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Examining the neurocognitive profile of dysnomia: a comparison of school-aged children with and without dyslexia across the domains of expressive language, attention/memory, and academic achievement

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EXAMINING THE NEUROCOGNITIVE PROFILE OF DYSNOMIA: A

COMPARISON OF SCHOOL-AGED CHILDREN WITH AND WITHOUT

DYSLEXIA ACROSS THE DOMAINS OF EXPRESSIVE LANGUAGE,

ATTENTION/MEMORY, AND ACADEMIC ACHIEVEMENT

by

Robyn Ann Howarth

<u>An Abstract</u>

Of a thesis submitted in partial fulfillment of the requirements for the Doctor of
Philosophy degree in Psychological and Quantitative Foundations (Counseling
Psychology) in the Graduate College of The University of Iowa

December 2010

Thesis Supervisors: Professor Elizabeth M. Altmaier
Professor Lynn C. Richman

ABSTRACT

Word-retrieval and rapid naming abilities play an important role in language processing and cognitive development. Researchers have demonstrated that early language difficulties may lead to later reading impairments and several decades of research has convincingly demonstrated that rapid automatized naming is a powerful predictor of concurrent and future reading development. As a result, researchers have argued that naming and reading tasks involve some shared cognitive processes.

Language and reading deficits have implications for academic success and self-esteem, particularly during childhood. Hence, the identification of children at-risk for developing reading impairments is an important task for educators and clinicians. Debates still exist about whether rapid naming difficulties reflect simple delays in language acquisition resulting from processing speed and/or attention problems or are suggestive of abnormalities in underlying cognitive processes. While the co-occurrence of rapid naming deficits and reading impairments is well established in the literature, few studies have explored the presence of Dysnomia without reading impairment.

The current study examined the nature of expressive language deficits for Dysnomic children with and without impaired reading by incorporating multiple neuropsychological measures. In a sample of children (N=104) between the ages of 6 and 12 years, performance differences were specifically investigated on measures of verbal fluency, confrontation naming, and rapid naming, as well as visual and verbal sequential memory. The impact of a concurrent diagnosis of a primary attention deficit was also examined within the context of cognitive performances.

Results of the current study indicated that a concurrent diagnosis of AD/HD significantly impacted performance on measures of verbal fluency and confrontation naming. When comparing the neurocognitive profiles of these children, those with Dysnomia performed significantly better on reading-related tasks and worse on a measure of visual sequential memory. No significant differences were found between groups on other neuropsychological measures, yet performances were consistently below average for children in both groups. Overall, findings revealed that children in both groups displayed similar neurocognitive profiles. However, children diagnosed only with Dysnomia were significantly younger than children with both Dysnomia and Dyslexia. Findings from this study have implications for research and intervention with school-aged children. Treatment approaches targeting reading fluency and automaticity may be particularly helpful for children with Dysnomia, in addition to intervention programs which integrate fluency-based with phonological-based treatment.

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Graduate College
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CERTIFICATE OF APPROVAL

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PH.D. THESIS

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This is to certify that the Ph.D. thesis of

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has been approved by the Examining Committee for the thesis requirement for the
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To all my family and friends who have offered continuous support, encouraging words, and opportunities to vent over the years…thank you for remaining by my side throughout this roller coaster of a journey.

And,

To my parents, Rob and Barbara Howarth, who instilled in me a love for learning and the belief that I could be anything I wanted to be…thank you for allowing me to find my own voice and follow my own path. I am forever indebted to you for your unconditional love and support!

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Word-retrieval and rapid naming abilities play an important role in language processing and cognitive development. Researchers have demonstrated that early language difficulties may lead to later reading impairments and several decades of research has convincingly demonstrated that rapid automatized naming is a powerful predictor of concurrent and future reading development. As a result, researchers have argued that naming and reading tasks involve some shared cognitive processes.

Language and reading deficits have implications for academic success and self-esteem, particularly during childhood. Hence, the identification of children at-risk for developing reading impairments is an important task for educators and clinicians. Debates still exist about whether rapid naming difficulties reflect simple delays in language acquisition resulting from processing speed and/or attention problems or are suggestive of abnormalities in underlying cognitive processes. While the co-occurrence of rapid naming deficits and reading impairments is well established in the literature, few studies have explored the presence of Dysnomia without reading impairment.

The current study examined the nature of expressive language deficits for Dysnomic children with and without impaired reading by incorporating multiple neuropsychological measures. In a sample of children (N=104) between the ages of 6 and 12 years, performance differences were specifically investigated on measures of verbal fluency, confrontation naming, and rapid naming, as well as visual and verbal sequential memory. The impact of a concurrent diagnosis of a primary attention deficit was also examined within the context of cognitive performances.

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INTRODUCTION

Language difficulties and delays may result in significant and on-going problems

for children and adolescents (Messer & Dockrell, 2006). However, due to variability in

definitions, differing models of language and development, and the heterogeneous nature

of language disorders, the study of developmental language deficits is particularly

challenging. Researchers have attempted to address these inconsistencies by identifying

subgroups of children with specific types of difficulties and, over the years, studies have

examined problems with morphosyntax, phonology, pragmatics, and word-finding

abilities (Conti-Ramsden & Botting, 1999). The word retrieval process plays a central

role in language processing and cognitive development, and difficulties within this

domain can negatively impact reading abilities and academic performance. Interestingly,

research on the lexical dimensions of language and the difficulties associated with word

retrieval is limited.

While prevalence rates vary, estimates for preschool-aged children with

developmental language impairments range between 2 and 8% (Feldman, 2005).

Research has documented a higher prevalence of language impairments among boys

compared to girls, and children are considered to be at-risk of developing language and/or

reading disabilities if there is a family history of the disorder or they are born prematurely

(Beeghly, 2006).

Since language impairments typically appear in clusters of related dysfunctions,

many children experience academic problems as a result of their language difficulties.

One of the most common deficits seen with children who exhibit impaired language is

Dyslexia, which refers to a developmental reading disorder in otherwise competent children who do not make adequate progress in reading. In particular, some estimates suggest that approximately 5-8% of young children display significant difficulty acquiring basic literacy skills and are diagnosed with Dyslexia (Muter & Snowling, 2009). Furthermore, in a population survey of children with language impairments conducted by Dockrell, Messer, George, & Wilson (1998), results revealed that 25% of the participants reported difficulties with word finding, while an estimated 50% of students with learning disabilities endorsed deficits in the area of word retrieval. Unfortunately, accurate detection of many language impairments is made difficult by the wide variability of "normal" language development.

<div align="center">Background</div>

The purpose of this chapter is to set the stage for the importance of studying word finding difficulties in school-aged children. In order to familiarize the reader with some of the issues addressed in this study, the introduction will briefly present a historical overview of language disorders, discuss the possible etiology of language difficulties, and mention important differences between the neuropsychological assessments of children compared to adults. The specific research pertaining to Dysnomia, or word-finding difficulties, and the nature of naming deficits in children will be highlighted, and links between Dysnomia and Dyslexia examined to provide a context for understanding. Terms relevant to this study will also be defined.

<div align="center">Historical Overview</div>

The identification and study of speech and language disorders dates back to the late-nineteenth century. Early studies primarily focused on adults (Berndt, Caramazza, &

Zurif, 1983) and were informed by autopsy findings of individuals with language disorders. Speech and language deficits were thought to be associated with damage to specific areas of the left hemisphere and became known as *Aphasia*. According to Richman & Wood (1999), Aphasia refers to "language problems not related to peripheral problems such as cleft palate or hearing loss" (p. 51).

Over the years, neurological advances have been made with regard to the understanding of brain-language relationships. For example, researchers assert that Broca's area, or the left cerebral frontal region, is associated with phonological short-term memory abilities while semantic language functions are related to the temporal regions of the left hemisphere, often referred to as Wernicke's area (Lezak, Howieson, & Loring, 2004). In particular, many older adults report memory and naming problems because they consistently display difficulties with retrieving verbal labels for common words. Lesions in the left temporal lobe can disrupt the word retrieval process and impair fluent speech. This form of *Anomia*, or word finding deficit, contributes to a patient's difficulty with remembering long lists of words, understanding complex verbal information, and learning new verbal material. Instead, information that is recalled tends to be confused with previously learned associations, resulting in intrusion-type errors (Crosson, Sartor, Jenny, Nabors, & Moberg, 1993).

Studies of brain damage and neurological deficits in adults provide a model for understanding different types of language disorders. Nevertheless, these models may not be appropriate for conceptualizing the language disorders of children because childhood language difficulties are typically related to developmental differences rather than a traumatic brain injury (Geschwind & Galaburda, 1987). A shift toward examining

developmental models of childhood language disorders, or *Developmental Dysphasia*, has occurred (Richman & Wood, 1999). This shift away from adult brain damage models led to a commonly used categorization of language deficits in children of *Developmental Language Disorders*. Current assessment approaches have focused on the development of diagnostic categories of language-disorder subtypes that will allow for the appropriate identification of children based on similar language deficits. Ultimately, establishing diagnostic clarity with regard to developmental language disorders will allow clinicians to use appropriate treatment strategies based on areas of weakness. Nevertheless, one of the most significant difficulties in conceptualizing and comparing children with different learning or language disorders is the lack of consistency in the tests and methodological procedures employed by various clinicians and researchers (Richman & Wood, 1999).

Etiology of Language Disorders

The origin and/or cause of speech and language disorders are typically unknown. While most hypotheses related to possible brain damage or abnormalities in the left hemisphere have been unfounded, more recent assumptions assert that deficits in auditory discrimination, sequencing, short-term memory, or rate of processing may explain some of the difficulties experienced by language disordered children (Richman, 2000). Literature also confirms that socio-demographic variables can impact the trajectories of language development and should be considered.

Language deficits have implications for academic success particularly during childhood (Wiig & Semel, 1975) and children with speech and language disorders are at higher risk for social-emotional concerns (Richman & Wood, 1999). Speech and language disorders are often associated with learning, behavior, and/or emotional

disorders (Richman, 2000) as well as a number of developmental and medical conditions (Bashir & Scavuzzo, 1992). More specifically, a number of research studies have suggested key developmental periods in which children are at an increased risk of developing low self-esteem, particularly prior to being diagnosed with a learning disability (Palombo, 2001; McNulty, 2003). For example, children later diagnosed with Dyslexia may start to question their intellectual capabilities and/or experience a decrease in motivation because of their unexplained learning difficulties, specifically during the late elementary and middle school years. Given the academic, social-emotional, and psychiatric problems associated with developmental language disorders, there is a strong need for the early and accurate identification of young children at-risk for such conditions to assist in the provision of timely, age-appropriate interventions (Beeghly, 2006).

According to Bashir & Scavuzzo (1992), the identification of children with communication and language difficulties is best achieved by focusing on performance rather than simply making inferences about language knowledge. Children with language disorders demonstrate changes in the type and severity of difficulties over time although deficits typically persist throughout childhood and into adolescence/adulthood. The progression of language difficulties appears to move from the broad to specific aspects of language. As a result, language difficulties may not become apparent in some cases until the middle school years, particularly when content becomes more complex and greater educational demands are placed on the student.

<div align="center">Dysnomia and Expressive Language Deficits</div>

The International Statistical Classification of Diseases and Related Health Problems, or ICD-10 (World Health Organization, 2004), provides a diagnostic

classification system for conditions and a wide variety of symptoms, abnormal findings, and causes of injury or disease. According to the ICD, specific developmental disorders of speech and language are defined as:

> "disorders in which normal patterns of language acquisition are disturbed from the early stages of development. The conditions are not directly attributable to neurological or speech mechanism abnormalities, sensory impairments, mental retardation, or environmental factors. Specific developmental disorders of speech and language are often followed by associated problems, such as difficulties in reading and spelling, abnormalities in interpersonal relationships, and emotional and behavioral disorders" (p. F80).

Developmental speech and language disorders are characterized by deficits in articulation, expressive language, or receptive language, and also include a category for acquired *Aphasia*. Aphasia is a cognitive disorder marked by an impaired ability to comprehend or express language in its written or spoken form.

While different types of Aphasia exist, most fall into one of three categories: expressive, receptive, or mixed. For the purpose of this study, the review will focus more specifically on the Expressive Aphasia types. Expressive Aphasia involves problems with spelling, sentence structure, verbal reasoning, and/or the rate of speech. The most common type of Expressive Aphasia is known as *Broca's Aphasia*. With this type of Aphasia, a person is able to comprehend language but unable to produce speech fluently. Instead, words are spoken in a telegraphic manner, using single words and gestures to convey meaning. Another type of Expressive Aphasia is *Neologism*, a condition marked by grammatical confusion, inappropriate word usage, and the substitution of nonsense words for real words. *Nominal Aphasia, or Anomia*, is a type of Aphasia characterized by problems recalling words or names. More specifically, Anomia refers to word-finding difficulties which the individual, at one time, did not have. Anomia is usually caused by

brain trauma (e.g., accident, stroke, tumor, etc.) and is often a result of damage to various parts of the parietal or temporal lobe of the brain. Subjects often speak in a roundabout way in order to express a certain word for which they cannot remember the name. An individual may sometimes recall the word when provided with specific cues (semantic or phonemic). This type of dysfunction can be quite complex, and usually involves a breakdown in one or more pathways between regions in the brain.

Dysnomia is considered a milder form of Anomia and refers to a word-finding dysfunction that is developmental in nature. For example, children with Dysnomia lack and/or never develop adequate recall and word-finding abilities. This condition is characterized by difficulties with or the inability to retrieve words from memory and can impact expressive language and speech skills, writing abilities, or both. In other words, an individual may be able to describe the object in question, but cannot provide the specific target name. People with Dysnomia may replace a word with a synonym in an attempt to express their thoughts without using the word they are having difficulty retrieving. Dysnomia is the inability to retrieve the correct word from memory when it is needed, a phenomenon often referred to as the "tip of the tongue" experience (Faust, Dimitrovsky, & Davidi, 1997).

While Dysnomia is not currently classified in the DSM-IV-TR, this specific language disorder is characterized by problems with "word retrieval, object naming, and auditory memory" (Richman, 2000, p.10). Children with word-finding difficulties may only demonstrate mild symptoms during the preschool years although they may develop Dyslexia and reading impairments later in childhood. Dysnomia is associated with difficulties similar to those seen with an Expressive Language Disorder yet individuals

with Dysnomia often do not show signs of reduced verbal output. Instead, children with Dysnomia may display deficits remembering information in a sequential manner despite good expressive language skills.

Tasks requiring the perception and identification of a visual stimulus in addition to the retrieval of an associated lexical label prove to be difficult for children with language and reading disorders (McCrory, Mechelli, Frith, & Price, 2004). More specifically, some researchers have suggested that poor readers experience distinct difficulties in rapidly accessing and retrieving verbal labels for visually presented stimuli (Savage, Pillay, & Melidona, 2007; Denckla & Cutting, 1999; Wolf & Bowers, 1999). Word finding difficulties are thought to occur when problems with word production are greater than would be expected given an individual's word knowledge and comprehension abilities (Messer & Dockrell, 2006). In other words, children and adults with Dysnomia often display a discrepancy between their ability to comprehend and produce words.

<div align="center">Diagnosis and Assessment of Retrieval Difficulties</div>

While adult assessments are typically conducted with individuals who have received an injury to the brain after a course of normal development, assessments administered to children must address how an injury or developmental abnormality has impacted the immature brain in the process of organizing itself and acquiring a repertoire of skills (Roman, 2004). Cognitive functions are more well-developed and localized in an adult brain, making it potentially easier to identify the location of an injury by determining the specific functions that are impaired. However, the relationship between brain and behavior is less direct with children. Problems relating neuropsychological

deficits to brain regions are compounded by additional factors that include the exact time or onset of dysfunction, pre-morbid levels of functioning, and environmental variables (e.g., family stresses or resources) (Aylward, 1988; Tramontana & Hooper, 1988). Based on these complexities, neuropsychological assessments of children typically emphasize the cognitive and behavioral profiles as well as implications for treatment rather than localization of a brain lesion.

Lesions to the dominant hemisphere involving the language areas, in particular the temporal lobe, are thought to be involved with the presence of Anomia in adults, making the use of neuropsychological assessments beneficial. Using a neuropsychological approach with children allows researchers to gain a better understanding of the specific mechanisms involved with language and reading impairments although the focus is not specifically focused on identifying brain abnormalities (Habib, 2000). Instead, Messer and Dockrell (2006) argue for the use of cognitive-models (Levelt, 2001) in the assessment of children with expressive language impairments to more clearly conceptualize the unique nature of word-finding difficulties. Findings from research that use these cognitive models can help to identify the associations between behavioral processes and brain substrates. Furthermore, determining the component processes involved with word-retrieval abilities will allow a more precise localization of the cognitive processes that cause the difficulty. Adhering to a cognitive model of assessment addresses the question of whether word-finding and retrieval difficulties in children can be viewed as an isolated difficulty or a by-product of other language disabilities.

When assessing children with word finding difficulties, multiple measures of expressive language should be used to better understand the nature of the Dysnomia. For example, Rapid Automatized Naming (RAN; Denckla & Rudel, 1976) is a commonly administered measure that times how quickly the patient can name familiar visual stimuli (e.g. common colors, objects, letters, and numbers). Completion times are compared against the average times for the patient's age group to determine the level of deficiency. While RAN measures the individual's ability to rapidly name visually presented material, two other tests of expressive language that are commonly used include the Boston Naming Test (BNT) and Word Fluency (commonly referred to as the F-A-S Test). The BNT is a measure of confrontation naming while the Word Fluency test assesses verbal fluency and word retrieval abilities. Documenting performance on multiple measures of expressive language would allow clinicians to more specifically identify the extent and nature of Dysnomia in children, particularly as it pertains to academic performance.

<p style="text-align:center">Links between Dysnomia and Dyslexia</p>

Several decades of research have consistently pointed to the strong relations between reading and serial naming tasks (see review by Bowers, Golden, Kennedy, & Young, 1994). Wolf (1984) has argued that naming and reading tasks involve shared processes that include the perception, recognition, and sequencing of visual symbols, access and retrieval of verbal labels, attention, and articulation. In particular, previous studies have found that deficits in rapid naming and expressive fluency are associated with reading disabilities in children (Vellutino et al., 1994). One component of these difficulties involves the slowing of verbal expression which impacts verbal fluency and potentially comprehension (Adams, 1990), while the other component of these deficits is

related to difficulties with retrieving verbal labels, thus creating problems with efficient word labeling in reading (Vellutino et al., 1996).

Previous studies have also substantiated the relationship between a visual memory deficit and reading disabilities, reiterating that difficulties in the efficient naming or labeling of visual stimuli is a strong predictor for Dyslexia (Wood et al., 1989; Adams, 1990; Vellutino, 1996). Memory for visual information may be impaired due to the inefficient verbal labeling of visual stimuli which often results in Dysnomia. Difficulties with rapid naming have been found in children who display impaired reading skills (Bowers & Wolf, 1993). More specifically, researchers suggest that many children who experience reading delays also display significant deficits in rapidly accessing and retrieving verbal labels for visually presented stimuli (Denckla & Cutting, 1999; Wolf & Bowers, 1999). According to the rapid automatized naming (RAN) theory, a common factor is thought to underlie the processes used for speeded naming and the representations of words encoded in the lexicon during reading acquisition (Savage et al., 2007).

In their review of the relevant literature on lexical access and retrieval difficulties in children, Messer and Dockrell (2006) reiterated that the heterogeneous nature of language impairment in children, making it a challenging issue for researchers and clinicians to address. While researchers have attempted to create "sub-groups" of difficulties, relatively little attention has been paid to lexical dimensions such as word retrieval. Nevertheless, previous research has speculated that the cognitive processes causing retrieval difficulties refer to semantics (word meaning), phonology (letter-sound associations), and processing speed.

Conclusions

Due to the importance of word-retrieval and naming in language processing and cognitive development, as well as its predictive power for reading and school performance, this is an important area for further research (Messer & Dockrell, 2006). Establishing a more comprehensive diagnostic profile of the processes involved with Dysnomia will enhance the understanding of successful versus deficient word retrieval abilities in children. In addition, gaining a more complete understanding of the processes involved with word retrieval and naming tasks will assist clinicians by allowing a more accurate and precise localization of the "cognitive processes that cause the difficulty and will address the question of whether word-finding difficulties can be viewed as an isolated difficulty or a by-product of other language disabilities" (Messer & Dockrell, 2006, p. 310).

Several studies have examined the nature of word finding and rapid naming difficulties, particularly within the context of developmental Dyslexia and specific language impairments. Some models of Dyslexia identify reading impairments as being caused by Dysnomia and propose that word retrieval deficits contribute to difficulties with short-term memory, thus resulting in poor word recall when reading (Richman & Ryan, 2000). While the relationship between rapid naming deficits and Dyslexia are well established in the literature, few empirical investigations have studied the multi-componential nature of Dysnomia outside the context of reading disabilities, especially with school-aged children.

With regard to naming difficulties, a uniform and consistent definition of "Dysnomia" is lacking in the literature. For example, various researchers postulate that

dysnomic-like behaviors pertain to deficits in rapid naming, naming access speed, lexical retrieval, or word finding processes. Furthermore, other researchers conceptualize Dysnomia as existing within the context of other learning disabilities (Wiig, Semel, & Nystrom, 1982; German 1985, 1987). This lack of consistency makes it difficult to determine how different authors are viewing expressive language deficits within the framework of Dysnomia. For the purpose of this study, Dysnomia is conceptualized as a marked difficulty or impairment in object naming, word retrieval, and short-term auditory memory. This definition seems to most closely align with definitions of Dysnomia used in the neuropsychological measures included in this study. As will be discussed in more detail later, symptoms of Dysnomia will be measured by the Rapid Automatized Naming ([RAN] Denckla & Rudel, 1976), Boston Naming Test ([BNT] Kaplan, Goodglass, & Weintraub, 1983), and Word Fluency test ([F-A-S Test] Spreen & Benton, 1969).

