*$p < .01$ (2-tailed).

Table 6

Total Variance Explained, Initial Extraction Rotation

	Initial Eigenvalues			Extracted Sums of Squared Loadings		
Component	Total	% of variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.766	59.576	59.576	4.766	59.576	59.576
2	.787	9.832	69.408			
3	.773	9.668	79.076			
4	.540	6.751	85.827			
5	.428	5.356	91.812			
6	.289	3.607	94.789			
7	.242	3.205	97.814			
8	.175	2.186	100.00			

Extraction method: Principal Component Analysis.

Table 7

Principle Components Analysis of Cognitive Processing Subtests, Two-Factor Extraction

	Rotated Component Matrix	
	Factor	Factor
Subtest	1	2
Phonological Awareness	.79	
Word Memory	.80	
Memory for Symbols	.82	
Auditory Gestalt: Synthesis	.63	.45
Rapid Symbol Naming	.66	.58
Visual Processing: Discrimination	.51	.71
Auditory Gestalt: Closure		.65
Visual Processing: Closure		.88

Extraction method: Principal Component Analysis.

Rotation method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Table 8

Principle Components Analysis of Cognitive Processing Subtests, Three-Factor Extraction

	Rotated Component Matrix		
	Factor	Factor	Factor
Subtest	1	2	3
Phonological Awareness	.78		
Word Memory	.79		
Memory For Symbols	.80		
Rapid Symbol Naming	.63	.57	
Visual Processing: Discrimination	.47	.80	
Auditory Gestalt: Synthesis	.61		.49
Visual Processing: Closure		.91	
Auditory Gestalt: Closure			.93

Extraction method: Principal Component Analysis.

Rotation method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Table 9

Principle Components Analysis of Cognitive Processing Subtests, Four-Factor Extraction

Subtest	Factor 1	Factor 2	Factor 3	Factor 4
Phonological Awareness	.83			
Auditory Gestalt: Synthesis	.77			
Memory For Symbols	.71		.43	
Rapid Symbol Naming	.50	.57	.41	
Visual Processing: Discrimination		.80		
Visual Processing: Closure		.91		
Word Memory			.90	
Auditory Gestalt: Closure				.94

Extraction method: Principal Component Analysis.

Rotation method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Table 10

Principle Components Analysis of Cognitive Processing Subtests, Two-Factor Extraction (Auditory Gestalt: Closure eliminated)

	Rotated Component Matrix	
Subtest	Auditory Processing	Visual Processing/ Speed
Phonological Awareness	.80	
Auditory Gestalt: Synthesis	.71	
Word Memory	.77	
Memory for Symbols	.81	
Rapid Symbol Naming	.65	.59
Visual Processing: Discrimination	.46	.81
Visual Processing: Closure		.94

Extraction method: Principal Component Analysis.

Rotation method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Table 11

Principle Components Analysis of Cognitive Processing Subtests, Three-Factor Extraction (Auditory Gestalt: Closure eliminated)

	Rotated Component Matrix		
Subtest	Auditory Gestalt	Visual Processing/ Speed	Memory
Phonological Awareness	.79		
Auditory Gestalt: Synthesis	.85		
Memory For Symbols	.65		.50
Rapid Symbol Naming	.47	.58	.47
Visual Processing: Discrimination		.80	
Visual Processing: Closure		.92	
Word Memory			.90

Extraction method: Principal Component Analysis.

Rotation method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

VITA

Elizabeth A. Cox will be receiving her Ph.D. in Education with a concentration in school psychology following the completion of an internship with the Lenoir City School System. She is from Johnson City, Tennessee, where she graduated from Science Hill High School. She received a Bachelor's Degree from Emory & Henry College and a Master's Degree from East Tennessee State University. Following her Master's Degree, Elizabeth worked as an out-patient counselor at Church Circle Counseling Center for one year. She obtained her Psychological Examiner's license during this time. Next, she was employed by Woodridge Psychiatric Hospital as the Program Director of the Diagnostic & Evaluation Center, a residential program for juvenile-delinquent teenagers. After working for six years in this capacity, Elizabeth enrolled in University of Tennessee's school psychology program. She has worked part-time as a psychological examiner throughout her doctoral program. She spent one summer at the Gifted Development Center in Denver, Colorado, working on pilot testing for the Stanford-Binet Intelligence Scale–Fifth Edition. Elizabeth's primary areas of interest include assessment and intervention issues regarding learning disabilities, test development, and giftedness. In her free time she enjoys fly fishing, playing tennis, snow skiing, and reading.