Research suggests that it is difficult to determine the specific origin of expressive language and word-finding difficulties within a developmental context. In order to better understand the impact of impairments on different cognitive processes involved with expressive language abilities, a systematic comparison of Dysnomia and the word finding process in children both with and without Dyslexia may help to better understand the hypotheses of impaired phonological or semantic representations in this population. More specifically, there is a need for more comprehensive and in-depth studies of the performance of subgroups of children with disabilities. By examining the neurocognitive profile of children with Dysnomia both with and without Dyslexia, advances can be made in determining whether Dysnomia represents a pre-cursor to developmental Dyslexia, is a by-product of another language impairment, or is a separate entity. Gaining a better

understanding of the unique nature of Dysnomia in school-aged children will allow clinicians to more adequately determine where to target educational interventions when working with children and their families. Psychologists are in a unique position to administer comprehensive evaluations of children with expressive language difficulties and make appropriate treatment recommendations. By exploring these specific questions and gaps in the existing research literature, we can begin to better understand the nature of expressive language deficits in children and, thus, tailor interventions for these children before the difficulties become more long-standing and impairing.

While previous studies have substantiated the relationship between memory deficits and reading disabilities, and researchers assert that difficulties in efficiently naming or labeling visual stimuli is a strong predictor for Dyslexia (Wood et al., 1989; Adams, 1990; Vellutino, 1994), a limited number of studies have specifically examined the incidence of Dysnomia, particularly outside the context of reading and language impairments. Therefore, the purpose of the current study is to clarify the nature of cognitive deficits experienced by children with Dysnomia. More specifically, the study examined the different types of expressive language deficits (verbal fluency, confrontation naming, rapid naming) displayed by children with Dysnomia in an effort to determine what type of expressive language deficits are associated with Dyslexia, a developmental reading disorder.

CHAPTER II

REVIEW OF THE LITERATURE

The following chapter provides a comprehensive review of research related to expressive language and word retrieval difficulties in children. This review will be outlined according to several important themes within the literature and relevant to the current study. Following a brief examination of pertinent research on language acquisition and developmental language disorders in children, the review will highlight some of the most important findings pertaining to expressive language deficits in children. The characteristics and identification of word-finding difficulties will be discussed, followed by the presentation of a lexical access model. Possible causes for Dysnomia will be presented and, more specifically, the relationship between expressive language deficits and reading ability will be explored. Finally, existing literature relevant to the unique nature of Dysnomia will be discussed, particularly as it pertains to the presence or absence of reading impairments.

Developmental Language Disorders in Children

The existing research on developmental language disorders in children focuses on a number of different areas. For the purpose of providing a context for understanding for this study, a brief overview of the early language acquisition process will be examined. Next, the components of typical language development will be highlighted and impact of early language impairments discussed. Finally, the implications of impaired language abilities and model of Developmental Dyslexia are reviewed below.

Early Language Acquisition

During early language acquisition, multiple processes are developed and used. In particular, visual and linguistic coding processes are activated to facilitate the storage of representations for written words and assist with language acquisition and the use of language for coding, storing, and retrieving information, respectively (Vellutino, Fletcher, Snowling, & Scanlon, 2004). Together the visual and language coding processes work to establish associations between the written (visual) and spoken (verbal) parts of printed words. Through this associative learning process, an individual obtains an understanding of print concepts and conventions. More specifically, linguistic tasks involve a number of complex processes in order to accurately identify and manipulate speech sounds and/or name common objects on demand (Savage & Frederickson, 2006).

Throughout the language acquisition process, individuals strive to build phonological-orthographic connections between orthographic patterns, sounds, and phonemes or syllables to support word identification skills (Adams, 1990)**.** Phonological awareness refers to an understanding of the sound structure of language, which is fundamentally necessary for the successful acquisition of reading skill (Noble & McCandliss, 2005). Knowledge of letter names helps a child learn the alphabetic principle that a letter represents a sound (phonological awareness); when a child is able to identify the names and sounds associated with different letters quickly, details of letter sequences can be attended to thus building an orthographic pattern (Adams, 1990). In typical development, children acquire language in a rapid and predictable sequence (Beeghly, 2006).

A solid theory of language acquisition needs to explain a range of developmental processes (Savage et al., 2007). In other words, interpreting variations in performance, identifying cognitive processes involved, and describing those mechanisms shared with and distinct from more general reasoning abilities should be done from a developmental perspective (Savage et al., 2007). The assessment of language ability requires the use of multiple domains including intelligence, listening comprehension, reading comprehension, spelling, and phonemic/phonological awareness (Bell, McCallum, & Cox, 2003). For example, with regard to reading abilities, it is important to examine the inter-relationships among cognitive processing variables and their relationship to reading skills. Different factors should relate to one another in a way that is consistent with their function (e.g., expressive language), and the data showing these relationships should help with the development of appropriate assessment and test interpretation strategies (Bell et al., 2003).

The developmental literature suggests that, during early stages of language acquisition, phonological representations are holistic rather than organized into a series of phoneme-like units (Truman & Hennessey, 2006). Early reading abilities are tied to phonological memory and retrieval as well as word recall and naming ability (Richman, 2000). Reading requires the ability to map between the distinct sounds in words and specific letter combinations (Noble & McCandliss, 2005). Since written letters are encoded representations of spoken words, the acquisition of different types of knowledge and skills is required to adequately learn to read (Vellutino et al., 2004). The order of language acquisition for children with language and learning difficulties mirrors that of

non-affected children although the process occurs more slowly and over an extended period of time (Bashir & Scavuzzo, 1992).

In recent years, a shift toward examining developmental models of childhood language disorders has occurred (Richman & Wood, 1999). Over the course of development, segmented structures emerge to compensate with the storage and retrieval needs of a growing vocabulary, a process that is thought to be delayed and/or impaired in children with Dyslexia. Components of the reading process change and develop as an individual matures and, often times, generalizations are made regarding performance on naming tasks with little specificity and attention to developmental changes (Wolf & Goodglass, 1986). When viewing these constructs from a developmental perspective, additional complexities arise because linguistic functions change over time. Furthermore, studies suggest that attention and memory systems improve with age (Morris, 1996).

<div style="text-align:center">Developmental Model of Dyslexia</div>

Researchers have demonstrated that early language difficulties may lead to later reading impairments although the manifestations of deficits are not necessarily the same at a cognitive or genetic level (Bishop & Snowling, 2004). One of the most common developmental problems seen in children is underachievement in reading and spelling. Despite average intelligence, adequate reading experience, and no known genetic or neurological condition, these children demonstrate significant difficulties learning to read compared to their peers (Snowling, 2000). Developmental Dyslexia has been defined as a "specific and significant impairment in reading abilities, unexplainable by any kind of deficit in general intelligence, learning opportunity, general motivation, or sensory acuity" (World Health Organization, 1993, p. 2,374). In general, children with Dyslexia

perform relatively poorly on cognitive tests of phonemic awareness, phonological skills, sound blending, rapid automatized naming, auditory memory, certain types of visual memory, and decoding of nonsense words, while performance on cognitive tests of verbal and nonverbal reasoning and visual-spatial abilities is better (Bell et al., 2003).

A number of different hypotheses for the learning problems underlying Developmental Dyslexia exist and many theories have been developed (behavioral, cognitive, neural levels) to explain the difficulties associated with poor spelling and reading (Savage, 2004). Some conceptualizations of Dyslexia assert that this disorder is fundamentally linked to characteristics in the brain (Habib, 2000). In particular, due to the prevalence of oral and written language deficits that accompany Dyslexia, a vulnerability of the left-hemisphere cortical systems sub-serving various aspects of language-related abilities is suspected.

In summary, the developmental research posits that early language acquisition involves multiple processes, and the activation of the visual and linguistic coding processes are emphasized to facilitate the storage of words and use of language. During development, children build phonological-orthographic connections between many different patterns, sounds, and phonemes to support word identification skills. Due to the complex nature of early language abilities, researchers recommend incorporating measures that assess multiple domains including intelligence, listening comprehension, reading comprehension, spelling, and phonemic/phonological awareness to gain a more accurate and comprehensive understanding of a child's specific areas of strength and weakness. Furthermore, researchers have demonstrated that early language difficulties may lead to later reading impairments, meaning that various skills associated with

reading development should be considered when children display expressive language deficits. Given this brief review, it is now appropriate to consider the research on the specific childhood language development concerns of Dysnomia and word-finding difficulties.

<div align="center">Nature of Dysnomia in Children</div>

The previously described literature provides a brief introduction to the research base surrounding developmental language and communication disorders in children. The following review and presentation of studies focuses more specifically on Dysnomia and word-finding difficulties in children. The characteristics and identification of Dysnomia will be discussed, followed by the presentation of a relevant model of word retrieval. Possible causes for Dysnomia will be highlighted including deficits in semantic representations, phonological representations, and speed of processing. Finally, the presence of Dysnomia within the context of learning, language, and reading disabilities will be presented to highlight the gaps in the current research pertaining to the unique nature of Dysnomia in children.

<div align="center">Overview of Dysnomia in Children</div>

Research has documented that children with learning disabilities display naming and word retrieval difficulties as well as a decrease in verbal fluency (Wiig & Semel, 1975, 1977). According to Wolf and Goodglass (1986), a number of processes are involved in word retrieval and naming tasks and some common explanations for retrieval difficulties include visual perceptual deficits, memory problems, vocabulary deficits, and rate deficiencies. For instance, verbal mediation has been postulated to underlie retrieval failure in a majority of individuals with Dyslexia. Rapid naming tasks seem to require the

coordination of attention, perceptual, conceptual, memory, lexical, and articulatory sub-processes (Savage et al., 2007; Bowers & Wolf, 1993; Wolf, 1991; Wolf, Bowers, & Biddle, 2000).

Dysnomia is associated with difficulties similar to those seen with an Expressive Language Disorder yet individuals with Dysnomia often do not show signs of reduced verbal output. Instead, Dysnomic children may display deficits with remembering information in a sequential manner despite good expressive language skills. Tasks requiring the perception and identification of a visual stimulus in addition to the retrieval of an associated lexical label may also prove to be difficult for children with language and reading disorders (McCrory et al., 2004). More specifically, some researchers have suggested that poor readers experience distinct difficulties in rapidly accessing and retrieving verbal labels for visually presented stimuli (Savage et al., 2007; Denckla & Cutting, 1999; Wolf & Bowers, 1999).

Deficits in language processing and the production abilities of learning-disabled children are thought to be attributed to cognitive-linguistic processing deficits and Dysnomia, or word finding difficulties (Wiig & Semel, 1977). Children with language difficulties may demonstrate Dysnomia characterized by difficulties in short-term auditory memory, word retrieval, and rapid object naming (Richman, 2000). Furthermore, subtle Dysnomia frequently coincides with reading impairments (Denkla & Rudel, 1976; Wolf & Goodglass, 1986).

In summary, multiple processes are thought to contribute to word retrieval and naming difficulties. Some common explanations for word finding problems include visual-perceptual deficits, memory problems, vocabulary deficits, and rate deficiencies.

Similarly, researchers consistently assert that language impairments are associated with reading problems. While there appears to be some agreement regarding the complex nature of rapid naming and word retrieval, little consensus exists regarding the distinct nature of Dysnomia, particularly in children. The specific characteristics associated with word finding difficulties and identification of Dysnomia will be discussed in the next section.

<p style="text-align:center">Characteristics and Identification of Dysnomia</p>

As previously mentioned, Dysnomia is often used to refer to individuals who have naming or word-retrieval difficulties that are severe enough to impact aspects of daily functioning. The word naming process can be influenced by a number of factors including word frequency, age of language acquisition, and type of word (Newman & German, 2002). In some instances, word finding difficulties are a result of poor vocabulary or a lack of exposure to certain words (Messer & Dockrell, 2006). In the following sections, studies of children diagnosed with lexical retrieval difficulties will be presented. More specifically, performance will be examined for children who display significant difficulty producing words they are able to accurately identify in comprehension assessments compared with their chronological-age (CA) peers.

In studies that used a story-telling paradigm to assess the word-retrieval abilities of children diagnosed with Dysnomia compared to CA-matched children, German and her colleagues found that children with word-finding difficulties (WFD) produced significantly fewer words and displayed significantly impaired lexical access abilities compared to controls (German, 1987; German & Simon, 1991). The clinical pattern that was observed involved both an inability to generate the appropriate word and the use of

alternative behaviors, such as unnecessary repetitions or word substitutions, to compensate for the Dysnomia. Despite findings such as these, questions still remain about the extent to which these various word-retrieval deficits constitute a distinct condition that is influenced by a single, cognitive mechanism or represent a by-product of other language and learning difficulties (Tingley, Kyte, & Johnson, 2003).

Previous research indicates that different neurological systems are involved on discrete picture-naming tasks (i.e., confrontation naming) compared to serial-picture naming tasks (e.g., Rapid Automatized Naming [RAN], Denckla & Rudel, 1976; Rapid Alternating Stimulus [RAS], Wolf, 1986). According to Wiig, Zureich, and Chan (2000), poor performance on tasks involving confrontation naming seems to be associated with the parietal and frontal lobes while serial-naming tasks access the left anterior and inferior frontal areas of the brain (Jacobsen, Nielsen, Minthon, Warkentin, & Wiig, 2004; Wiig, Neilsen, Minthon, McPeek, Said, & Warkentin, 2002). Based on these findings, it is unclear whether the processes underlying different expressive language tasks constitute separate patterns of naming difficulties or components of a single process.

Lexical Access Models and Word-Finding Processes

A number of separate processing components are thought to be involved in the word retrieval process. While a multitude of adult processing models exist, they may not be adequate for the assessment and identification of word-finding difficulties with children. To date, no developmental models of lexical retrieval and access have been established (Dockrell & Messer, 2004) meaning that current conceptualizations of Dysnomia in children are largely informed by adult processing models. Simply adapting an adult model of lexical processing may not directly address the unique questions that

arise within a developmental context (Thomas & Karmiloff-Smith, 2002). Hence,

Dysnomia has been under-researched from a developmental perspective making this an

important area of focus for the current study.

Models of lexical retrieval suggest that multiple facets of stored knowledge about

words are called upon in the process of producing words including word meaning,

syntactic properties, morphological composition, and sound structure (Indefrey & Levelt,

2000; Levelt, 1999). Incorporating such models into the diagnostic evaluation of children

with word-finding difficulties may help to distinguish the sub-processes utilized in lexical

retrieval by identifying the underlying impaired mechanisms (Faust, Dimitrovsky, &

Shacht, 2003). Models of naming suggest that lexical access proceeds in two distinct

steps with semantic and phonological codes being processed independently of one

another, indicating that different brain areas are being used (Indefrey & Levelt, 2000).

Semantic representations refer to those codes pertaining to the meaning of language while

phonology defines the letter-sound associations involved in language production. The

lexical retrieval deficit could be a result of a disconnect between semantic and

phonological codes, implying that the target word is selected yet the appropriate

phonological code of the word fails to be recognized and activated (Faust, Dimitrovsky,

& Shacht, 2003).

A two-stage model of lexical access has been proposed by Levelt, Roelofs, and

Meyer (1999). Lexical access refers to the process by which information about words is

retrieved from memory and mapped to a lexical concept on an articulatory program. The

process of word production is started by the intent to produce a word. Activation of the

conceptual representation of the word first occurs in the semantic system before

attempting to retrieve a lexical-semantic representation that triggers lexical items into action. The two stages of lexical access include (1) lexical selection, or the retrieval of an appropriate word which makes the semantic and syntactic information available and (2) phonological encoding in which the stored phonological form of a word is accessed and input results in speech production.

Researchers have recently focused more explicitly on the semantic (lemma) and phonological (lexeme) frameworks to better analyze the nature of word-finding difficulties of children (Faust, Dimitrovsky, & Davidi, 1997). Based on the knowledge gained from studying adult models of naming, word-retrieval deficits in children may be a result of faulty semantic or phonological representations that interfere with fast and accurate lexical retrieval (Messer & Dockrell, 2006). Therefore, assessments of children should consider the accuracy of responses, patterns of errors, and speed of word retrieval. Working within a developmental framework requires that specific factors, such as speed of information processing and developmental parameters of language acquisition be taken into consideration; thus, a broader, more general conceptualization of the process may be needed (Thomas, 2003). In the following section of the review, possible causes of Dysnomia will be explored, including the differential role of semantic and phonological representations.

<div align="center">Possible Causes of Dysnomia</div>

Within the framework of the previously discussed model of lexical access, some possible reasons for word finding difficulties include disruptions in the lexical selection or phonological processes. As a result, researchers have recently focused more explicitly on the semantic and phonological frameworks to better analyze the nature of word-

finding difficulties of children. According to Wolf and Goodglass (1986), a number of

processes are involved in word retrieval and naming tasks and some common

explanations for retrieval difficulties include visual perceptual deficits, memory

problems, vocabulary deficits, and rate deficiencies (Wolf & Goodglass, 1986).

Moreover, word-retrieval tasks seem to require the coordination of attention, perceptual,

conceptual, memory, lexical, and articulatory sub-processes (Savage et al., 2007; Bowers

& Wolf, 1993; Wolf, 1991; Wolf, Bowers, & Biddle, 2000). In order to conceptualize the

unique nature of Dysnomia, common hypotheses regarding the locus of word-finding

difficulties will now be explored.

Semantic Representations

       According to models of adult word production, the processing of semantic

information occurs at the lemma level (Levelt et al., 1999). The association between

semantic representations and word-finding difficulties has been examined through the

study of semantic errors, semantic priming, the ability to produce definitions, and

semantic fluency. With regard to naming errors, research documents the assumption that

semantic errors are a result of incomplete semantic representations while phonological

errors are likely a result of phonological representations that are inadequate (Messer &

Dockrell, 2006). The most frequently encountered type of naming error in children with

Dysnomia is semantic errors (Rubin & Liberman, 1983).

       McGregor (1997) conducted a study examining the performance of preschoolers

between the ages of 3:3 and 5:9 years, with and without word-finding deficits.

Participants completed three different tasks requiring word finding that included two

subtests from the Test of Word Finding (noun-naming and verb-naming) and a story

retelling task. While the error profiles of the two groups were similar, semantic rather than phonological errors were the most common type of error made for both groups. Nevertheless, children with word-finding deficits displayed a higher rate of errors. Results from this study seemed to suggest that the differential proportions of semantic versus phonological substitutions constitutes developmental evidence for lemma and lexeme distinctions as proposed in adult-based models of lexical storage. Furthermore, the predominance of semantic errors produced by participants indicates the early organization and storage of lexical information. However, children with word-finding difficulties may simply have a less well-developed language system compared to typical language-learning controls that results in a higher rate of errors.

Dockrell, Messer, and George (2001) found similarities between the performance of children with word-finding deficits compared to both language-age (LA) and CA-controls on naming tasks. In particular, the amount of errors made by children with word-finding difficulties and the LA controls was similar, while both groups performed significantly worse than CA controls. These results reiterate that semantic errors were the most frequently encountered type across all groups, and no significant groups differences were found in the proportion of semantic errors made. Based on these findings, semantic errors while naming objects are common across all groups of children and do not appear to specifically differentiate between groups; thus, the origin of semantic errors is not entirely clear.

Semantic errors may occur due to a failure to access the target phonological representation of a word, resulting in the activation of a related semantic-phonological code (McGregor, 1994). In other words, semantic errors may arise when the causes of

retrieval difficulties are at the phonological, or lexeme, level. Examining different types

of naming actions or the effects of semantic priming for children may also provide some

additional insights into the source of semantic errors. With regard to naming actions,

differences between children with WFD compared with LA and CA controls have been

documented (Dockrell et al., 2001). For example, Dockrell and her colleagues (2001)

found that children with word-retrieval deficits produced fewer errors when verbs were

closely related to the target and, instead, had a tendency to produce more general or

inappropriate verbs. McGregor (1997) also reported that, when children with word-

finding difficulties were naming verbs or actions words, fewer "I don't know" responses

were noted.

In an effort to more closely examine the processing of semantic information,

McGregor and Windsor (1996) studied the effects of semantic priming. The performance

of eight children with word-finding (WF) deficits (ages 3:8-5:9 years) was compared to

eight CA-matched and eight adult controls with normal word-finding on naming tasks

under primed and unprimed conditions. Participants were asked to name a total of 40

pictured objects, each which could be correctly labeled with a simple noun or a

compound (e.g., cane or walking stick). The primed condition involved semantic

(meaning) primes for both the simple and compound targets as well as a partial lexical

(phonological) prime for the compound targets. Results indicated that naming errors

decreased across groups when primes were provided although the primes did not allow

the children with WF difficulties to fully compensate. The gap between the error rates of

the WF group and the two control groups was not reduced in the primed condition and

the quality of errors made by the WF group did not improve in response to primes. These

findings suggest deficiencies in lexicon size, elaboration, and/or organization skills in children with WFD.

In a later study conducted by McGregor and Waxman (1998), no group differences were found in the pattern of accuracy or errors despite using a technique of questioning designed to investigate the differential nature of semantic representations. However, children with word-retrieval deficits displayed more "I don't know" responses and errors. Although small sample sizes were used with both investigations, neither one of these studies provided adequate support for the notion that children with WFD have an impaired semantic system compared to CA controls.

In order to test the hypothesis that deficient lexical storage abilities play a role in the naming problems associated with language impairments, the naming and drawing responses of a child with specific language impairments (SLI) were used (McGregor & Appel, 2002). On tasks measuring confrontation and repeated naming skills, the participant demonstrated frequent semantic substitutions and occasional phonologic substitutions. Comparative picture naming and picture drawing performances revealed that some semantic naming errors were due to sparse semantic representations while others were a result of sparse phonological input and output representations. Phonological naming errors, in contrast, were typically associated with strong semantic representations. Overall, McGregor and Appel (2002) concluded that the naming errors of children with specific language impairments appear to be associated with less detailed representations.

Through the use of word production tasks, such as verbally defining words, Dockrell, Messer, George, and Ralli (2003) demonstrated that children with WFD produced a comparable number of adequate definitions when compared to CA and

naming age peers. While the generation of definitions was similar across groups, children with WFD provided significantly less accurate definitions, particularly for object names. Dysnomic children appeared to have a difficult time retrieving features pertaining to the semantic category while they were able to access a higher proportion of descriptors regarding an object's appearance. These findings suggest the possibility that mode of presentation and response may impact performance for children with word-finding difficulties. Due to the verbal nature of the required responses, it is difficult to definitively conclude the impact that this mode of responding may have had on performance.

Another way to examine the role of semantic (and phonological) representations on the word-retrieval process is to assess children's serial free recall or fluency skills. Tasks measuring the word retrieval and recall of information typically ask the child to generate as many words as possible that correspond to an identified target (e.g. words beginning with a certain letter or pertaining to a specific category). Performance on this type of task, such as the Word Fluency test, is likely to provide additional information about the strength of links among different elements within the lexical system.

In their study, Messer, Dockrell, and Murphy (2004) required children with WFD to generate as many words as possible within a specified amount of time using items from the Phonological Assessment Battery (PhAB: Frederickson, Frith, & Reason, 1997). Researchers examined word retrieval for items in the same semantic domain (semantic fluency), with the same initial phoneme (alliteration fluency), and the same rhyme (rhyme fluency). Results indicate that children with WFD performed better on phonological tasks (alliteration and rhyme fluency) compared to their performance on the

semantic fluency tasks. One possible explanation for these findings is that children with WFD performed poorly on semantic tasks not containing a phonological component because the networks of connections between semantic elements in the lexicon were less sophisticated than those of other children and less developed than their phonological representations. Greater difficulties with semantic fluency tasks compared to alliteration and rhyme fluency may suggest that these findings were not simply a result of general retrieval deficits.

Other studies have examined the nature of semantic deficits in a group of children defined as *poor comprehenders* in an effort to better understand the nature of semantic difficulties. According to Nation, Snowling, and their colleagues, *poor comprehenders* are those children with intact phonological skills who display impaired performance on tasks of discrete picture naming in addition to poor comprehension skills, difficulties with contextual facilitation when reading, and deficient semantic priming in a lexical decision making task (Nation, Marshall, & Snowling, 2001; Nation & Snowling, 1998; Nation & Snowling, 1999). Results from this collection of studies suggest that children described as poor comprehenders display similar patterns of semantic errors compared to children with word-finding difficulties. Furthermore, children with semantic-based comprehension difficulties also demonstrate slower and more inaccurate naming abilities. Children described as *poor comprehenders* have also been found to display adequate standardized scores on decoding and phonological awareness tasks while lower scores on tasks measuring semantic fluency and naming (Messer et al., 2004). Overall, these findings suggest that there may be similar underlying deficits in children with WFD and those individuals described as *poor comprehenders*.

In summary, some research suggests that word-finding difficulties may originate at the lemma, or semantic, level. Children with WFD have been found to display subtle problems with verb usage, defining words, and semantic generation compared to CA controls. However, the evidence found for children with WFD making significantly more semantic errors across research studies in relation to CA and LA controls is not definitive. These findings suggest that there is a need for assessments of expressive language deficits to incorporate differential modes of responding and presenting information rather than solely focusing on the use of verbal processes. Furthermore, multiple measures should be used to examine a cognitive domain (e.g. expressive language) to more accurately pinpoint the nature of the impairment. As a result, these components were incorporated into the design of the current study. In particular, differential modes of responding and multiple measures of expressive language were used during the diagnostic assessment of the sample.

<u>Phonological Representations</u>

While a number of studies suggest that impoverished semantic representations contribute to word-finding difficulties in children, other researchers have found evidence to suggest that expressive language deficits occur at the lexeme, or phonological, level.

Recent studies have built upon the findings of earlier single case designs by investigating larger samples of children with word-finding deficits. In particular, two larger studies have specifically examined the lexical access process, nature of word substitutions, and error patterns in this group of individuals (German & Newman, 2004; Newman & German, 2002). For instance, Newman and German (2002) studied the influence of lexical factors known to impact lexical access in adults on the word retrieval

processes of children. The lexical factors examined were word frequency, age-of-acquisition, and stress pattern. Participants included 320 typical and atypical (word-finding difficulties) language-learning children, ranging in age from 7 to 12 years. Results from this study suggest that various lexical factors influence the lexical accessing process in children. Words that were higher in frequency (e.g., more familiar), acquired at an earlier age, and which contained the typical stress pattern for the language were easier for children to name. Significant interactions indicate that age-of-acquisition effects decreased with maturation for typically-learning children whereas these effects continued to impact lexical access of children with WFD across the ages studied. These findings suggest the possibility that word-finding and retrieval difficulties in children may prevent them from developing strong access paths to these words, which subsequently leads to further expressive language and possible reading deficits.

In a retrospective, exploratory investigation, German and Newman (2004) examined the types of target words that children with WFD had difficulty naming and the types of errors made. Subjects included 30 children with WFD between the ages of 8 to 12 years. Findings indicated that successful word-finding was predicted by word frequency, and both target word substitutions and error patterns were affected by the lexical factors being examined in the study including age of acquisition and familiarity. More specifically, participants had the tendency to produce substitutions that were higher in frequency and learned earlier than the target words. Results from this examination of how various lexical factors impact word-finding errors in children suggest that different types of words are more likely to result in failures of lexical access at different stages of

processing. Therefore, when assessing children with WFD, it seems necessary to consider the potential impact of specific lexical factors on performance.

Findings from these studies suggest that lexical factors may influence an individual's ability to accurately name stimuli, the substitutions used, and type of errors made. While some children in these studies were able to access the semantic representation of words, difficulties at the phonological level were documented. Researchers speculate that impoverished phonological representations may impact performance or difficulties may arise because of organizational features of the phonological lexicon that prevent access to the complete phonological representation of a target word (German & Newman, 2004). The inability to adequately retrieve words seems to correspond with the "tip-of-the-tongue" phenomenon in which difficulties are thought to arise at the phonological level of representation rather than the lemma, or semantic, level. More specifically, blocked responses appear more common in words that are less familiar and "might indicate that such errors occur when listeners fail to gain access to the appropriate region of the lexical space" (German & Newman, 2004, p. 631).

As children continue to develop and mature, significant changes in phonological representations take place. While the progression of language acquisition for children with WFD mirrors that of non-affected children, the process occurs more slowly and over an extended period of time (Bashir & Scavuzzo, 1992). Furthermore, children with language disorders demonstrate changes in the type and severity of difficulties over time and the progression of language difficulties appears to move from the broad to specific aspects of language. According to the lexical restructuring hypothesis, representations in the lexicon gradually become more segmented, particularly between the ages of 1 and 8

years (Metsala, 1997). Restructuring is thought to occur on an item-by-item basis starting with high-frequency words.

In summary, the more frequently information is retrieved from the lexicon, the stronger the connections between cognitive processes. Therefore, the errors of children with WFD at the lexeme, or phonological, level may reflect reduced experience with retrieving these specific lexical items. As previously mentioned, when children learn more words, lexical representations become less holistic and more segmented (Bashir & Scavuzzo, 1992). Because phonological awareness and decoding abilities are often relative areas of strength in children with WFD (Messer et al., 2004), it seems doubtful that impaired phonological processing and representations are the sole causal mechanism of children's difficulties. Clearly, interpretations of phonological errors require additional study and appropriate comparison groups are needed to more accurately identify the source of Dysnomia, particularly with children not displaying impaired reading abilities.

Slower Speed of Processing

In addition to reviewing the possibility that word-finding difficulties stem from inadequate semantic and/or phonological representations, speed of processing represents an integral component of language impairments in children. Several studies have reported that children with word-retrieval problems perform slower on tasks of naming compared to controls groups.

In a study conducted by German (1985), the word-retrieval abilities of Dysnomic children (defined as learning disabled children with word-finding deficits) were compared to LD children without WFD with regard to the naming of letters, numbers, and colors. Results indicated that, when asked to name stimuli with more complex

semantic representations (e.g. colors), children with WFD were slower compared to CA controls. However, Dysnomic children did not demonstrate naming difficulties when naming letters and numbers, which are considered to have minimal semantic content. Furthermore, more errors and secondary characteristics were noted for Dysnomic children when naming colors and letters, but not numbers.

In a follow-up study, German (1987) examined the word-finding skills of Dysnomic children (defined as learning disabled children with word-finding deficits) compared with those of LD and normal children without word-finding difficulties when naming letters, numbers, and colors. Each group consisted of nine Caucasian males between the ages of 8 to 12 years. Comparisons of word finding skills between groups and conditions were made with respect to completion time, errors, and secondary characteristics. Dysnomic children manifested significantly more errors and longer completion times on letter and color naming while performance was similar to controls on number naming tasks. LD children demonstrated comparable performance to the normal controls when naming colors, letters, and numbers. Overall, these findings indicate that children with Dysnomia were significantly slower on naming tasks than children without word-finding difficulties. While research has consistently documented the higher incidence of males with reading and expressive language difficulties compared to females, results from this study should be interpreted with caution due to the absence of females from the sample.

There is growing evidence to support the notion that processing speed is a reliable predictor of developmental difficulties, including reading and literacy problems (Savage et al., 2007). In particular, some studies have sought to clarify the nature of cognitive

difficulties in below-average readers by examining a range of variables thought to be associated with word-finding abilities such as rapid naming, phonological awareness, nonsense word reading, motor-balance automaticity, and working memory. For instance, Catts, Gillespie, Leonard, Kail, and Miller (2002) investigated the role of speed of processing, rapid naming, and phonological awareness in reading achievement. Group comparisons indicated that poor readers were proportionally slower than good readers across response time measures and on the rapid object naming task. Results suggest that some poor readers have a general deficit in speed of processing, and difficulties in rapid object naming may partly reflect this deficit. Further analyses demonstrated that speed of processing explained unique variance in reading achievement.

While research is inconsistent, findings seem to support the notion that Dysnomic children are typically slower on naming tasks than comparison groups and, more specifically, perform poorly on tasks that involve the naming of semantically complex stimuli (e.g., colors, objects) rather than all stimuli. Based on these findings, additional studies are needed to confirm the specific nature of naming differences among groups of children with Dysnomia while an examination of differences across different developmental ages would be useful.

In summary, the findings in the literature described above regarding the locus of word-finding difficulties in children are somewhat mixed. Some researchers postulate that the semantic representations of children with WFD are not well developed, making retrieval less accurate and slower. However, there is not sufficient evidence to suggest that semantic errors are more prevalent in Dysnomic children compared to control groups without word-finding deficits. The strongest evidence supporting the notion that semantic

difficulties impact word-finding skills in children is the ability of children with WFD to more adequately name stimuli with less semantic content (e.g. letters and numbers). Additional evidence supporting this claim includes difficulties with semantic fluency tasks and the quality of definitions produced (Messer & Dockrell, 2006).

The nature of phonological representations in Dysnomic children is also not clear. While some researchers have suggested impoverished lexical representations as the source of naming difficulties (McGregor, 1994), not all children with Dysnomia display poor phonological skills. Instead, word-finding difficulties may be a result of poor links between the semantic and phonological representations of a word (e.g. tip-of-the-tongue; Faust et al., 1997; German & Newman, 2004). Due to the lack of consistency across numerous research studies, it is possible that multiple causal factors influence patterns of naming in children. Producing a model of naming development that adequately explains how these processes work together, which cognitive processes may contribute to naming difficulties, and how children can compensate when one process is comprised is a challenging endeavor that has not been tackled in the current research literature. Therefore, it seems necessary to consider the nature of word-finding difficulties among various groups of children to help identify the relative cognitive parameters involved in the naming processes of children.

<center>Studies of Lexical Access in Children</center>

Due to the lack of research examining lexical retrieval processes in children and the importance of considering comparative data, the following sections review the nature of word-finding difficulties among three additional groups of children who commonly display dysnomic-like behaviors: children with learning disabilities (LD), specific

language impairments (SLI), and Dyslexia, or reading difficulties. While some degree of overlap has been suggested among these various subgroups, it is unclear to what extent these three groups are distinct. The purpose of this section is to demonstrate that lexical retrieval problems occur in a range of children, to consider whether different groups of children with expressive language deficits have similar profiles of language abilities, and to discuss how findings from these different groups help to inform the unique nature of Dysnomia.

Learning Disabilities

The word-finding difficulties of children diagnosed with a learning disability or who were selected based on their lack of academic progress at school are examined in this section. While a variety of selection criteria and assessment measures were used in the studies reviewed, Dysnomia appears to be a common feature of a significant proportion of these children.

Early investigations of children with lexical access difficulties documented that these children displayed low school achievement, poor verbal fluency (Johnson & Myklebust, 1967; Wiig & Semel, 1975), a narrow understanding of word meanings, and limited imagery (Johnson, 1968). Wiig and Semel (1975) assessed and compared the accuracy and speed with which participants verbally named visual stimuli, produced sentences based on stimulus words, and defined words. The authors concluded that the language production deficits in LD children were related to delays in specific aspects of cognition, the convergent and divergent production of semantic units, and a reduction in the retrieval of verbal labels and syntactic structures.

In a comparison study conducted by German (1979, 1985), children with average levels of intelligence and adequate receptive language abilities who displayed below grade level performance on academic tasks were assessed. More specifically, the word finding skills of Dysnomic children (learning-disabled (LD) children with WFD) were compared to those of LD children without WFD when naming letters, numbers, and colors (German, 1985). Participants included children between the ages of 7 to 11 years, and results indicated that the sample had a range of WFD compared to typically developing CA controls. Retrieval difficulties included more errors, longer latencies to produce words, differences in the types of errors made (German, 1982), and more lexical difficulties in spontaneous speech.

In another study conducted by German (1987), she assessed the presence of specific word-finding characteristics and spontaneous language abilities among a sample of 56 normal and language-disordered children between the ages of 7 and 12 years. Results found that two spontaneous language profiles emerged that were unique to participants with word-finding problems, and both productivity level (i.e., Expressive Dysphasia) and specific word-finding behaviors (i.e., Dysnomia) differentiated the groups. Children with word-retrieval difficulties produced shorter stories and manifested significantly more word-finding behaviors than did the normal controls.

Based on the available research examining Dysnomia among children with learning disabilities, it seems that children who are making poor academic progress in the school environment may be at greater risk for lexical difficulties compared to CA and IQ-matched controls. However, most of the previous studies did not use LA-control groups or standardized assessments, making it difficult to determine whether low-achieving

children experience general difficulties with language that impact lexical skills or whether Dysnomia was truly present.

Specific Language Impairment (SLI)

Early studies pertaining to lexical access of children with specific language impairments suggested that performance on discrete naming tasks was slower, contained more errors, and involved naming difficulties compared to that of CA-matched peers. In particular, Wiig, Semel, and Nystrom (1982) evaluated the sensitivity of two independent rapid naming tests, Naming Pictured Objects and Producing Names on Confrontation, in differentiating children with language and learning disabilities (LLD) from same-age peers with normal language development and academic achievement. Total naming time and accuracy measures differentiated between the two groups. All LLD children displaying word-finding difficulties in spontaneous speech were identified by total naming time measures on the Naming Pictured Objects Test which fell more than 1 SD above the mean for the control group. Based on these findings, the authors concluded that the Naming Pictured Objects Test may be used as a quick screening measure for word-finding difficulties, particularly among first- and second-graders.

The nature of language deficits among children with SLI are considered to be heterogeneous. These children display a range of abilities, and SLI is thought to be caused by a variety of different mechanisms (Leonard, 1998), meaning that investigations of this population may include some children with WFD and some who do not. Despite the uncertainty about the relationship between studies of SLI and WFD, studies examining this group of children can help to further define the nature of word-retrieval deficits in children with language impairments. Some researchers argue that children with

language difficulties have a less well-developed lexical system than CA controls,

resulting in less elaborate semantic entries entering into the language system and word-

retrieval access problems (Kail, Hale, Leonard, & Nippold, 1984; Kail & Leonard, 1986).

McGregor, Friedman, Reilly, and Newman (2002) suggested that naming errors result

from less elaborate semantic representations.

Another possible reason for word-finding difficulties among children with SLI

could be that children with impaired language abilities are generally slower at responding

to stimuli, and an overarching reduction in processing speed accounts for slow naming

speed (Kail, 1994). More specifically, Kail (1994) demonstrated a method that could be

used to test the hypothesis that children with specific language impairment (SLI) respond

slower than unimpaired children on a range of tasks. The data consisted of 22 pairs of

mean response times (RSTs) obtained from previously published studies. Each pair

consisted of a mean RST for a group of children (aged 6-13 yrs) with SLI for an

experimental condition and the corresponding mean RST for age-matched children

without SLI. If children with SLI always respond slower than unimpaired children by an

amount that does not vary across tasks, then RSTs for children with SLI should increase

linearly as a function of RSTs for age-matched control children without SLI. This result

was obtained and is consistent with the view that differences in processing speed between

children with and without SLI reflect some general (i.e., non-task specific) component of

cognitive processing.

Results from several studies comparing the performance of children with SLI to

CA peers across a range of tasks have supported the hypothesis that a general reduction

in processing speed accounts for slow naming speed (Kail, 1994; Windsor & Hwang,

1999). While many of the tasks used in these studies rely on linguistic processes and/or responses, some studies have also documented slower performance when participants are presented with non-linguistic stimuli (Miller, Kail, Leonard, & Tomblin, 2001; Windsor & Hwang, 2002).

Miller and colleagues (2001) investigated the speed with which children with SLI respond on a range of tasks. Participants included 77 children in the third grade between the ages of 8 and 9 years. They participated in ten different tasks that included both linguistic and non-linguistic activities. Results indicated that children with SLI responded more slowly across all task conditions, including when linguistic and non-linguistic measures were analyzed separately. Findings from the group analyses support the hypothesis that speed of processing in children with SLI is generally slower than that of children with normal language abilities. However, some children with SLI did not show these deficits. More recently, Montgomery (2002) has suggested that slower processing speed for identifying target words among children with SLI may actually be a result of the inability to carry out specific cognitive operations such as those involving working memory.

In their study examining the developmental patterns for three continuous rapid naming tasks among children with SLI and typical children aged 6 to 16 years, Wiig, Zureich, and Chan (2000) found similar naming speeds across groups for naming colors and shapes. However, on the more complex task involving the serial naming of colored shapes, children with SLI performed slower than CA-matched controls across all ages except at 15 and 16 years of age. These findings indicate that the requirements for two-

dimensional, continuous naming resulted in reduced naming speed and interference with fluency in language production in about half of the clinical sample.

Children with SLI may also experience difficulties in accessing the specific phonological form of a word (McGregor & Appel, 2002). For instance, Faust and colleagues (1997) applied the "tip of the tongue" (TOT) paradigm to the study of naming problems in children between the ages of 7 to 8 years with language disabilities compared to individuals without LD. A picture-naming task usually used with normal children was given to the sample and, although the two groups did not differ in the semantic information they had on words not fully retrieved, the LD children had less valid and more invalid phonological information. They also had fewer correct responses and spontaneous recalls, more "I don't know" and TOT responses, and less accurate "feeling of knowing" (FOK) judgments. These results demonstrate that dissociations may exist between the semantic and phonological levels of word representation, supporting a two-stage model of word retrieval. These findings provide evidence in favor of a phonological treatment approach for naming problems in LD children.

In summary, the studies of naming abilities in children with SLI suggest slower and less accurate naming processes among this group. Possible reasons for these word-finding difficulties include less elaborate semantic representations in the lexicon, a less well-developed language system, or a delay in vocabulary development (Dockrell & Messer, 2004). However, arguments have also been made that slower, more inaccurate responses are a result of a slower speed of processing. With the absence of LA-control groups from many studies, coupled with the lack of systematic investigations pertaining

to information processing skills, researchers are reluctant to draw a firm conclusion about the reasons for slower naming abilities among children with SLI.

Dyslexia

The word-finding difficulties of children with Dyslexia will be examined in this next section. As in previous sections, recent findings have indicated that different mechanisms may be responsible for naming deficits in this group of children. Before examining the specific nature of naming difficulties in Dyslexic children, some of the common risk factors associated with this developmental disorder will be highlighted. Several risk factors have been associated with a higher incidence of language and reading disabilities. Research has demonstrated a higher incidence of Dyslexia in males, with a significant familial occurrence (Habib, 2000). A strong genetic component for Dyslexia has been documented and children are considered to be at a higher risk of displaying reading difficulties when at least one family member, specifically a parent, has a history of Dyslexia. Similarly, children with a history of language and speech delays may be more susceptible to develop impaired reading. Thus, children with a family history and/or a history of early speech delays are particularly vulnerable to developmental Dyslexia. Children with Dyslexia often have associated deficits in related domains including expressive language (dysphasia), writing abilities (dysgraphia), mathematical abilities (dyscalculia), motor coordination (dyspraxia), and attention ability (hyperactive or inattentive type) (Dewey, 1995; Fawcett, Nicolson, & Dean, 1996).

In a study conducted by Savage, Pillay, and Melidona (2007), the cognitive predictors of variable performance in reading and spelling skills among a sample of poor readers and spellers were investigated. More specifically, the associations between RAN

tasks and measures of decoding and processing speed were explored in an effort to determine which of these underlying variables appear to be uniquely associated with literacy. The sample included 65 children, ranging in age from 7:9 to 13:2 years, who were identified as below-average readers and spellers. Results of the factor analyses identified three primary factors (1: Rapid Naming; 2: Alphanumeric Naming; 3: Decoding), with Decoding representing the strongest predictor of literacy and explaining approximately 50% of the variance. While an additional effect was found for Alphanumeric Naming after Decoding was entered into the regression, the unique effect was relatively modest, explaining only 2% of the variance in literacy.

Results from this study do not support the claim that performance on alphanumeric naming tasks and phonological decoding are largely independent in poor readers as found by Wolf and her colleagues (2000). Instead, letter/digit naming and decoding were correlated and they were found to load together in the factor analysis. Due to the weak but significant loading found for non-word reading on Alphanumeric Naming, caution should be taken in interpreting performance on the alphanumeric RAN as a pure measure of naming rather than independent of decoding ability. An additional analysis found literacy to load strongly only with the Decoding factor while not at all with either of the other factors that involved RAN. Based on these findings, it seems that only those aspects of RAN that are related to non-word decoding ability are strongly associated with variation in literacy performance. The data from this study suggest nonsense word decoding is the strongest indicator in the cognitive assessment and identification of reading difficulties.

In a longitudinal study, Meyer, Wood, Hart, and Felton (1998) examined the predictive value of rapid naming tests for various aspects of later reading performance. Two large samples of students were evaluated (Grades 3-8) via a test battery of neuropsychological, intelligence, and achievement measures. Results indicated that rapid naming strongly predicted single-word reading skills, but only for poor readers. Findings did not support the predictive value of RAN in the average reading group. Therefore, the authors concluded that the automaticity of retrieval, rather than a lack of word knowledge, contributes to the predictive value of performance on RAN tasks.

Felton and Brown (1990) examined the possibility that rapid naming predicts only a subset of reading skills. In a sample of at-risk students, the authors found that rapid naming of alphanumeric stimuli (letters and numbers) in kindergarten was one of the best predictors of first-grade word identification but not word attack skills. These results suggested some degree of variance between decoding and naming skills. The differential effects of naming rate for letters versus objects were examined in a sample of 6- to 10-year-olds considered at-risk for developing learning problems. Findings indicated that the speed of naming letters made the largest independent contribution to level of word recognition (16.6% of variance), while speed of object naming made a substantial contribution to level of reading comprehension (14% of variance). Badian (1995) later found that untimed letter naming of children in kindergarten, rather than rapid naming, was a strong predictor of reading level through sixth grade.

In the same vein, Bowers (1995) studied the naming skills of poor and average readers between Grades 2 through 4, and findings indicated that measures of vocabulary knowledge, phonological awareness, and rapid naming contributed differentially to the

prediction of specific reading sub skills. Measures of rapid naming better predicted speed of naming words in isolation than word attack (decoding) skills. In addition, performance on rapid naming tasks contributed to the prediction of reading comprehension based on its contribution to word latency. Furthermore, performance on naming tasks differentiated between poor and moderately poor readers but not between moderately poor and good readers.

Performance is thought to predict reading acquisition and distinguish average from poor readers, particularly when alphanumeric stimuli are presented (Bowers & Swanson, 1991; Wolf, Bally, & Morris, 1986). Further, RAN has been substantiated as a significant predictor of reading even after statistically controlling for other variables including IQ, SES, attention deficits disorder, and phonological awareness (Bowers, 1995; Bowers & Swanson, 1991). Despite consistent findings in the research that RAN is associated with aspects of reading ability, specifically how RAN influences reading and how this influence changes over time is still not completely understood by researchers. Due to the multi-componential nature of RAN, interpreting performance on naming tasks is complicated (Wolf & Bowers, 1999; Wolf, Bowers, & Biddle, 2000).

Wolf and Goodglass (1986) conducted a longitudinal study examining confrontation naming abilities in three groups of children (average readers, impaired readers, and bilingual readers). Results indicated that kindergarten performance on confrontation naming tasks predicts reading performance in Grade 2, particularly reading comprehension. Confrontation naming differentiated average from impaired readers and findings also suggested that lexical retrieval, not vocabulary knowledge, is a major source of difference between reading groups. In another longitudinal study of RAN, group

differences for naming letters and numbers (graphological symbols) were found regardless of reading level or age while only early age group differences were supported for naming of objects and colors (non-graphological symbols) (Wolf, Bally, & Morris, 1986).

In a study investigating the relationship between phoneme awareness and rapid naming skills with subsequent reading and spelling ability, Cardoso-Martins and Pennington (2004) examined performance across two developmental periods (K-Grade 1; Grade 1-2). Results suggest that both phoneme awareness and rapid naming play an important role in early literacy acquisition although, relative to phoneme awareness, rapid naming plays a modest role. A specific effect for rapid naming was only found among children in the high-risk group (e.g. familial history of reading difficulties) and was limited to rapid naming of letters and numbers.

Savage and Frederickson (2006) conducted a study to examine multiple deficit areas among average and below-average readers and spellers. Participants were compared on various factors including handedness, phonological processing, verbal short-term and working memory, rapid naming, and perceptual-motor fluency tasks. With regard to performance on measures of rapid naming, significant differences were found in naming speed between the two groups. Furthermore, groups differed significantly on rapid digit naming while no significant differences were noted between groups when rapidly naming objects. These results suggest that naming effects in reading and spelling are specific to alphanumeric stimuli (Savage & Frederickson, 2006; Semrud-Clikeman, Guy, & Griffin, 2002) and demonstrate that associations between RAN, reading, and spelling may reflect a more specific deficit rather than a general processing speed difficulty. Following

analyses of effect sizes, support was found for the hypothesis that RAN is relatively less important than phonological factors in reading. However, performance on alphanumeric RAN tasks appears to be more strongly associated with spelling. On measures of short-term and working memory, no reliable differences were found between average and below-average readers.

In summary, results from this body of research demonstrate that rapid naming abilities affects the development of word identification, not word attack, skills and may impact reading comprehension as well as the speed and accuracy of passage reading (Meyer et al., 1998). Other researchers agree that deficits in rapid naming strongly predict difficulties with sight word identification as well as speed and accuracy of reading, but suggest that poor performance on naming tasks is unrelated to comprehension (Bowers & Swanson, 1991; Cornwall, 1992; Torgesen, Wagner, Simmons, & Laughon, 1990).

<u>Overlap between Dysnomia and Dyslexia</u>

The next section of this chapter will present theories of reading development to demonstrate the overlap between Dysnomia and Dyslexia in children. More specifically, the three deficit theories of developmental Dyslexia – phonological core deficit, rapid naming deficit, and double-deficit hypothesis - will be presented. Finally, some alternative explanations for the presence of both naming deficits and reading impairments will be explored.

Processes Involved with Reading

Theories of reading development highlight the importance of phonological processing and numerous studies have demonstrated the unique contribution of phonological processing to reading acquisition (Savage et al., 2007). Reading difficulties

are thought to stem primarily from core deficits in phonological skills, or understanding the sound structure of words (Faust, Dimitrovsky, & Shacht, 2003). Further, many researchers have documented that poor readers demonstrate significant difficulties on a range of phonological processing as well as nonsense decoding tasks, suggesting the presence of a phonological core deficit (Snowling, 2000; Vellutino et al. 1996).

In their review of the literature, Vellutino, Fletcher, Snowling, and Scanlon (2004) summarized some of the most important findings from research evaluating the hypothesized causes of developmental Dyslexia. The authors outlined components of reading ability, discussed manifest causes of reading difficulties, and addressed the hypothesized deficiencies in reading-related cognitive abilities as underlying causes of deficiencies in component reading skills. Evidence suggested that, in most cases, phonological core deficits are the probable cause of impaired reading rather than visual, semantic, or syntactic deficits, although some reading difficulties may be associated with general language deficits.

Wolf and Bowers (1993) postulated three subtypes of reading disability: (1) deficiencies in phonological skills; (2) slow naming speed that disrupts orthographic processing and reading fluency; and (3) a combination of both deficits (Vellutino et al., 2004). More specifically, they claimed that naming speed deficits are caused by a disruption in the "precise timing mechanism" that normally influences temporal integration of the phonological and visual counterparts of printed words, and thereby impairing the ability to detect and represent orthographic patterns (Wolf & Bowers, 1993). Furthermore, they hypothesized that slow letter (or digit) naming may signal a

disruption of the automatic processes which support induction or orthographic patterns leading to quick word recognition.

<u>Phonological Core Deficit</u>

The phonological core deficit postulates that verbal processing impairments may be attributable to difficulties with the phonological aspects of language (Snowling, 2000). Phonological coding has been defined as the ability to use speech codes to represent information in the form of words and parts of words and previous research has demonstrated highly convergent evidence in support of weak phonological coding as an underlying cause of Dyslexia (Vellutino et al., 2004). This theory suggests that phonological processing is involved in the reading process and, thus, poor readers exhibit phonological core deficits (Savage et al., 2007). According to this hypothesis, Dyslexia stems from impairments in phonological processing, or the representation and manipulation of phonemes (Brizzolara et al., 2006).

Researchers have consistently documented that deficits in phonological processing are common although these deficits do not necessarily explain all difficulties experienced by children with reading disorders (Bashir & Scavuzzo, 1992). Poor readers have consistently been found to perform below the level of normally achieving readers not only on tests evaluating word identification, phonological awareness, and letter-sound decoding, but also on measures of confrontational naming, rapid naming, verbal learning, and verbal memory (Vellutino et al., 2004). Therefore, children with reading difficulties may have a difficult time making word learning automatic and, as a result, display particular difficulty in tasks requiring speeded and serial access to, and retrieval of,

verbal labels for visually presented stimuli (Savage & Frederickson, 2006; Wolf &

Bowers, 1999).

<u>Rapid Naming Deficits</u>

Early research on naming speed and developmental Dyslexia stems from the

hypothesis that performance on a color-naming task may predict reading readiness

(Geschwind, 1965; Wolf & Goodglass, 1986). Research examining the correlation

between color-naming and reading readiness was conducted and found that speed of

naming differentiated between average and impaired readers (Wolf & Goodglass, 1986).

As a result, Denkla and Rudel (1974) created the Rapid Automatized Naming (RAN) task

to assess the ability to rapidly name alphanumeric (letters and numbers) and non-

alphanumeric (colors and objects) symbols. Studies consistently found that poor readers

were significantly slower in naming tasks compared to average readers (Denkla & Rudel,

1974; Wolf & Goodglass, 1986).

Over the past three decades, an abundance of research has convincingly

demonstrated that rapid automatized naming is a powerful predictor of concurrent and

future reading development (Bowers, 1995; Bowers & Wolf, 1993; Scarborough, 1998;

Wagner & Torgesen, 1987). A large number of studies have reported that children with

reading difficulties, compared to average readers, perform slower on serial naming tasks

(Manis, Doi, & Bhadha, 2000; Wolf, Bowers, & Biddle, 2000). While researchers have

proposed the presence of various deficit areas, rapid automatized naming and word

retrieval difficulties appear to contribute unique variance to reading impairment.

Therefore, although phonological skill deficits are thought to interfere with the process of

learning to read, researchers continue to examine other areas of difficulty including automaticity, or speed, of reading (Savage, 2004).

Difficulties in making word-reading skills automatic is a frequently occurring deficit associated with Dyslexia, and rapid naming is thought to approximate the repeated/speeded access to visual-phonological associations required in fluent reading (Savage, 2004; Wolf, 1991). Examining performance on rapid naming tasks may allow researchers to determine whether a deficit exists that is independent of general processing speed differences (Savage, 2004). According to Wolf and her colleagues (Bowers & Wolf, 1993; Wolf & Bowers, 1999), rapid naming and reading fluency require the integration of precisely-timed perceptual, attention and naming sub-mechanisms in order to fluently match visual representations to phonological codes.

Double-Deficit Hypothesis

Recently, a two-factor theory (Bowers & Wolf, 1993; Wolf & Obregon, 1997) has proposed that a rapid naming deficit may be a distinct construct that is separate from phonological processing, and represents a powerful predictor of Dyslexia. Furthermore, dyslexic children with rapid naming deficits may follow a developmental path that is different from those with only phonological deficits. The *Double Deficit Hypothesis* suggests that name retrieval deficits in impaired readers are not necessarily due to weak phonological coding and phonological memory problems (Vellutino et al., 2004).

In this two-factor, double-deficit theory, performance on rapid naming tasks is thought to tap into one's speed of processing and, thus, RAN appears to contribute unique variance to the processing of orthographic information (Meyer et al., 1998). Speeded naming, particularly for letters and numbers, has consistently been found to account for

unique variance in reading performance beyond that explained by phonological skills (Vellutino et al., 2004). Similarly, previous research suggests that phonological awareness and rapid naming may be differentially related to reading sub skills. For instance, research findings indicate that phonological awareness has been strongly correlated with the accuracy of word identification and letter-sound decoding while rapid naming correlates with the speed of word identification and letter-sound decoding (Manis et al., 2000; Wolf et al., 2000).

Nevertheless, some researchers disagree with the assertion that phonological processing and rapid naming are two separate entities. According to Torgesen and Burgess (1998), rapid naming is thought to be a predominantly phonological task and, thus, the link between RAN and reading may reflect efficient retrieval of visual-phonological paired associations required for speeded performance on both tasks. Support for the idea that rapid naming reflects a phonological output problem rather than additional early perceptual automaticity problem comes from relative performance on rapid naming of colors/objects in relation to letters/numbers (alphanumeric stimuli) in young children.

With research supporting both sides of the argument, a challenge exists about whether RAN represents an independent deficit, separate from phonological processing, or whether it reflects general or more specific processing speed skills (Savage, 2004; Savage et al., 2007; Wolf & Bowers, 1999). In other words, one critical question that remains to be answered is whether rapid naming can be subsumed under the framework of phonological processing or is representative of a separate, unique process such as Dysnomia (Meyer et al., 1998).

Links between Reading and Naming

Components of naming speed are thought to represent a micro-version of the

components of reading. In other words, word retrieval processes may represent the

multiple perceptual, lexical, and motor processes which must function together smoothly

and rapidly in order to produce a verbal match for an abstract, visually presented stimulus

(Wolf, 1999). Therefore, naming speed deficits often accompany Dyslexia, especially

since naming is a multi-componential version of reading. Furthermore, researchers have

suggested that cognitive processes involved with reading coincide with processes needed

to name stimuli (Geschwind, 1965; McCrory et al., 2004; Wolf, 1991).

Naming tasks require that a visual stimulus be perceived and identified while also

retrieving the associated lexical (or verbal) label (McCrory et al., 2004). During the

reading and naming processes, a phonological code is retrieved and articulated. Findings

support the notion that Dyslexia is a result of a phonological memory deficit as opposed

to a more general language difficulty. Furthermore, research has suggested that poor

readers experience distinct difficulties in rapidly accessing and retrieving verbal labels

for visually presented stimuli (Denckla & Cutting, 1999; Savage et al., 2007; Wolf &

Bowers, 1999). A deficit in this rate-limiting factor is thought to represent a common

process involved in rapid naming speed and the quality as well as "accessibility of

orthographic representations of words established in the lexicon during reading

acquisition" (p.130); consequently, this deficit appears to have a negative impact on

word-level recognition processes and reading fluency (Savage et al., 2007). Despite

difficulties with rapidly naming visually presented information, it is unclear whether

children with Dyslexia also experience the range of word retrieval and confrontation

naming difficulties experienced by those with Dysnomia. Within the context of developmental Dyslexia, many evaluations have focused exclusively on RAN while studies using numerous measures of expressive language and naming abilities are rare.

<div align="center">Other Explanations for Dysnomia with Dyslexia</div>

Based on the current research literature, there are several, potentially conflicting explanations about the reasons for slower naming speed in children, particularly with Dyslexia. While the phonological difficulties in children with Dyslexia are well documented (Bishop & Snowling, 2004; Snowling, 2000), two key studies addressed this issue in relation to lexical access. Snowling, van Wagtendonk, and Stafford (1988) compared the naming abilities of dyslexic children and average readers matched on their word knowledge and receptive vocabulary skills. While individuals in both groups appeared to have similar levels of semantic knowledge, children with Dyslexia displayed less accuracy when naming pictures compared to the control group. The authors concluded that these naming difficulties were a result of "faulty or impoverished" (p. 80) phonological representations in the lexicon.

In the second study, conducted by Swan and Goswami (1997), the picture and word naming performance of children with developmental Dyslexia to non-dyslexic ("garden variety") poor readers, as well as reading age and CA-matched controls were compared. Findings indicated that both groups of impaired readers exhibited a picture naming deficit relative to controls. These children also obtained better scores on the word naming task compared to picture naming, while both control groups showed no differences in performance across tasks. Results are discussed in terms of Dyslexics'

difficulty with encoding full segmental phonological representations of names in long-term memory and/or processing these representations.

Some children demonstrate short-term (STM) and working memory (WM) deficits, and some research supports the notion that poor readers display delays in memory abilities (Savage & Frederickson, 2006). Balanced automaticity may be another area of deficit, meaning that children have difficulties with automatizing aspects of learning which likely result in problems achieving fluency. Difficulties in making rote, over-learned tasks automatic can also be masked by use of specific compensation strategies (Nicholson & Fawcett, 1990, 1995, 2000, 2001). Another explanation of impaired reading in children is that difficulties may arise from the inability to utilize the articulatory loop as efficiently as children without Dyslexia (Torgesen & Davis, 1996). While naming difficulties involve processes at the peripheral (overt speech) level, there is some suggestion that children with Dyslexia may be deficient in speeded processes used to maintain activation of phonological memory codes prior to recall (Torgesen & Davis, 1996). Thus, poor performance on verbal, short-term memory tasks may coincide with difficulties on tasks involving rapid identification processes.

On the other hand, Pennington, Van Orden, Kirson, and Haith (1991) ruled out the possibility that memory problems are a prerequisite for reading difficulties, because comparisons of typical and impaired readers did not always yield significantly impaired phonological memory. Differences in phonological memory are usually greater for measures of other phonological skills such as phonological awareness or rapid automatized naming (Fletcher et al., 1995); thus, it is probable that studies showing reliable differences between good and poor readers on verbal memory tasks would have

found larger differences on measures of phonological awareness and RAN (Torgesen & Davis, 1996). Poor performance on verbal short-term memory tasks appear to be correlated with difficulties acquiring alphabetic reading skills although this correlation is weak.

When evaluating children with developmental difficulties, it is also important to consider the possible effects of co-occurring deficits in attention. Some researchers have tried to tease apart the impact of attentional difficulties on naming performances although results have been inconsistent. However, few studies have examined the relationship of AD/HD to potential naming deficits in children without learning disabilities (Semrud-Clikeman et al., 2000). While children with attention deficits display problems with rapidly naming stimuli, these difficulties seem to diminish over time and with age. Results from previous studies (Ackerman & Dykman, 1993) demonstrated that children with poor attention spans were faster on all RAN tasks compared to poor readers. Similarly, Nigg, Hinshaw, Carte, and Treuting (1998) found that children with co-occurring attention and reading problems showed naming speed deficits whereas children with only an attention deficit did not. However, in a final analysis that controlled for reading and disruptive behaviors, slowing performance on the RAN was noted for children with attention problems. Results from this study indicate some contribution of attention problems to performance on RAN tasks although the co-occurrence of AD/HD is unlikely to account for all RAN deficits.

To summarize, the current research on lexical access processes of children with Dyslexia indicates that these children demonstrate slower performance on serial naming tasks and appear to make more errors on discrete-naming tasks than control groups.

While a single consensus does not currently exist, explanations for naming difficulties have primarily focused on inadequate phonological processing deficits. Slower speed of processing has also been proposed as a possible reason for poorer performance on tasks measuring naming speed of children with Dyslexia, although this hypothesis does not adequately explain the presence of naming errors. Consequently, different theories exist about the mechanisms responsible for lexical access difficulties in children with Dyslexia and Dysnomia. These various explanations help to account for the different profiles of abilities seen in the two groups of children, namely that literacy is typically an area of strength for children with word-finding difficulties in the absence of reading impairments (Messer et al., 2004).

<div align="center">Summary</div>

The above literature examined several cognitive variables found to be pertinent to Dysnomia and word-finding difficulties in children. Language and reading deficits have implications for academic success and self-esteem, particularly during childhood. The identification of children at-risk for developing reading impairments is an important task for educators and clinicians. Debates still exist about whether rapid naming difficulties reflect simple delays in acquisition resulting from processing speed and/or attention problems or are suggestive of abnormalities in underlying language processes and competence.

While the co-occurrence of rapid naming deficits and reading impairments is well established in the research, few studies have explored the presence of Dysnomia without reading impairment. Lovett (1987) identified a group of children with less severe reading impairments who displayed slow naming speed. These "rate disabled" children displayed

word recognition skills that were average while their rates of reading and naming speed were much slower than controls. "Accuracy disabled" readers displayed both word recognition and speed of reading difficulties, as well as impaired phonological processing and naming speed. In particular, speed of letter naming was found to be even slower than the performance of "rate disabled" participants.

As previously mentioned, research suggests that rapid naming of familiar, visually presented stimuli is a good predictor of word identification skills and text-reading fluency (Wolf & Bowers, 1999; Wolf, Bowers, & Biddle, 2000). Furthermore, several studies have supported the idea that performance on RAN tasks is linked to text-reading speed (Bowers, 1993; Levy, Abello, & Lyschynchuk, 1997). Interestingly, many previous studies have examined only a single measure of rapid processing speed (e.g. digit naming speed) rather than assessing performance across multiple tasks (Bowers, 1993; Levy et al., 1997). Further, multiple measures of expressive language abilities are rarely used. Examining performance on tasks of rapid naming, confrontation naming, and word retrieval, as well as visual and verbal sequential memory, may help to establish a clearer diagnostic picture of Dysnomia. This review of the literature on developmental language disorders and, more specifically, Dysnomia in children suggests that expressive language abilities and academic achievement may be impacted by word retrieval deficits. Nevertheless, this phenomenon has not been adequately examined from a developmental perspective.

Therefore, the aim of the current study is to examine patterns of performance on multiple measures of cognitive functioning for Dysnomic children with and without impaired reading. The specific research questions to be addressed include:

(1) Is there a relationship between performance on reading-related tasks compared to performance on measures of expressive language and sequential memory?

(2) Does a concurrent diagnosis of a primary attention deficit (AD/HD) have a significant impact on the performance of children with Dysnomia compared to those diagnosed with both Dysnomia and Dyslexia?

(3) Do differences exist between the neurocognitive profiles of Dysnomic children with and without Dyslexia (measured as academic achievement, rapid naming, word/verbal fluency, confrontation naming, and sequential memory)?

CHAPTER III

METHODOLOGY

The purpose of this chapter is to describe the methodology and research design used in this study. First, the participants and procedure for selection will be described. Next, information about selected measures and their psychometric properties will be reported.

Participants

Participants were a total of 104 outpatients evaluated in the Department of Pediatrics at the University of Iowa Hospitals and Clinics. Children are referred to the Pediatric Attention and Learning Disorders Clinic for evaluation of attention, learning, and social-emotional concerns by their parents, primary care doctors, and/or school personnel. Existing clinic records were screened, and children between the ages of 6 and 12 years at the time of testing were initially selected. Those individuals meeting inclusion criteria (see below) were included in the study.

Procedure

For this retrospective study, evaluation results were selected from an existing data set of children evaluated in the Pediatric Psychology clinic from January 2004 to January 2009. The typical neuropsychological test battery consists of measures of intelligence, expressive language, memory, visual-spatial/motor abilities, academic achievement, and attention/impulsivity. For the purpose of this study, scores from specific test measures examining expressive language, attention/memory, and academic achievement were used. Furthermore, chronological age, gender, and grade of the child at the time of the evaluation were obtained.

This study was approved by the IRB at the University of Iowa in March of 2009. All research was conducted within one year of this approval. Following an examination of the data currently housed in the Pediatric Psychology Attention and Learning Disorders Clinic, individuals between the ages of 6 and 12 years at the time of testing who were diagnosed with Dysnomia or both Dysnomia and Dyslexia were initially selected for consideration. Only data gathered from an initial evaluation of each patient were included so as not to have duplicate data from the same subject. Since the neuropsychological assessment battery was individualized for each child based on the presenting concern and chronological age, all children did not necessarily complete the same examination battery. Participants were considered for inclusion in the present study if they completed the necessary tests for the proposed analyses and met DSM-IV-TR or ICD-9 criteria for a diagnosis of Dysnomia with or without Dyslexia.

Inclusion criteria were cognitive abilities (Verbal Comprehension and Perceptual Reasoning domains) within the "average" range. Cognitive abilities were considered average for children who achieved at least a standard score of 8 on both the Block Design and Similarities subtests of the Wechsler Intelligence Scale for Children – 4th Edition (WISC-IV; Wechsler, 2003). Exclusion criteria were a history of a neuro-developmental disorder (e.g. seizures), head injury, or other major psychiatric condition. Children with a diagnosis of Dysphasia or Dysmnesia, developmental language and memory disorders, were also excluded because of possible confounds. Due to the naturally occurring incidence of attention difficulties, and the research findings that children with a primary attention deficit do not perform as poorly as children with reading and/or expressive

language impairments, children diagnosed with Attention Deficit Hyperactivity Disorder (AD/HD) were included in the sample.

<div align="center">Measures</div>

<div align="center">Intelligence</div>

The Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV, Wechsler, 2003) is a test of general intellectual ability for children and adolescents between the ages of 6 years, 0 months to 16 years, 11 months. The normative information was based on national standardization samples representative of the United States population according to age, gender, race, parent education level, and geographic region. The normative sample included 2,200 children divided into 11 age groups, each consisting of 200 participants. The average reliability coefficients of WISC-IV subtests ranged from .79 to .90. Based on available data, two subtests were specifically used for this study.

<u>Block Design</u>

Block Design is a performance subtest that requires perceptual organization and visual-motor coordination. Participants are presented with modeled and/or printed, two-dimensional geometric patterns which they replicate using red and white cubes. The minimum number of questions administered is two while the most is twelve. The task is timed and additional points are awarded for speed. Scaled scores range from 1 to 19.

Reliability coefficients based on the split-half method ranged from .83 to .88 (mean r=.86). Test-retest reliability was assessed with a sample of 243 children and testing intervals ranged from 13 to 62 days (mean=32 days). For Block Design, the average for all ages was .82, suggesting adequate stability over time. Further, Block

Design has an intercorrelation of .81 with the Performance Reasoning Index and .70 with the Full Scale (Wechsler, 2003).

Similarities

Similarities represents a verbal subtest of the WISC-IV which specifically measures verbal reasoning and concept formation (Wechsler, 2004). Participants are presented a series of paired words, with increasing difficulty, and asked to describe how they are conceptually alike or similar. The examiner scores each answer based on a scale of 0-2 points according to the level of abstraction. Children can receive a raw score total ranging from 0-33 which translates into scaled scores between 1 and 19.

Reliability coefficients based on the split-half method ranged from .82 to .89 (mean r=.86). Test-retest reliability was assessed with a sample of 243 children and testing intervals ranged from 13 to 62 days (mean=32 days). For Similarities, the average for all ages was .86, suggesting adequate stability over time. Further, Similarities has an intercorrelation of .89 with the Verbal Comprehension Index and .77 with the Full Scale (Wechsler, 2003).

<center>Expressive Language</center>

Expressive language abilities were assessed by three measures: Word Fluency Test (F-A-S), Boston Naming Test (BNT), and Rapid Automatized Naming (RAN).

Word Fluency

The Word Fluency, or F-A-S, test (Neurosensory Center Examination for Aphasia [NCCEA]; Benton, Hamsher, & Sivan, 1994; Spreen & Benton, 1977) is a clinical test for expressive dysphasia that assesses expressive language skills. The purpose of this test is to measure verbal association fluency, or the spontaneous production of words

beginning with a specific letter within a limited amount of time. To administer the test, the examiner asks the participant to say as many words as s/he can think of that begin with a given letter of the alphabet (F, A, and S) in one minute, excluding proper nouns, numbers, and the same word with a different suffix. (Since the test is dependent upon basic spelling skills, categories [e.g. food, animals] have been used for younger children.) This task involves sound-symbol association and rapid retrieval of verbal labels based on beginning sound association. Word fluency tasks provide a means of determining how well children organize their thinking (Lezak et al., 2004). The score represents the total number of admissible words provided by the child for all three letters. Since the child is expected to name as many words in a minute as possible, the maximum raw score is indefinite, though the minimum score is zero. Higher scores indicate adequate word retrieval abilities while lower scores are indicative of word finding deficits.

The Word Fluency test presents normative data based on results of performances by typically developing children and adults from the Unites States. Normative data have also been developed for children ages 6 to 13 years experiencing learning disabilities, diabetes, epilepsy, or brain damage using the letters F, A, and S. The normative sample for Word Fluency consisted of 353 children between the ages of 6 and 13 years, and there are separate norms based on gender for each age level. The reliability findings for this instrument are considered adequate. Test-retest reliability after 19 to 42 days is .88 and remains at .65 after 8 months (Des Rosiers & Kavanagh, 1987).

Concurrent validity has been established in several studies, and findings generally indicate better validity for letter than for concrete category names (Coelho, 1984). In a factor-analytic study with children's data, Crockett (1974) found that the word fluency

test mainly contributed to factors involved with reading-writing and reading-writing-sentence construction. According to Spreen and Strauss (1998), these results are likely due to the developing spelling skills in young children.

Boston Naming Test

The Boston Naming Test (BNT) is a test of confrontation naming useful in detecting mild word-retrieval problems in children and adults (Kaplan, Goodglass, & Weintraub, 1983). Further, the test assesses the ability to spontaneously name pictures of objects and inferences can be drawn from test performance regarding language facility.

Participants are asked to name line drawings of familiar objects that are presented in order of descending word frequency. The test consists of 60 large ink drawings of objects ranging in familiarity from such common items as "tree" and "pencil" at the beginning of the test to "sphinx" and "trellis" toward the end. Children begin at item one and continue until eight consecutive incorrect responses are given. When children are unable to name the object, a semantic cue is provided (e.g., for pelican, "it's a bird"). If the child is still unable to name the object, a phonemic cue is given (e.g., for pelican, "it starts with the sound *pe*"). Children receive one point for each correct response (either without a cue or with a semantic cue) although no points are given when a phonemic cue is provided. Children can receive a raw score between 0 and 60. High scores on this instrument suggest better confrontation naming skills.

While a majority of studies examining the utility of the BNT examined the performance of older adults, numerous researchers have attempted to establish developmental norms for this instrument (Cohen, Town, & Buff, 1988; Kirk, 1992). However, these norms are mostly based on small homogeneous samples, leading to

problems with comparability and generalizability (Yeates, 1994). While the clinical

validity of the BNT within pediatric settings remains unclear, this measure is frequently

used with child populations because of its documented validity in various unpublished

research reports. In an effort to improve the normative standards work with children,

Yeates (1994) collapsed the mean levels of performance at each age level across

published studies. He suggested that these collapsed norms were sufficient in establishing

adequate reliability and validity for the clinical utility of the BNT with pediatric

populations (Spreen & Strauss, 1998; Yeates, 1994).

Some previous studies have shown gender differences in performance,

particularly at younger ages. For example, Kindlon and Garrison (1986) found that

females scored approximately 5 points higher than males between the ages of 6 and 7.

However, another study (Halperin, Healy, Zeitschieck, Ludman, & Weinstein, 1989)

failed to find sex differences. Nevertheless, these authors did report that scores increase

by two or three points after a phonemic cue is provided.

Construct validity of this measure was investigated by Halperin and colleagues

(1989) using a sample of children. Results from this study indicated that the BNT loaded

highly on a word knowledge, or vocabulary, factor but demonstrated low loadings on a

verbal fluency or memory factor. These findings suggest that the BNT is a relatively pure

measure of confrontation naming in children (Spreen & Strauss, 1998). Cooper and

Rosen (1997) found that the BNT successfully identified children with language

disabilities and reading disabilities.

Rapid Automatized Naming

Rapid Automatized Naming ([RAN], Denckla and Rudel, 1976) is a clinical test of naming deficits. More specifically, the test requires rapid naming of common objects, colors, letters, and numbers. RAN stimuli are presented on 8.5 x 11" pieces of white paper and arranged in five rows with 10 items in each one. The test requires the child to name the stimuli as quickly and accurately as possible. Before administering each naming task, the child is asked to name each of the five stimuli in each group (e.g. color, object, letter, number). Once the examiner has determined that the child is familiar with the appropriate stimuli, the child is presented with the card containing 50 stimuli each and the score is the total time needed to name all the stimuli.

The time-based score is compared to the expected time from the normative sample. One advantage of this instrument is that it can be administered easily to young children before reading skills have developed (Jaffe, Pringle, & Anderson, 1985). The total time to complete the 50 items of each subtest has been shown to decrease with age, and also to discriminate among individuals with reading disorders, learning disabilities without reading disorders, and age-matched controls (Denckla & Rudel, 1976). Another study also found this instrument to accurately discriminate between children with language impairment versus children with no language impairment (Katz, Curtiss, & Tallal, 1992).

RAN has been widely used in the study of reading and reading disabilities, and has shown validity in differentiating reader types across numerous studies (Badian, Duffy, Als, & McAnulty, 1991; Denckla & Rudel, 1976; Wolf, 1991). Results from studies using the RAN have consistently predicted later reading ability for children in

kindergarten and the early primary grades (Badian et al., 1991; Blachman, 1984; Catts, 1991; Wolf, Bally, & Morris, 1986). Although difficulties with rapid naming have suggested deficits in sight word identification, poor performance appears to be unrelated to later reading comprehension abilities (Meyer et al., 1998; Scarborough, 1998).

Research indicates that deficits in the rapid access to lexical information present a prevalent characteristic of the reading disabled (Bowers &Wolf, 1993; Denckla & Rudel, 1976). Tasks that measure skills in this area may offer a simple and effective predictor of children at risk of failure in literacy acquisition, although the precise reason why this might be the case is uncertain. For example, it may be that tests of rapid naming ability should be subsumed under phonological skills as they require verbal labeling of visual stimuli (Wagner & Torgesen, 1987). Alternatively, Wolf and Bowers (1999), for example, have proposed that rapid naming deficits should be regarded as separate from phonological skills, arguing instead for a double deficit perspective involving dissociated causes of literacy difficulties.

In addition to predicting sight word recognition and word reading skills, RAN has been regarded as a test of phonological coding because of its requirement to verbally label visual stimuli (Wagner & Torgesen, 1987). Rapid naming might be particularly difficult for children with poor phonological awareness or processing abilities. The findings of Stanovich, Fee, and Cunningham (1983) challenged the view that RAN is only a measure of phonologically based processes since discrete trial letter naming did not predict reading as well as serial letter naming. While both types of naming require phonological retrieval, non-phonological factors have also been hypothesized to account

for the strong relation between RAN and reading (Bowers & Wolf, 1993; Felton &

Brown, 1990; Wolf 1991).

<center>Sequential Memory</center>

<u>Color Span Test</u>

The Color Span Test (Richman & Lindgren, 1988) is an instrument designed to

measure immediate sequential memory. Color Span assesses an individual's ability to

retain color names in sequences with increasing length. The test consists of three 8×11-

inch cards with the same eight color chips arranged in differing positions on each card.

The colors are regularly spaced with no common horizontal or vertical alignment to

eliminate verbal or spatial cues to aid memory.

The Color Span Test consists of four trials that are administered in the following

order: (a) visual presentation/pointing response; (b) visual presentation/verbal response;

(c) verbal presentation/pointing response; (d) verbal presentation/verbal response.

Depending on the trial, the child either listens to the examiner verbally name a list of

colors, or watches as the examiner points to the sequence of colors on the card. The

child's response modality also varies between pointing to the colors and verbally reciting

the colors back to the examiner. The number of colors per sequence increases

progressively from two to eight colors. During administration, the examiner alternates the

three cards for each trial to minimize the use of verbal and spatial mediation strategies. In

order for the child to receive credit for accuracy, s/he must accurately provide the colors

in sequential order.

Based on the available clinic data, only scores from Color Span Trial 1 and Trial 4

were collected. Inclusion of these two trials was important since researchers have

postulated that performance on Trial 1, in which information is presented visually and requires a pointing response, is often lower for children with language disabilities, particularly because the task requires more active verbal mediation strategies, a skill that may be particularly difficult for children with language and/or reading impairments (Eliason & Richman, 1990; Richman, Eliason, & Lindgren, 1988; Richman, 2000). Comparisons to performance on Trial 4, in which a verbal label is provided for the child and processing of visual stimuli is not required, allow sequential memory performances to be examined across visual as well as verbal modalities.

The normative sample of the Color Span Test consisted of 415 children between the ages of 6 and 13 years, and separate norms are reported based on gender and age level. Minimal psychometric data are currently available for this test although the inter-correlations of the four subtests range from .38 to .79. The first two trials, which are presented visually, are correlated .63 and the last two trials, which are presented verbally, are correlated .79. Correlational data suggests that the scores of reading disabled children on each Color Span subtest tend to increase with age. This finding is consistent with developmental trends found in non-disabled children, suggesting that the Color Span data are not directly influenced by intellectual measures. Overall, results indicate that the Color Span Test is an adequate measure of immediate memory recall since a child's score is more dependent on verbal mediation strategies than intellectual functioning (Wood, Richman, & Eliason, 1989).

The Color Span Test has been shown to be valuable in detecting language development in young children (Eliason & Richman, 1990), in children with reading disability (Lindgren & Richman, 1984; Richman & Eliason, 1984; Richman, Eliason, &

Lindgren, 1988) and in children with speech and language disorders (Richman, 2000).

Specific reading disorders have been detected using the Color Span Test including

Dyslexia (Richman & Ryan, 2003) and Hyperlexia (Richman & Wood, 2002). The Color

Span Test has also been shown to be helpful in examining differential memory functions

of children with Attention Deficit Disorder versus Reading Disability (Johnson, Altmaier,

& Richman, 1999).

<center>Academic Achievement</center>

Wide Range Achievement Test - Third Edition (WRAT-3)

Academic achievement skills were measured by the reading and spelling subtests

of the Wide Range Achievement Test - Third Edition ([WRAT-3], Wilkinson, 1993). The

WRAT is one of the most frequently administered measures of academic achievement

because it is quick and easy to administer. On the reading subtest, the reading skills that

are measured include letter and word recognition. The test requires that participants read

a list of words out loud that are presented on a card. The test begins with letter reading

and continues with a word reading and pronunciation list. Four words are presented on

each line and the words become increasingly longer and more complex. The test is

discontinued after ten consecutive failures. On the Spelling subtest, the spelling skills

assessed include copying marks, writing one's name, and writing single words from

dictation. In other words, children are asked to write letters and single words that are

presented orally. Following the presentation of each word, the examiner reads a sentence

that contains the word. The test-retest reliability for the WRAT ranges from .91 to .98.

CHAPTER IV

RESULTS

The results of the data analyses conducted for this study are presented in this chapter. First, a description of the demographic characteristics of the sample is provided. Next, preliminary data analyses are presented, including data on norms and reliability. Finally, the original research questions are addressed and subsequent analyses explained. All analyses were conducted using SPSS (17th Edition).

Sample Characteristics

The participants were a total of 104 outpatients evaluated in the Department of Pediatrics at the University of Iowa Hospitals and Clinics who met inclusion criteria for this study. Fifty-two children were diagnosed with Dysnomia and fifty-two children were diagnosed with both Dysnomia and Dyslexia. The participants included 36 females and 68 males, and ages ranged from 6 to 12 years, with an overall mean age of 9.2 (SD = 1.6) years. Further, a total of 49 children were also diagnosed with a primary attention deficit (AD/HD) while 55 children were not. Overall, the mean grade placement was the third grade.

As expected, participants in each of the two groups were relatively similar in terms of gender (Dysnomia: 63% male; Dysnomia/Dyslexia: 67% male) and presence of AD/HD (Dysomia: 50% AD/HD; Dysnomia/Dyslexia: 44% ADHD). Approximately 2/3 of the children in each group were male and between 45-50% of the children in each group were also diagnosed with a primary attention deficit, which is consistent with estimates of co-occurrence for AD/HD and reading disorders (Riccio & Jemison, 1998). Significant differences were found between groups with regard to age ($t = -3.35$, $p =$

.001) and grade placement (t = -3.01, p = .003), with children diagnosed with only

Dysnomia being younger in age and earlier in grade placement. More specifically,

children diagnosed with both Dysnomia and Dyslexia had a mean age of 9.7 (SD = 1.5)

years and grade placement of 3.6 (SD = 1.4), compared to a mean age of 8.7 (SD = 1.5)

years and grade placement of 2.7 (SD = 1.5) for children only diagnosed with Dysnomia.

Table I provides a summary of the demographic characteristics of participants.

<center>Descriptive Statistics for Measures</center>

Means, standard deviations, ranges, and reliability coefficients for the measures

used in the present study are found in Table II. Since an existing dataset was utilized for

the data analyses in this study and specific item responses were not available for certain

measures (e.g., WISC-IV, Word Fluency, BNT, and WRAT subtests), cronbach alpha

coefficients could not be calculated. Comparisons made between the sample and

available normative data on all the study measures employed are presented in Table III.

Intellectual functioning was assessed using subtests from the WISC-IV. Although

additional scores were gathered as part of the neuropsychological battery, only

information from the Similarities and Block Design subtests were used in the analyses for

this study. Subtests on the WISC-IV are scaled to have a mean equal to 10 with a

standard deviation of 3 (Wechsler, 2003). In this sample, scores on the Similarities (M =

10.73, SD = 1.89) and Block Design (M = 11.72, SD = 2.53) subtests were significantly

higher compared to the normative sample.

Expressive language and word retrieval skills were assessed using three measures:

the Word Fluency test, BNT, and RAN. On the Word Fluency test, the score represents

the total number of admissible words provided for all three letters (F, A, S). Higher

Table I
Demographic Characteristics of the Participant Sample (N = 104)

Variables	Dysnomia n (%)	Dysnomia/Dyslexia n (%)	Total N (%)
Gender:			
Male	33 (63.5)	35 (67.3)	68 (65.4)
Female	19 (36.5)	17 (32.7)	36 (34.6)
Diagnosis:			
AD/HD	26 (50.0)	23 (44.2)	49 (47.1)
No AD/HD	26 (50.0)	29 (55.8)	55 (52.9)
Grade:			
K	2 (3.8)	0 (0.0)	2 (1.9)
1	11 (21.2)	2 (3.9)	13 (12.5)
2	14 (26.9)	12 (23.1)	26 (25.0)
3	7 (13.4)	13 (25.0)	20 (19.2)
4	12 (23.1)	10 (19.2)	22 (21.2)
5	3 (5.8)	8 (15.4)	11 (10.6)
6	3 (5.8)	7 (13.4)	10 (9.6)

Table II
Descriptive Raw Data for the Psychometric Instruments

Test	Range	Mean	SD	Cronbach Alpha
WISC-IV				---
Similarities	8-16	10.73	1.89	
Block Design	8-18	11.72	2.53	
Word Fluency	4-38	17.76	7.11	---
BNT	23-54	38.33	6.91	---
RAN				.862
Colors	28-110	53.02	13.11	
Objects	41-131	73.63	17.73	
Numbers	18-89	41.16	12.85	
Letters	18-97	39.18	12.31	
Color Span				.603
Trial 1	0-8	4.35	1.87	
Trial 4	4-9	6.02	1.29	
WRAT-3rd Edition				---
Reading	64-120	90.71	10.41	
Spelling	65-111	88.70	9.04	

Table III
Comparison of Means and Standard Deviations for the Sample and Normative Data

| | Sample | | | Norms | | | T-Test | |
	N	M	SD	N	M	SD	T	Sig.
WISC-IV								
Similarities	104	10.73	1.89	2,200	10	3	2.458	.014*
Block Design	104	11.72	2.53	2,200	10	3	5.751	<.001*
Word Fluency	104	17.76	7.11	353	21.7	6.53	5.298	<.001*
BNT	104	38.33	6.91	241	44.7	4.35	10.339	<.001*
RAN								
Colors	104	53.02	13.11	180	45.21	9.47	5.796	<.001*
Objects	104	73.63	17.73	180	53.14	13.31	11.035	<.001*
Numbers	87	41.16	12.85	180	28.57	7.79	9.915	<.001*
Letters	104	39.18	12.31	180	28.43	7.73	9.036	<.001*
Color Span								
Trial 1	52	4.35	1.87	415	7.16	1.51	12.296	<.001*
Trial 4	52	6.02	1.29	415	7.13	1.42	5.365	<.001*
WRAT-3rd Edition								
Reading	104	90.71	10.41	4,433	100	15	6.280	<.001*
Spelling	104	88.70	9.04	4,433	100	15	7.650	<.001*

*   *Correlation coefficient significant at p < .05*

scores indicate adequate word retrieval abilities while lower scores are indicative of word finding deficits. Based on the normative data for children between the ages of 6 and 12 years, Word Fluency is scaled to have a mean equal to 21.7 with a standard deviation of 6.53 (Benton, Hamsher, & Sivan, 1994). In this sample, scores on the Word Fluency test (M = 17.76; SD = 7.11) were significantly lower than the normative sample, suggesting potential difficulties with word retrieval and verbal associative fluency performances.

Confrontation naming was measured with the Boston Naming Test (BNT). The BNT is a test of confrontation naming useful in detecting mild word-retrieval problems in children and adults (Kaplan, Goodglass, & Weintraub, 1983). Scores may range from 0 to 60, which reflect the number of correct responses. In the normative sample, the BNT has a mean of 44.7 with a standard deviation of 4.35 for children between the ages of 6 and 12 years. In the present sample, the mean was 38.33 with a standard deviation of 6.91, and scores ranging from 23 to 54. The performance for this sample was significantly lower than that of the original normative sample, indicating differences in performance on confrontation naming tasks.

Rapid Automatized Naming (RAN) is a clinical test of automatic short-term memory for labels of visual stimuli and naming deficits. The test requires rapid naming of common objects, colors, letters, and numbers. All four trials were used in the current test battery. The child is timed and the time-based score is compared to the expected time from the normative data based on gender and age.

In a normative sample of typically developing children between the ages of 6 and 12 years, the mean performances on each of the RAN trials were: RAN-Colors (M = 45.21, SD = 9.47), RAN-Objects (M = 53.14, SD = 13.31), RAN-Numbers (M = 28.57,

SD = 7.79), and RAN-Letters (M = 28.43, SD = 7.73). In the present study, mean scores

of the participants were consistently higher, representing slower naming performance.

The sample means on each of the RAN trials were: RAN-Colors (M = 53.02, SD =

13.11), RAN-Objects (M = 73.63, SD = 17.73), RAN-Numbers (M = 41.16, SD = 12.85),

and RAN-Letters (M = 39.18, SD = 12.31). Differences between the normative data and

the current sample were statistically significant across trials, meaning that children in this

study performed significantly slower on naming tasks compared to the normative sample.

Although no reliability information was located for the normative sample, the Cronbach's

alpha for the RAN in this study was equal to 0.86, which is acceptable.

The Color Span Test is an instrument designed to measure immediate sequential

memory consisting of four trials. However, only information from Trial 1 (visual

presentation/pointing response) and Trial 4 (verbal presentation/verbal response) was

used in the analyses. The normative sample of the Color Span Test consisted of 415

children between the ages of 6 and 12 years. In the normative sample, the mean

performance on Trial 1 was 7.16 (SD = 1.51); whereas, in the present study, the mean

performance ranged from 0 to 8 with a mean of 4.35 (SD = 1.87), a difference that was

statistically significant.

In the normative sample of children between the ages of 6 and 12 years,

performance on Trial 4 of Color Span yielded a mean of 7.13 (SD = 1.42). In this sample,

the mean performance was 6.02 (SD = 1.29), which is significantly lower than normative

data. Minimal psychometric data are currently available for the Color Span test although

the inter-correlations of the four subtests range from .38 to .79 (Richman & Lindgren,

1988). While reliability information for the normative sample is presented as a range, the

alpha for the Color Span trials used in this study was equal to 0.60, which is consistent with normative data.

Academic achievement was measured with the Reading and Spelling subtests from the Wide Range Achievement Test-Third Edition (WRAT-3). In the normative sample, subtests on the WRAT-3 are scaled to have a mean equal to 100 with a standard deviation of 15 (Wilkinson, 1993). In this sample, the mean performance on WRAT-Reading was 90.71 (SD = 10.41) and scores ranged from 64-120. Similarly, the mean performance of this sample on WRAT-Spelling was 88.70 (SD = 9.04) and scores ranged from 65-111. Data collected in this study revealed significantly lower scores compared to the normative sample.

Overall, when examining performance trends of the current sample, the means for most of the neuropsychological test measures fall significantly below the population mean. However, performances on measures of general intellectual functioning were comparable with the normative data while academic achievement was slightly lower than expectations. Thus, the sample used in this study demonstrated mostly below average performances, which is not surprising since a clinical sample of children was used.

<u>Research Questions</u>

The first research question examined if there was a relationship between performance on reading-related tasks compared to performance on measures of expressive language and sequential memory. Pearson correlations were calculated among the two reading-related scores (WRAT-Reading, WRAT-Spelling), six expressive language tests (Word Fluency, BNT, RAN-Colors, RAN-Objects, RAN-Numbers, RAN-Letters), and two trials of Color Span, a test of visual and verbal sequential memory.

The correlations revealed that the two academic scores were significantly related to one another (r=.628). In addition, WRAT-Reading was found to be significantly correlated with a measure of verbal fluency and two trials of RAN (Objects, Letters). The strongest correlation was found between WRAT-Reading and Word Fluency (r = .359) followed by RAN-Objects (r = .247) and RAN-Letters (r = .210), respectively. No significant correlations were found between WRAT-Reading and BNT, RAN-Colors, RAN-Numbers, or either trial of Color Span.

With regard to WRAT-Spelling, this reading-related task was also significantly correlated with a measure of verbal fluency and two trials of RAN in addition to Color Span Trial 4, a measure of sequential visual memory. More specifically, the strongest correlations were between WRAT-Spelling and Word Fluency (r = .254) as well as RAN-Letters (r = .272). Correlations with RAN-Objects (r = .229) and Color Span Trial 4 (visual memory) (r = .276) were slightly weaker yet still statistically significant. Again, no significant correlation was noted between WRAT-Spelling and BNT, RAN-Colors, RAN-Numbers, or Color Span Trial 1 (see Table IV).

In summary, the first research question examined if there was a relationship between performance on reading-related tasks compared to performance on measures of expressive language and sequential memory. Correlations revealed that the two academic scores were significantly related to one another. Both academic measures were correlated with Word fluency, RAN-Objects, and RAN-Letters. WRAT-Spelling was also significantly correlated with Color Span Trial 4, a test of sequential visual memory.

For the second and third research questions, certain tests were investigated simultaneously (e.g., WRAT-Reading/WRAT-Spelling; RAN-Colors/RAN-

Table IV
Pearson Correlations of Neuropsychological Tests Measure Means

Variable	1	2	3	4	5	6	7	8	9	10
1. WF	--	**.291****	.152	**.231***	.122	.141	.030	.271	**.359****	**.254****
2. BNT		--	.072	.115	.159	-.090	.245	**.424****	.183	.043
3. RAN-C			--	**.548****	**.299****	**.597****	.232	.124	.091	.132
4. RAN-O				--	.183	**.282****	-.196	.194	**.247***	**.229***
5. RAN-L					--	**.592****	.046	-.002	**.210***	**.272****
6. RAN-N						--	.069	-.083	.158	.188
7. CS1							--	.144	-.212	-.073
8. CS4								--	.268	**.276***
9. WRAT-R									--	**.628****
10. WRAT-S										--

*   *Correlation coefficient significant at p < 0.05*

**   *Correlation coefficient significant at p < 0.01*

Objects/RAN-Letters) based on the strength of correlations. Scores for each of the

neuropsychological test measures were converted to z-scores to ease comparability.

Means and standard deviations for each measure are found in Table V and comparisons

of performance on the various neuropsychological measures between groups are

presented in Figure I.

The purpose of the second research question was to examine whether a concurrent

diagnosis of a primary attention deficit (AD/HD) had a significant impact on the

performance of children with Dysnomia compared to those diagnosed with both

Dysnomia and Dyslexia. First, a 2x2 multivariate analysis of variance (MANOVA) was

conducted for academic achievement. The independent variables were LD type

(Dysnomia; Dysnomia/Dyslexia) and AD/HD type (AD/HD; No AD/HD) while the

dependent variables included the two academic achievement measures (WRAT-Reading;

WRAT-Spelling). Next, a 2x2 MANOVA was done with the rapid naming tasks. The

independent variables were LD type and AD/HD and the dependent variables included

three trials of RAN (Colors; Objects; Letters). Finally, two-way analyses of variance

(ANOVA) were conducted for Word Fluency, BNT, Color Span Trial 1, and Color Span

Trial 4, respectively. For those results found to be significant, follow-up tests were

conducted. It was hypothesized that performance across tasks would not be significantly

impacted by a concurrent diagnosis of a primary attention deficit.

The first 2 x 2 MANOVA was conducted with the academic achievement

subtests. LD type and AD/HD type were the independent variables and the two academic

measures (WRAT-Reading, WRAT-Spelling) were the dependent variables. These results

Table V

Means (z-scores) and Standard Deviations on Neuropsychological Test Measures

| Test Measure | Dysnomia | | | | | | | Dysnomia/Dyslexia | | | | | |
| | No AD/HD | | AD/HD | | Total | | | No AD/HD | | AD/HD | | Total | |
	M	SD	M	SD	M	SD		M	SD	M	SD	M	SD
Similarities	0.06	0.53	0.04	0.49	0.05	0.50		0.45	0.65	0.42	0.74	0.44	0.68
Block Design	0.38	0.72	0.49	0.79	0.44	0.75		0.74	0.85	0.68	1.00	0.71	0.91
Word Fluency	-0.64	0.84	-0.30	1.25	-0.47	1.06		-0.74	0.79	-0.19	0.94	-0.50	0.89
BNT	-0.64	1.39	-0.66	1.25	-0.65	1.31		-1.32	1.78	0.07	1.53	-0.70	1.80
RAN-Colors	-0.81	1.43	-1.22	1.65	-1.01	1.54		-0.76	1.52	-0.36	1.35	-0.58	1.45
RAN-Objects	-1.33	0.97	-1.54	1.59	-1.43	1.31		-2.08	2.19	-1.56	1.36	-1.85	1.87
RAN-Letters	-1.49	1.16	-2.05	1.72	-1.77	1.48		-2.24	1.80	-1.90	1.44	-2.09	1.64
Color Span Trial 1	-2.01	1.38	-2.14	0.89	-2.08	1.12		-1.37	1.33	-1.07	0.76	-1.24	1.11
Color Span Trial 4	-0.58	1.19	-0.49	0.84	-0.53	0.99		-0.57	0.81	-1.14	1.35	-0.81	1.09
WRAT-Reading	-0.21	0.55	-0.07	1.31	-0.14	0.99		-0.99	0.61	-0.98	0.78	-0.99	0.68
WRAT-Spelling	-0.54	0.51	-0.49	0.38	-0.52	0.44		-0.97	0.59	-1.02	0.73	-0.99	0.65

Figure I
Comparison of Performance on Neuropsychological Test Measures between Groups
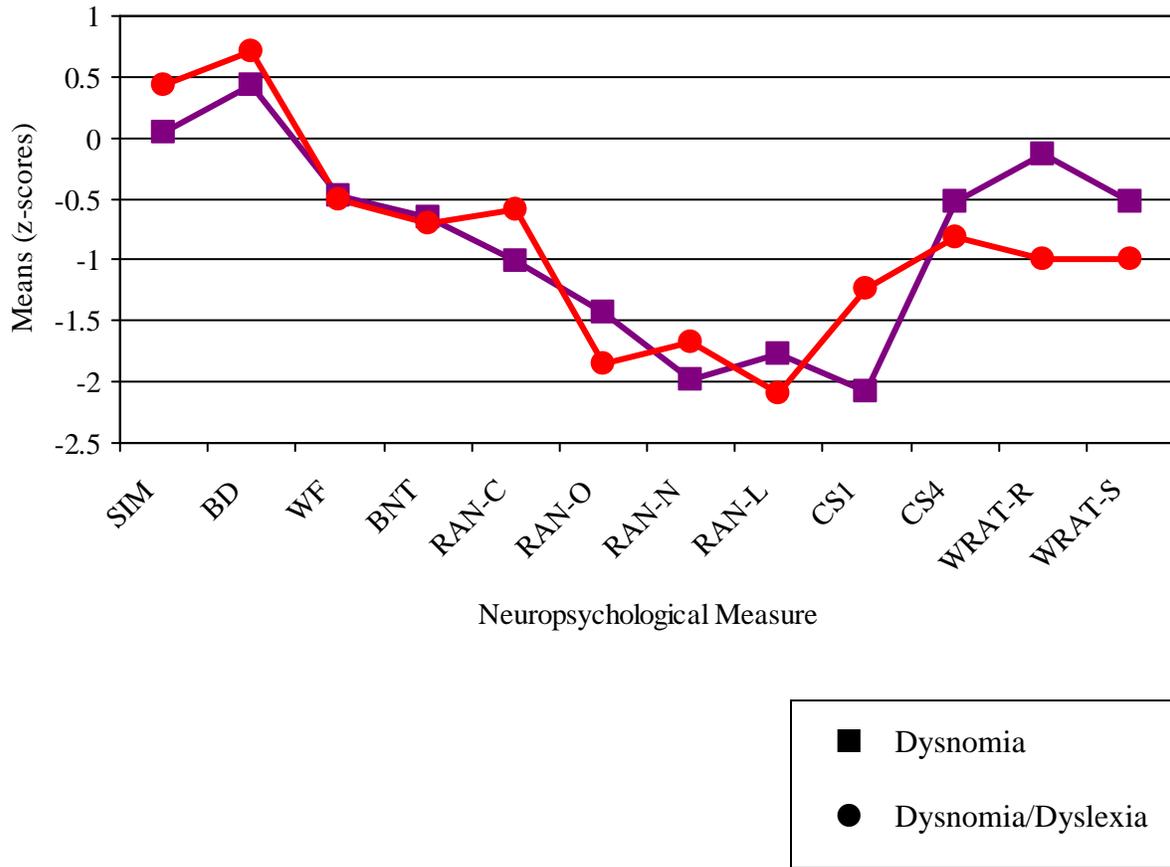
indicated no significant interaction effect ($F_{2,99}$ = .116, p = .891) or main effect for

ADHD ($F_{2,99}$ = .129, p = .879). However, there was a significant main effect for LD type

($F_{2,99}$ = 14.133, p < .001) suggesting that performance differences on the WRAT-Reading

and WRAT-Spelling differs by LD type. More specifically, children with Dysnomia and

Dyslexia demonstrated significantly lower scores on both academic measures when

compared to children only diagnosed with Dysnomia. However, a concurrent diagnosis of

a primary attention deficit (AD/HD) did not significantly impact performance on WRAT-

Reading or WRAT-Spelling subtests (see Table VI).

The second 2x2 MANOVA was conducted with three trials of rapid naming. LD

type and AD/HD type were the independent variables while the three dependent variables

included RAN-Colors, RAN-Objects, and RAN-Letters. Based on the results, no

significant interaction effect ($F_{3,98}$ = 1.097, p = .354) or main effect for AD/HD ($F_{3,98}$ =

.168, p = .918) was found although there was a significant main effect found for LD type

($F_{3,98}$ = 3.688, p = .015) indicating that overall performance differences on the RAN trials

differ by LD type. In particular, children with Dysnomia performed significantly faster on

RAN-Objects and RAN-Letters compared to the children with both Dysnomia/Dyslexia.

However, better performance was noted for children with Dysnomia/Dyslexia on RAN-

Colors. With regard to AD/HD, results of the analysis indicated that a concurrent

diagnosis of AD/HD does not significantly impact RAN performances between the two

groups (see Table VII).

Next, a two-way ANOVA was conducted for Word Fluency. LD type and AD/HD

type were the independent variables, and Word Fluency was the dependent variable. No

significant interaction effect (F = .333, df = 1, p = .565) or main effect for LD type

Table VI
2x2 MANOVA (using Wilks' Lambda): WRAT

	Hypothesis df	Error df	F value	p
TYPE	**2**	**99**	**14.133**	**<.001***
ADHD	2	99	.129	.879
TYPE*ADHD	2	99	.116	.891

Table VII
2x2 MANOVA (using Wilks' Lambda): RAN

	Hypothesis df	Error df	F value	p
TYPE	**3**	**98**	**3.688**	**.015***
ADHD	3	98	.168	.918
TYPE*ADHD	3	98	1.097	.354

(F = .001, df = 1, p = .980) were found; yet, there was a significant main effect for

AD/HD (F = 5.130, df = 1, p = .021) revealing that a significant difference in

performance on Word Fluency exists for children with a diagnosis of AD/HD compared

to those without a primary attention deficit, regardless of LD type. More specifically,

these findings suggest that children with AD/HD (M = -0.247, SD = 1.102) performed

significantly better on the Word Fluency task than those without AD/HD (M = -0.692,

SD = 0.807) (see Table VIII).

The next two-way ANOVA was performed on a measure of confrontation

naming. The independent variables were LD type and AD/HD type, and BNT was the

dependent variable. Results of this analysis revealed a significant interaction effect (F =

5.639, df = 1, p = .019) and main effect for AD/HD (F = 5.282, df = 1, p = .024) while

the effect for LD type was not significant (see Table IX). To further examine the nature

of this significant interaction, two independent t-tests were performed, first for children

diagnosed only with Dysnomia. Performance was compared within this group for

children with and without AD/HD. No significant differences were found (t = .062, df =

50, p = .951). However, a significant difference in performance was found for children in

the Dysnomia/Dyslexia group (t = -.2967, df = 50, p = .005) indicating that children

diagnosed with both Dysnomia and Dyslexia without AD/HD (M = -1.32, SD = 1.78)

performed significantly lower than those with a primary attention deficit (M = 0.07, SD =

1.53) (see Table X). No significant differences in performance were noted for children

only diagnosed with Dysnomia.

Then, a two-way ANOVA was conducted for Color Span Trial 1, a measure of

sequential visual memory. The independent variables were LD type and AD/HD type,

Table VIII
Two-Way ANOVA: Word Fluency

	df	Sum of Squares	Mean Square	F value	p
TYPE	1	0.001	0.001	0.001	.980
ADHD	**1**	**5.130**	**5.130**	**5.511**	**.021***
TYPE*ADHD	1	0.310	0.310	0.333	.565
Error	100	93.082	0.931		
Corrected Total	103	98.524			

Table IX
Two-Way ANOVA: BNT

	df	Sum of Squares	Mean Square	F value	p
TYPE	1	0.021	0.021	0.009	.924
ADHD	**1**	**12.045**	**12.045**	**5.282**	**.024***
TYPE*ADHD	**1**	**12.859**	**12.859**	**5.639**	**.019***
Error	100	228.037	2.280		
Corrected Total	103	252.844			

Table X
t-tests Comparing Performance within Groups on BNT

	Mean (z-scores)	SD	T-value	p-value
Dysnomia:				
No ADHD	-0.639	1.389	.062	.951
ADHD	-0.661	1.254		
Dysnomia/Dyslexia:				
No ADHD	**-1.316**	**1.783**	**-2.967**	**.005***
ADHD	0.0730	1.529		

and Color Span Trial 1 was the dependent variable. No significant interaction effect (F = .602, df = 1, p = .497) or main effect for AD/HD type (F = .091, df = 1, p = .791) were found; yet, there was a significant main effect for LD type (F = 9.438, df = 1, p = .009), revealing that a significant difference in performance on Color Span Trial 1 differs by LD type. More specifically, children with Dysnomia performed lower on this measure compared to children with both Dysnomia and Dyslexia. However, a concurrent diagnosis of a primary attention deficit (AD/HD) did not significantly impact performance on Color Span 1 (see Table XI).

Finally, a two-way ANOVA was performed with Color Span Trial 4, a measure of verbal sequential memory. The independent variables were LD type and AD/HD type, and Color Span Trial 4 was the dependent variable. No significant interaction effect (F = 1.381, df = 1, p = .267), main effect for AD/HD type (F = .749, df = 1, p = .412), or main effect for LD type (F = 1.297, df = 1, p = .282) were found. Thus, a concurrent diagnosis of a primary attention deficit (AD/HD) did not significantly impact performance on Color Span 4 (see Table XII).

In summary, the second research question investigated whether a concurrent diagnosis of a primary attention deficit impacts performance on test measures. Results of the analyses with the WRAT subtests, RAN trials, and two trials of Color Span indicated that a concurrent diagnosis of AD/HD does not significantly impact performance between the two groups. When examining performance on Word Fluency and BNT, significant results were found. More specifically, children with AD/HD performed significantly better on the Word Fluency task than those without AD/HD, regardless of LD type. Further, children diagnosed with both Dysnomia and Dyslexia without AD/HD

Table XI
Two-Way ANOVA: Color Span Trial 1

	df	Sum of Squares	Mean Square	F value	p
TYPE	**1**	**9.438**	**9.438**	**7.347**	**.009***
ADHD	1	0.091	0.091	0.071	.791
TYPE*ADHD	1	0.602	0.602	0.469	.497
Error	48	61.663	1.285		
Corrected Total	51	71.533			

Table XII
Two-Way ANOVA: Color Span Trial 4

	df	Sum of Squares	Mean Square	F value	p
TYPE	1	1.297	1.297	1.186	.282
ADHD	1	0.749	0.749	0.685	.412
TYPE*ADHD	1	1.381	1.381	1.263	.267
Error	48	52.477	1.093		
Corrected Total	51	55.591			

performed significantly lower on BNT than those with a primary attention deficit. No significant differences in performance were noted for children only diagnosed with Dysnomia.

The final research question investigated whether significant differences exist between the neuro-cognitive profiles of these children (measured as academic achievement, rapid naming, word fluency, confrontation naming, and sequential memory). First, a split-plot analysis of variance (ANOVA) was performed with the academic achievement scores (WRAT-Reading, WRAT-Spelling) viewed as a repeated measure. The independent variable was LD type and academic achievement was the dependent variable. Next, a split-plot ANOVA was done with RAN scores (Colors, Objects, Letters) viewed as a repeated measure. The independent variable is LD type and rapid naming performance was the dependent variable. A split-plot ANOVA was not conducted for the measures of general intelligence since these subtests represented inclusion criteria variables. For those results found to be significant, follow-up tests were conducted. Finally, independent t-tests were performed for Word Fluency, BNT, and Color Span Trials 1 and 4, respectively, using LD type as the independent variable and test measure as the dependent variable. It was hypothesized that children with both Dysnomia and Dyslexia would specifically display slower performance on tasks measuring rapid naming abilities and lower scores on measures of visual sequential memory as well as academic achievement.

The first split-plot analysis of variance (ANOVA) was performed with the academic achievement scores (WRAT-Reading, WRAT-Spelling) viewed as a repeated measure. The independent variable was LD type and academic achievement was the

dependent variable (Table XIII). As previously mentioned, results of the 2 x 2 MANOVA revealed a significant main effect for LD type suggesting that performance differences on the WRAT-Reading and WRAT-Spelling depend on LD type. To further examine the nature of this LD type main effect, a split-plot ANOVA was performed with the LD type viewed as the between subjects variable and WRAT scores viewed as a repeated measure. After adjusting for an assumption violation (using the Huynh-Feldt), a significant interaction between LD type and performance on the two WRAT subtests was revealed (F = 6.962, df = 1, p = .010). Thus, two independent t-tests were conducted in order to further investigate and explain the nature of this interaction.

The first t-test compared the means for performance on the WRAT-Reading subtest between the two LD groups. Results indicated that children diagnosed with Dysnomia (M = -0.14, SD = 0.99) performed significantly higher on the WRAT-Reading subtest compared to those children diagnosed with both Dysnomia and Dyslexia (M = -0.99, SD = 0.68; t = 5.053, p < .001). On the second t-test, means were compared for performance on the WRAT-Spelling subtest between groups. Equal variances could not be assumed so a corrected t-value was used to determine significance. Once again, results suggested that children diagnosed with Dysnomia performed significantly higher on the WRAT-Spelling subtest (M = -0.52, SD = 0.44) compared to those children diagnosed with both Dysnomia and Dyslexia (M = -0.99, SD = 0.65; t = 4.364, p < .001). These findings suggest that children with Dysnomia performed significantly better on word reading and spelling tasks compared to children diagnosed with both Dysnomia and Dyslexia. Further, a bigger difference was specifically noted in WRAT-Reading performances (see Figure II).

Table XIII
Split-Plot ANOVA: WRAT

	df	Sum of Squares	Mean Square	F value	p
Within-Subject Effects:					
WRAT	**1**	**429.813**	**429.813**	**7.350**	**.008***
WRAT*TYPE	**1**	**407.120**	**407.120**	**6.962**	**.010***
ERROR	102	5964.567	58.476		
Between-Subjects Effects:					
TYPE	**1**	**5130.236**	**5130.236**	**29.144**	**<.001***
ERROR	102	17955.221	176.032		

Figure II
Comparison of Performance on WRAT-3 Measures between Groups
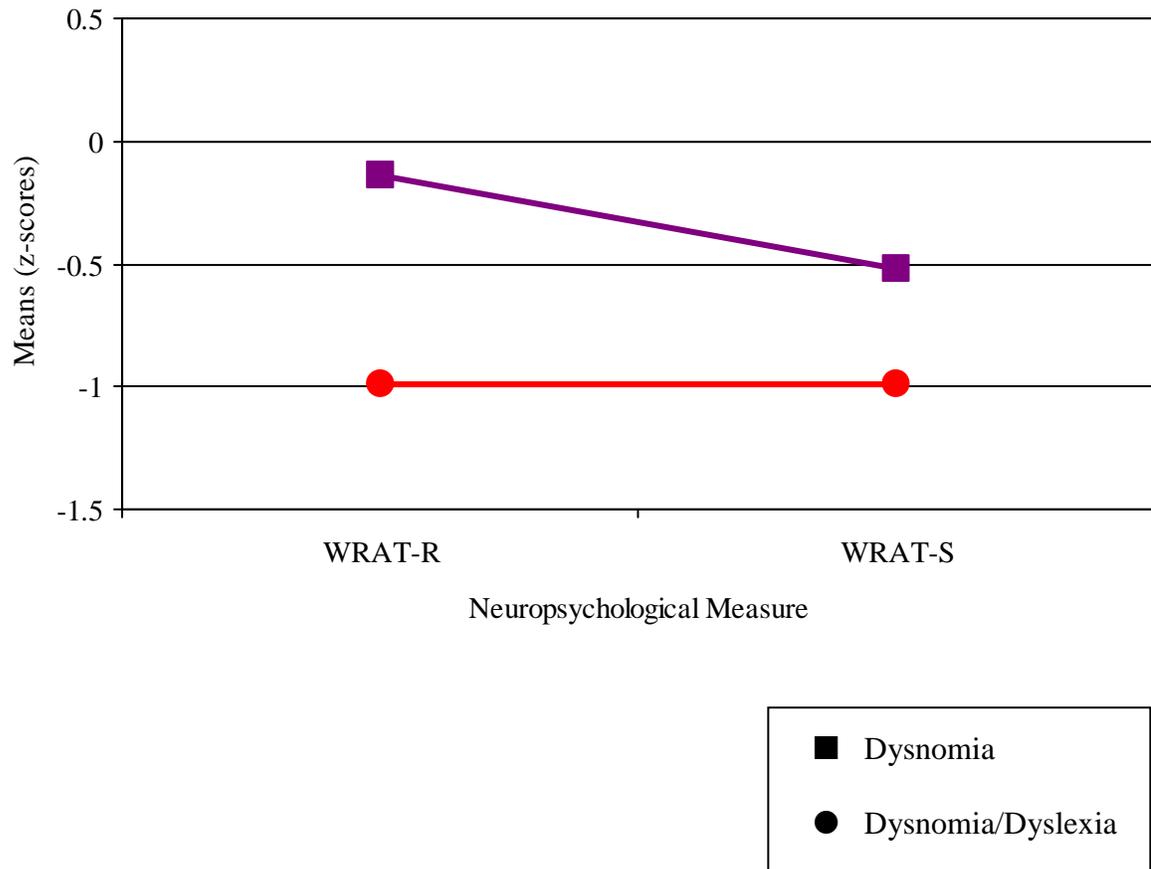
The second split-plot ANOVA was done with RAN scores (Colors, Objects, Letters) viewed as a repeated measure. The independent variable was LD type and rapid naming performance was the dependent variable (Table XIV). According to the MANOVA discussed earlier in the chapter, a significant main effect for LD type was found suggesting that overall performance differences on the RAN trials depends on LD type. To further examine the nature of this LD type main effect, a split-plot ANOVA was performed with the RAN scores viewed as a repeated measure. After adjusting for a violation of assumptions using the Huynh-Feldt procedure, a significant interaction between LD type and performance on the three RAN trials was revealed (F = 3.542, df = 1.779, p = .036). Thus, three independent t-tests were conducted in order to further investigate and explain the nature of this interaction. However, no significant differences were found between groups for RAN-Colors (t = -1.467, p = .145), RAN-Objects (t = 1.316, p = .191), or RAN-Letters (t = 1.030, p = .306).

Analyses next examined within group differences in the patterns of performance on the three RAN trials. First, a repeated measures ANOVA was performed for children diagnosed only with Dysnomia and significant differences were found (F = 6.050, df = 2, p = .003). Dependent t-tests were then conducted and significant differences in performance were revealed when comparing performance on RAN-Colors with both RAN-Objects (t = 2.183, p = .034) and RAN-Letters (t = 3.427, p = .001). No significant differences were noted between performance on RAN-Objects with RAN-Letters (t = 1.417, p = .163). More specifically, results indicated that children diagnosed only with Dysnomia displayed significantly faster performances on RAN-Colors (M = -1.02, SD =

Table XIV
Split-Plot ANOVA: RAN

	df	Sum of Squares	Mean Square	F value	p
Within-Subject Effects:					
RAN	**1.779**	**71.582**	**40.228**	**22.743**	**<.001***
RAN*TYPE	**1.779**	**11.148**	**6.265**	**3.542**	**.036***
ERROR	181.5	321.035	1.769		
Between-Subjects Effects:					
TYPE	1	0.793	0.793	0.191	.663
ERROR	102	17955.221	176.032		

1.54) compared to RAN-Objects (M = -1.43, SD = 1.31); further, these children

displayed even better performance when comparing RAN-Colors to RAN-Letters (M =

-1.77, SD = 1.48). Thus, children with Dysnomia performed best on RAN-C followed by

RAN-O; the slowest performance for this group was on RAN-L.

Follow-up analyses were then performed for children diagnosed with both

Dysnomia and Dyslexia. A repeated measures ANOVA was conducted and, after

correcting for unequal variances using Huynh-Feldt, significant differences were also

found (F = 17.701, df = 1.667, p < .001). Dependent t-tests revealed significant

differences when comparing performance on RAN-Colors with RAN-Objects (t = 6.133,

p < .001) as well as RAN-Letters (t = 5.511, p < .001). No significant differences were

noted between performance on RAN-Objects and RAN-Letters (t = 0.732, p = .468).

Similar to the pattern of performance found for children only diagnosed with Dysnomia,

results indicated that children diagnosed with both Dysnomia and Dyslexia displayed

significantly faster performances on RAN-Colors (M = -0.58, SD = 1.45) compared to

RAN-Objects (M = -1.85, SD = 1.87). Further, performances were even better when

comparing RAN-Colors to RAN-Letters (M = -2.09, SD = 1.64). Thus, children with

both Dysnomia and Dyslexia also performed best on RAN-Colors followed by RAN-

Objects. The slowest performance for this group was on RAN-Letters (see Table XV and

Figure III).

Finally, independent t-tests were performed for Word Fluency, BNT, and Color

Span (Trials 1 and 4), respectively, using LD type as the independent variable and test

measure as the dependent variable. The purpose of these t-tests was to examine the

significance of any differences between groups for each measure, regardless of an

Table XV
t-tests Comparing Performance within Groups on RAN Trials

	Mean	SD	T-value	p-value
Dysnomia:				
RAN-C - RAN-O	**0.418**	**1.380**	**2.183**	**.034***
RAN-C - RAN-L	**0.756**	**1.590**	**3.427**	**.001***
RAN-O - RAN-L	0.338	1.720	1.417	.163
Dysnomia/Dyslexia:				
RAN-C - RAN-O	**1.266**	**1.488**	**6.133**	**<.001***
RAN-C - RAN-L	**1.502**	**1.965**	**5.511**	**<.001***
RAN-O - RAN-L	0.236	2.328	0.732	.468

Figure III
Comparison of Performance on RAN Measures between Groups
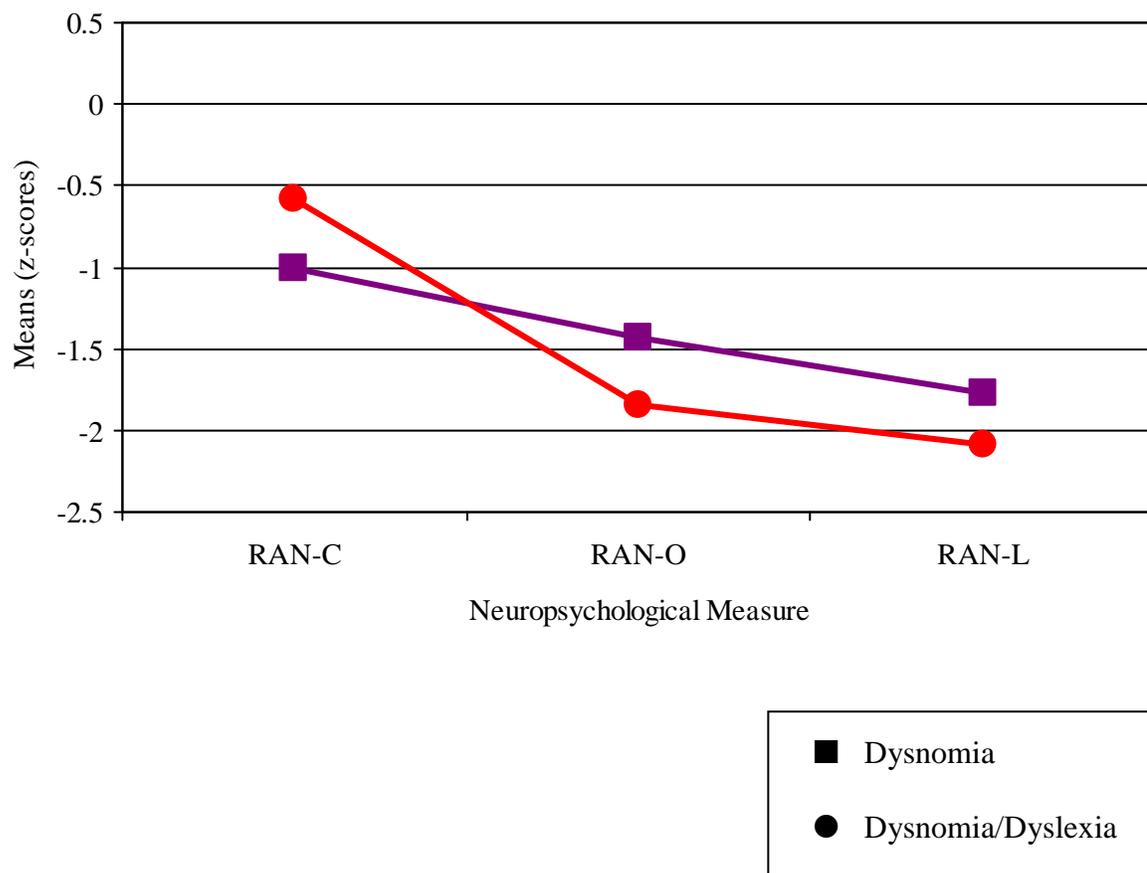
AD/HD diagnosis. As previously mentioned, no significant differences were found for performances on Word Fluency, BNT , or Color Span Trial 4. However, children with Dysnomia (M=-2.08; SD = 1.12) performed significantly lower on Color Span Trial 1 (M = -1.24, SD = 1.11; t = -2.713, p = .009), a measure of visual sequential memory.

Overall, the third research question explored the differences between the neuro-cognitive profiles (measured as academic achievement, rapid naming, word fluency, confrontation naming, and sequential memory) of children with Dysnomia both with and without Dyslexia. Findings suggested that children with Dysnomia performed significantly better on word reading and spelling tasks compared to children diagnosed with both Dysnomia and Dyslexia. Performance on Trial 1 of Color Span (Visual Memory) was also significantly lower for children with Dysnomia. On the Word Fluency, BNT, RAN, and Color Span Trial 4 (verbal memory) measures, , no significant differences were found between groups. However, within-group analyses of the RAN trials revealed significantly better performance on RAN-Color compared to RAN-Objects for both groups. Performance on RAN-L was also the slowest for both groups.

CHAPTER V

DISCUSSION

Language and reading deficits have implications for academic success and self-esteem, particularly during childhood. Thus, the identification of children at-risk for developing reading impairments is an important task for clinicians and educators. Several studies have examined the nature of word finding and rapid naming difficulties, particularly within the context of developmental Dyslexia and specific language impairments. Nevertheless, debates still exist about whether naming dysfluency simply reflects a delay in acquisition resulting from processing speed and/or attention deficits or is suggestive of abnormalities with underlying language processes. While the co-occurrence of rapid naming deficits and reading impairments is well established in the research, few studies have explored the presence of Dysnomia without reading impairment.

Previous research suggests that rapid naming of familiar, visually presented stimuli is a good predictor of word identification skills and text-reading fluency (Wolf & Bowers, 1999; Wolf, Bowers, & Biddle, 2000). Several studies have also supported the idea that performance on RAN tasks is linked to text-reading speed (Bowers, 1993; Levy, Abello, & Lyschynchuk, 1997). Interestingly, many previous studies have examined only a single measure of rapid processing speed (e.g. digit naming speed) rather than assessing performance across different tasks (Bowers, 1993; Levy et al., 1997).

The purpose of this study was to examine the nature of expressive language deficits for Dysnomic children with and without impaired reading by incorporating multiple measures of expressive language. More specifically, examining performance on

tasks of verbal fluency, confrontation naming, and rapid naming, as well as visual and verbal sequential memory, may help to establish a clearer diagnostic picture of Dysnomia. This was an important area of study because if neurocognitive similarities exist between children with and without Dyslexia, results would provide support for establishing additional early intervention programs for children diagnosed with Dysnomia regardless of whether reading is impaired.

The following chapter is a discussion of the findings from this research study. The results are discussed in relation to the specific research questions and hypotheses, within the context of existing research in the areas of language and learning disabilities in children. First, the specific research questions and hypotheses will be highlighted, and the major findings discussed. Next, limitations of the current study are presented and implications for research examined. Finally, the implications for clinical practice are outlined and conclusions to be drawn from this research explained.

<u>Major Findings</u>

The current study examined different types of expressive language deficits (verbal fluency, confrontation naming, rapid naming) displayed by children with Dysnomia, both with and without Dyslexia, in an effort to delineate and better understand the specific factors associated with impaired reading. Due to the complex nature of early language abilities, researchers have recommended incorporating measures that assess multiple domains of cognitive functioning including intelligence, listening comprehension, reading comprehension, spelling, and phonemic/phonological awareness to gain a more accurate and comprehensive understanding of a child's specific areas of strength and weakness. Research studies have demonstrated that early language difficulties may lead

to later reading impairments, meaning that various skills associated with reading development should be considered when children display expressive language deficits. Thus, multiple neuropsychological test measures were included in the battery used for this study, specifically tests of expressive language and word retrieval functioning.

The first research question examined if there was a relationship between performance on reading-related tasks compared to performance on measures of expressive language and sequential memory. In the current study, pairwise comparisons revealed that the two academic scores were significantly correlated to one another. Similarly, significant correlations were found between the four trials of RAN. Based on previous research and the normative data, these findings were not surprising. Results also indicated a significant correlation between the two other expressive language measures, Word Fluency and BNT. Even though stimuli for these two tests are presented using different modalities (e.g., verbal versus visual), the correlation may be indicative of an overlap with the word retrieval processes involved with both tasks.

With regard to the reading-related tasks, WRAT-Reading was significantly correlated with a measure of verbal associative fluency and two trials of rapid naming (RAN-Objects; RAN-Letters). The strongest correlation was between word reading and verbal fluency. WRAT-Spelling was also significantly correlated with Word Fluency, RAN-Objects, and RAN-Letters, in addition to Color Span Trial 4, a test of sequential visual memory. In this case, spelling was most strongly correlated with measures of verbal fluency and rapid naming of letters.

Interestingly, word reading and spelling were only significantly correlated with two of the four RAN trials, one non-alphanumeric (Objects) and one alphanumeric

(Letters) task. There are some different possibilities for why there was no significant correlation found between reading related tasks and the other two trials of RAN, namely RAN-Numbers. First, the number of children who were administered RAN-Numbers was less compared to the other trials, 87 and 104 participants, respectively. Therefore, it is possible that the number of children was too small to have enough power to detect a relationship between word reading and rapid naming of numbers if, in fact, one did exist. Thus, a larger-scale study with a bigger sample size would be required to further explore this potential relationship. One possible reason for the non-significant relationship between word reading and RAN-Colors is that performance on this task becomes less predictive of literacy acquisition as children get older. In the literature, early age group differences for naming of colors have been noted, specifically for children in kindergarten through second grade (Wolf, Bally, & Morris, 1986); therefore, since the mean age of the children used in this study was 9.2 years, the relationship may decrease with age.

Several decades of research have consistently pointed to the strong relations between reading and serial naming tasks (see review by Bowers, Golden, Kennedy, & Young, 1994). Wolf (1984) has argued that naming and reading tasks involve shared processes that include the perception, recognition, and sequencing of visual symbols, access and retrieval of verbal labels, attention, and articulation. In particular, previous studies have found that deficits in rapid naming and expressive fluency are associated with reading disabilities in children (Vellutino et al., 1994).

Previous literature has also documented differential performances on non-alphanumeric (colors/objects) and alphanumeric (letters/numbers) naming tasks

(Cardoso-Martins & Pennington, 2004; Felton & Brown, 1990; Wolf, Bally, & Morris, 1986). Some researchers have postulated that naming effects in reading and spelling are specific to alphanumeric stimuli (Savage & Frederickson, 2006; Semrud-Clikeman, Guy, & Griffin, 2002). Further, particularly when alphanumeric stimuli are presented, performance is thought to predict reading acquisition and distinguish average from poor readers (Bowers & Swanson, 1991; Wolf, Bally, & Morris, 1986). In addition, performance on alphanumeric RAN tasks appears to be more strongly associated with spelling (Savage & Frederickson, 2006).

The second research question investigated whether a concurrent diagnosis of a primary attention deficit impacts performance on test measures. Based on the existing research literature, it was hypothesized that performance across tasks would not be significantly impacted by a concurrent diagnosis of Deficit/Hyperactivity Disorder (AD/HD). Evidence from a number of investigations suggests a considerable overlap between Dyslexia and AD/HD. When children with both Dyslexia and AD/HD are examined, the linguistic deficits associated with Dyslexia and the behavioral characteristics associated with AD/HD are apparent, although these deficits do not necessarily act together (Shaywitz, Fletcher, Holahan, Shneider, Marchione, Stuebing, et al, 1995). In essence, some researchers have concluded that Dyslexia and AD/HD represent separate disorders that frequently co-occur.

As expected, results of the analyses with the WRAT subtests and RAN trials indicated that a concurrent diagnosis of AD/HD does not significantly impact performance between the two groups. Some previous research studies have shown that children with co-morbid reading and attention deficits are most impaired in the domains

of attention/control and phonological/linguistic functions when compared to either group individually (Willcutt Pennington, Boada, Ogline, Tunick, Chabildas et al., 2001; Nigg, Hinshaw, & Treuting, 1998). Other researchers found that performances by children in the co-morbid group were less impaired, specifically on language measures, compared to children only diagnosed with Dyslexia (Purvis & Tannock, 1996).

When examining word fluency and confrontation naming performances in the current study, significant differences were found. More specifically, a significant main effect for AD/HD was found on a measure of verbal associative fluency and findings revealed that children with AD/HD performed significantly better on the Word Fluency task than those without AD/HD, regardless of LD type. Further, interaction and main effects for AD/HD were noted on a measure of confrontation naming. Results indicated that children diagnosed with both Dysnomia and Dyslexia without AD/HD performed significantly lower on BNT than those in the Dysnomia/Dyslexia group with a primary attention deficit. No significant differences in BNT performance were noted for children only diagnosed with Dysnomia.

With regard to rapid naming, previous studies have demonstrated that children with poor attention spans performed faster on all RAN tasks compared to poor readers (Ackerman & Dykman, 1993). Similarly, Nigg and colleagues (1998) found that children with co-occurring attention and reading problems showed naming speed deficits whereas children with only an attention deficit did not. Hence, researchers indicate some contribution of attention problems to performance on RAN tasks although the co-occurrence of AD/HD is unlikely to account for all RAN deficits. Hence, this research question was attempting to identify whether poorer performance on measures of verbal

fluency, confrontation naming, rapid naming, or academic achievement may be associated with and/or compounded by attention problems.

Based on the hypothesis that a concurrent diagnosis of AD/HD would not significantly impact performance on measures of verbal fluency or confrontation naming, the current results were somewhat surprising. From a neuropsychological perspective, AD/HD is most notably associated with deficits in well-defined cognitive domains including executive functioning, a term which encompasses the ability to successfully engage in purposeful and self-directed tasks independently (Lezak et al., 2004). Successful performance on fluency and naming tasks relies on both attention capacity and executive functioning, cognitive domains which are frequently impacted by AD/HD (Barkley, 1998). Therefore, it seems particularly surprising that children with AD/HD performed significantly better than those without a primary attention deficit.

With regard to Word Fluency, previous studies of AD/HD and verbal fluency have produced inconclusive results, particularly when examining performance on semantic category fluency versus initial letter fluency tasks (Grodzinsky & Barkley, 1999; Grodzinsky & Diamond, 1992; Pineda, Ardila, & Rosselli, 1999; Reader, Harris, Schuerholz, & Denckla, 1994). Most research, including the current study, has included the total number of words produced within a set timeframe (e.g., 60 seconds), while recent studies have examined the pattern of word production over the course of the task. Researchers postulate that words which are more common and readily accessible are automatically activated at the start of the task while word production significantly decreases over time (Hurks, Hendriksen, Vles, Kalff, Feron, Kroes, et al., 2004).

There are a few possible explanations for the current findings on measures of verbal fluency and confrontation naming. One possible explanation for Word Fluency is that children with AD/HD demonstrate more difficulty producing words at the start of the task, yet gain momentum as time progresses. Another possibility is that the children with AD/HD were better able to focus their attention for the short duration of the task, due to the short and specified time limit for Word Fluency. On the BNT, it is possible that executive difficulties were somewhat managed by the design of the test. For instance, the test is not timed and children receive prompts (e.g., semantic, phonemic) which may assist to maintain focus. Clearly, based on the documented high incidence of co-morbidity between AD/HD and oral language deficits (Tirosh & Cohen, 1998), the links between reading domain abilities and executive functions should continue to be explored.

The final research question investigated whether significant differences exist between the neuro-cognitive profiles of these children (measured as academic achievement, rapid naming, verbal fluency, confrontation naming, sequential memory, and intelligence). Research has documented that children with learning disabilities display naming and word retrieval difficulties as well as a decrease in verbal fluency (Wiig & Semel, 1975, 1977). According to Wolf and Goodglass (1986), a number of processes are involved in word retrieval and naming tasks. Some common explanations for retrieval difficulties include visual perceptual deficits, memory problems, vocabulary deficits, and rate deficiencies. Research has also shown that children with Dysnomia have difficulties with verbal mediation that lead to poorer performance on tasks involving the visual presentation of information. As a result, it was hypothesized that children with both Dysnomia and Dyslexia would specifically display poorer performance on tasks

measuring rapid naming, word reading, and spelling. Performance on a measure of visual memory was also hypothesized to be lower while general intellectual performances were expected to be within normal limits for both groups.

Consistent with the stated hypotheses, general intellectual performances were within normal limits for both groups. Since average intellectual functioning was a criterion for inclusion in this study, this finding was not surprising. However, a significant difference was found between groups on the Similarities subtest. More specifically, children diagnosed with both Dysnomia and Dyslexia performed significantly better on a measure of verbal reasoning (e.g., Similarities) compared to children only diagnosed with Dysnomia. No differences on Block Design performance were noted.

With regard to reading-related tasks, findings indicated that children with Dysnomia performed significantly better on word reading and spelling tasks compared to children diagnosed with both Dysnomia and Dyslexia. In other words, children with both naming and reading deficits performed significantly lower on reading-related tasks compared to children who only experience word-finding difficulties. Once again, results are not surprising since these performance trends were needed in order to make a specific diagnosis of Dyslexia in the clinic setting.

Current results indicated no significant differences between groups on measures of verbal fluency and confrontation naming, although it should be noted that performance was consistently below average for children in both groups. Poor performances on Word Fluency and BNT likely suggest the presence of mild word-retrieval and/or verbal

fluency problems, even though the exact reason for these difficulties is not easily

identified.

According to the two-stage model of lexical access proposed by Levelt, Roelofs,

and Meyer (1999), lexical access refers to the process by which information about words

is retrieved from memory to map a lexical concept onto an articulatory program. Lexical

access proceeds in two distinct steps which include: (1) lexical selection, or the retrieval

of an appropriate word which makes the semantic and syntactic information available and

(2) phonological encoding in which the stored phonological form of a word is accessed

and input results in speech production. As a result, deficits with lexical retrieval could be

reflective of a disconnect between semantic and phonological codes (Faust, Dimitrovsky,

& Shacht, 2003) and/or the result of faulty semantic or phonological representations that

interfere with fast and accurate lexical retrieval (Messer & Dockrell, 2006).

In order to further investigate the possibility of faulty semantic and/or

phonological processing systems, assessments of children should consider the accuracy

of responses, patterns of errors, and speed of word retrieval on these specific tasks.

Working within a developmental framework requires that specific factors, such as speed

of information processing and developmental parameters of language acquisition be taken

into consideration, meaning that a broader, more general conceptualization of the process

may be needed (Thomas, 2003).

When examining rapid naming performances in the current study, significant

differences were not found. Nevertheless, below average performance was noted across

trials for both groups. Performance on RAN-Colors was highest for both groups while

RAN-Letters was the slowest. Within-group analyses also revealed significantly better

performance on RAN-Colors compared to RAN-Objects for both groups. These findings are not surprising since children with expressive language and reading impairments often display slower naming speed and naming dysfluency; more specifically, difficulties with rapid naming have suggested deficits in sight word identification (Meyer et al., 1998; Scarborough, 1998).

One noteworthy finding, however, is that rapid naming of letters is slowest for both groups. Speeded naming, particularly for letters and numbers, has consistently been found to account for unique variance in reading performance beyond that explained by phonological skills (Vellutino et al., 2004). Researchers have suggested that naming effects in reading and spelling are specific to alphanumeric stimuli (Savage & Frederickson, 2006; Semrud-Clikeman, Guy, & Griffin, 2002) and performance on alphanumeric RAN tasks appears to be more strongly associated with spelling.

Results from two longitudinal studies of RAN performance found that naming speed differentiates average from impaired readers (Wolf & Goodglass, 1986). Further, group differences for naming letters and numbers were found regardless of reading level or age while only early age group differences were supported for naming of colors and objects (Wolf & Goodglass, 1986; Wolf, Bally, & Morris, 1986). Therefore, it is not surprising that performance on RAN-Colors in this study was highest for children in both groups. However, it is interesting that performance between the two non-alphanumeric trials (colors/objects) is discrepant. One possible explanation for the significant difference between RAN-Colors and RAN-Objects is the higher semantic content of naming objects. In addition, colors represent content which is typically over-learned in childhood while naming objects may represent a more novel task.

Previous research suggests that rapid naming of familiar, visually presented stimuli is a good predictor of word identification skills and text-reading fluency (Wolf & Bowers, 1999; Wolf, Bowers, & Biddle, 2000). Naming tasks require that a visual stimulus be perceived and identified while also retrieving the associated verbal label (McCrory et al., 2004). Researchers indicate that poor readers experience distinct difficulties in rapidly accessing and retrieving verbal labels for visually presented stimuli (Denckla & Cutting, 1999; Savage et al., 2007; Wolf & Bowers, 1999). While both phoneme awareness and rapid naming play an important role in early literacy acquisition, rapid naming has been found to play a modest role compared to phonological processing (Cardoso-Martins & Pennington, 2004). Hence, rapid naming abilities have been found to affect the development of word identification, not word attack, skills and may eventually impact reading comprehension as well as the speed and accuracy of passage reading (Meyer et al., 1998). Based on the current results and similarities in RAN performances between groups, children with Dysnomia may be at an increased risk for developing later reading impairments.

With regard to sequential memory performances in the current study, some significant differences were found. More specifically, no significant differences were noted between groups on a measure of verbal sequential memory (Color Span Trial 4) while visual sequential memory performance was significantly lower for children with Dysnomia compared to children with both Dysnomia and Dyslexia.

Based on existing research literature, these results were somewhat surprising. Previous studies have substantiated the relationship between a visual memory deficit and reading disabilities, suggesting that difficulties in the efficient naming or labeling of

visual stimuli is a strong predictor for Dyslexia (Wood et al., 1989; Adams, 1990; Vellutino, 1996). Further, memory for visual information may be impaired due to the inefficient verbal labeling of visual stimuli which often results in Dysnomia. More specifically, researchers suggest that many children who experience reading delays also display significant deficits in rapidly accessing and retrieving verbal labels for visually presented stimuli (Denckla & Cutting, 1999; Wolf & Bowers, 1999).

Interestingly, children with Dysnomia performed significantly lower on the measure of visual memory compared to children with impaired reading. One possibility for why a significant difference was found is that children with Dysnomia have more difficulty with verbal mediation, particularly when presented with material that is not meaningful. Similarly, poor performance on Color Span Trial 1 may be reflective of greater difficulty with accessing the verbal label for information presented visually. When reading, these children may be able to more readily encode the information because of the semantic quality of words. Another possible explanation for a significant difference is the number of children who were administered the Color Span Trials 1 and 4 was less compared to the other neuropsychological measures, 52 and 104 participants, respectively. Therefore, it is possible that the difference is actually an artifact of the sample characteristics rather than representative of an actual occurrence. Future research should include more participants and incorporate measures of semantic as well as sequential visual memory to further delineate the nature of specific memory weaknesses.

In summary, several cognitive variables have been thought to be pertinent to Dysnomia and word-finding difficulties in children, and different theories exist about the mechanisms responsible for lexical access difficulties in children with Dyslexia and

Dysnomia. Research studies have demonstrated that early language difficulties may lead to later reading impairments, meaning that various skills associated with reading development should be considered when children display expressive language deficits. Results of the current study indicated that a concurrent diagnosis of AD/HD does not significantly impact performance on reading-related and rapid naming tasks although significant differences were found when examining word fluency and confrontation naming performances. When examining the neurocognitive profiles of these children, some significant differences were noted. General intelligence was within normal limits, yet children with both Dysnomia and Dyslexia performed significantly better on Similarities. Children with Dysnomia performed significantly better on reading-related tasks and worse on a measure of visual sequential memory. No significant differences were found between groups on measures of verbal fluency, confrontation naming, rapid naming, or verbal sequential memory, although performances were consistently below average for children in both groups.

<div align="center">Limitations of the Study</div>

There are several limitations to this study to be considered. The first limitation is the sample was drawn from a clinically referred population and the sample was restricted to children evaluated in an outpatient pediatric psychology clinic. The prevalence of language and learning disabilities is higher when a clinic sample is used, so it may have been helpful to draw from a broader group of children. Clinically referred children likely represented the more severe end of the diagnostic spectrum and, thus are more easily identified as needing assessment and intervention.

Second, the homogeneity of the sample was a limitation of the study. While specific demographic characteristics were not collected (e.g., race/ethnicity, parent education), participants in this study consisted of children from Iowa, for which the typical population is Caucasian and lives in rural communities. Therefore, the generalizability of the findings from this study may be limited by the restricted geographic region in which the participants lived.

Another limitation is the current study used an existing dataset, which impacted the number of appropriate analyses to be run as well as the inclusion of specific test measures in certain analyses. Demographic information regarding socioeconomic status, race/ethnicity, special education assistance, and/or specific geographic location was not included within this study and, therefore, it is unclear whether they are major contributors to the presence of language and learning disabilities.

Further, the sample was drawn from extant data of a clinically referred population, meaning there was not data collected for a comparison group. In other words, there was no group against which to compare the results of the study. While this study primarily examined differences between children with Dysnomia both with and without Dyslexia, a comparison group would have been ideal to better determine how groups differed from typically developing children without expressive language and/or reading impairments.

A final limitation of this study is that there was no control of external variables. Participants included in the current study reside in different areas and attend different schools. Thus, children are likely exposed to different curriculum demands, exposure to

instruction, and psychosocial stressors. Because these variables were not assessed or controlled, the results of this study are difficult to generalize to the larger population.

Implications for Research

The purpose of this study was to examine the nature of expressive language deficits for Dysnomic children with and without impaired reading. Interestingly, previous studies examining children with Dysnomia typically have not used multiple measures of expressive language. Hence, the current study examined different types of expressive language deficits (verbal fluency, confrontation naming, rapid naming) displayed by children with Dysnomia, both with and without Dyslexia, in an effort to delineate and better understand the specific factors associated with impaired reading. Results from the present study highlight some specific implications for future research.

First, research addressing the underlying connection between reading and rapid naming processes needs to continue. In particular, future research should investigate the specific variance for performance on rapid naming tasks to better understand the specific processes involved. Based on the lack of consistency across numerous research studies, it is likely that multiple causal factors influence patterns of naming in children. Producing a model of naming development that adequately explains how these processes work together, which cognitive processes may contribute to naming difficulties, and how children can compensate when one process is comprised is a challenging endeavor that has not been tackled in the current research literature. If researchers can more clearly identify the processes involved and assessed through rapid naming, more appropriate treatment interventions can be developed.

Next, using a neuropsychological approach with children allows researchers to gain a better understanding of the specific mechanisms involved with language and reading impairments. Messer and Dockrell (2006) argue for the use of cognitive-models (Levelt, 2001) in the assessment of children with expressive language impairments to more clearly conceptualize the unique nature of word-finding difficulties. Findings from research that use these cognitive models can help to identify the associations between behavioral processes and brain substrates. Furthermore, determining the component processes involved with word-retrieval abilities will allow a more precise localization of the cognitive processes causing difficulty. Adhering to a cognitive model of assessment addresses the question of whether word-finding and retrieval difficulties in children can be viewed as an isolated difficulty or a by-product of other language disabilities.

Another implication for future research is incorporating measures that assess multiple domains of cognitive functioning which include intelligence, listening comprehension, reading comprehension, spelling, and phonemic/phonological awareness in an effort to better understand the profile of cognitive strengths and deficits. In addition, due to the complex nature of early language acquisition, researchers have recommended including multiple measures of expressive language to better understand the nature of word-finding difficulties experienced by children with Dysnomia. In a recent study, Arnell and her colleagues (2009) examined the relation between rapid naming and reading in college-age adults by "decomposing" the RAN task into various cognitive subcomponents. More specifically, participants completed specific perceptual, processing, and performance tasks designed to tap into the mental processes required when performing RAN to determine which subcomponents explained its connection to

reading performance. Findings revealed that working memory encoding specifically underlies part of the relationship between RAN and reading performance.

In addition to investigating performance on multiple measures of expressive language, there is a need for assessments to incorporate differential modes of responding and presenting information. Rather than solely focusing on the use of verbal processes, measures which use nonverbal (e.g., pointing) means to demonstrate understanding may help to more thoroughly examine a cognitive domain (e.g. expressive language) and accurately pinpoint the nature of the impairment.

The nature of phonological representations in Dysnomic children is also not clear. While some researchers have suggested impoverished lexical representations as the source of naming difficulties (McGregor, 1994), not all children with Dysnomia display poor phonological skills. Instead, word-finding difficulties may be a result of poor links between the semantic and phonological representations of a word (e.g. tip-of-the-tongue; Faust et al., 1997; German & Newman, 2004). As a result, neuropsychological test batteries should also include additional measures of language processing (expressive/receptive), word attack and/or pseudoword decoding, and comprehension.

Another direction for future research is incorporating neuroimaging procedures and tools to better pinpoint where cognitive processes are breaking down for a child with language and/or reading impairments. Research suggests that it is difficult to determine the specific origin of expressive language and word-finding difficulties, particularly within a developmental context. As previously mentioned, cognitive functions are more well-developed and localized in an adult brain, making it potentially easier to identify the location of an injury by determining the specific functions that are impaired. However,

the relationship between brain and behavior is less direct with children. Problems relating

neuropsychological deficits to brain regions are compounded by additional factors that

include the exact time of onset of dysfunction, pre-morbid levels of functioning, and

environmental variables (e.g., family stresses or resources) (Aylward, 1988; Tramontana

& Hooper, 1988). For example, Functional Magnetic Resonance Imaging (fMRI) may be

used to aid researchers in the localization of specific cognitive functions involved in

various tasks. By using specific neuroimaging procedures, researchers may be able to

further delineate specific neurocognitive pathways involved with rapid naming and

reading processes.

Future research should also incorporate longitudinal designs, especially since both

Dysnomia and Dyslexia are developmental disorders. During development, myelination

of fiber systems in the brain occurs at varying speeds and different points in time.

Researchers have suggested that the myelination process proceeds rapidly until two years

of age although continues into adulthood (Rourke, 1995). In an effort to better understand

Dysnomia and word-finding difficulties from a developmental perspective, future

research should incorporate a longitudinal design following children over time.

Longitudinal studies from early childhood through adulthood would allow researchers to

more clearly identify the trajectory of language and learning disabilities in childhood as

well as inform the development and implementation of early intervention programs.

Finally, due to the documented association between low self-esteem and learning

disabilities, research should also include screening measures for social-emotional and/or

behavioral factors. Further, demographic information pertaining to race/ethnicity, socio-

economic status, parent education, special education assistance, and geographic location

should be collected to investigate whether these factors contribute to the behavioral manifestations of language and/or learning disabilities in children.

In summary, Dysnomia is a developmental condition characterized by deficits and strengths that require a comprehensive battery of neuropsychological measures for accurate diagnosis. By incorporating longitudinal research designs and neuroimaging techniques, researchers may gain more clarity into the developmental trajectory of language processing and the acquisition of reading skills. Due to the importance of word-retrieval and naming in language processing and cognitive development, as well as its predictive power for reading and school performance, this is an important area for further and continued research (Messer & Dockrell, 2006).

<div align="center">Implications for Practice</div>

The present findings highlight some important implications for both assessment and intervention in clinical practice. Currently, the diagnosis of individuals with Dyslexia is based on psychological assessment practices which include measures of general cognitive ability and reading achievement. Previous research has consistently demonstrated that numerous cognitive skills may predict reading ability, suggesting that reading achievement is a multi-faceted process consisting of numerous underlying components. In the complex system of reading, a breakdown in any part of the process will likely impact reading performance. However, the nature of difficulties experienced by children with reading impairments is heterogeneous rather than a unitary construct.

With regard to assessment, assessment practices need to comprehensively assess numerous subsystems that are important for positive reading performance. Rather than identifying if reading is lower than expected, it is important for clinicians to work toward

pinpointing the reason why reading is impaired. Often times, clinicians may focus more on the referral problem, rather than examining the presenting concern(s) in a more holistic manner. Hence, the need to better understand and delineate the difficulties experienced by children with language and reading processing means that the question driving the assessment process changes and assessment practices are adjusted.

Assessment practices that are sensitive to and focused on the underlying cause of reading problems should focus on evaluating different subsystems of reading in a comprehensive manner. This can be accomplished through selecting various subtests and/or psychological measures that tap into different cognitive processes involved with naming and reading. For example, a comprehensive battery can be developed which includes measures of auditory processing, phonological processing/pseudoword decoding, rapid naming, visual processing, and memory skills. Additional domains to assess may include word reading, spelling, reading comprehension, and reading fluency. While some overlap and shared variance exists, each of these cognitive and academic measures is dependent upon different regions of the brain and associated with different aspects of the reading process. Measures of executive function and attention are also needed since these higher-level cognitive skills are required for reading.

Clearly, a comprehensive assessment of the cognitive domains involved in the reading and naming processes is important because thorough assessment practices lead to a more well-developed diagnosis and intervention plan. When the underlying causes of reading impairment are understood, treatment and intervention becomes more targeted and specific. Interventions can then specifically address the deficit areas impacting reading performance, thus increasing the likelihood of effective treatment outcomes.

Due to the correlation between academic underachievement and self-esteem, social-emotional factors should also be included in the assessment. When a referral is made for an evaluation of a language and/or learning disability, it is not uncommon for a child to never be evaluated for a coinciding emotional/behavioral disorder and vice versa. If a psychologist does not evaluate the learning patterns of a child, s/he may attempt to conduct cognitive-behavioral interventions that are less than successful due to academic and/or cognitive weaknesses. On the contrary, if a child is referred for a re-evaluation of a learning disability and an emotional assessment is not included, the presence of a mood disorder may go undetected.

With regard to intervention, the importance of rapid naming to the prediction of reading performance has specific implications for treatment. A number of intervention programs developed for children with reading difficulties specifically target phonemic awareness and aim to improve phonological deficits. However, many previous studies indicate the importance of addressing rapid naming processes in treatment, namely to foster reading fluency. Some treatments have been developed to address reading fluency, although research is quite limited in this area (Wolf & Katzir-Cohen, 2001). More recent interest in the area of fluency may be reflective of an increased understanding into the complex subsystems involved with reading as well as continued curiosity about children who do not respond to phonological treatment (Wolf & Katzir-Cohen, 2001).

Treatment approaches targeting reading fluency have been proposed and most emphasize the importance of continued practice, broad exposure to reading, and repeated reading experience (Wolf, Miller, & Donnelly, 2000). Reading practice has specifically been emphasized in the development of reading fluency, especially since this process

reinforces decoding and word reading skills in the context of connected text (Vadasy, Sanders, & Peyton, 2005). Stahl, Heubach, and Cramond (1997) sought to enhance fluency outcomes by revamping a reading curriculum. More specifically, lessons were redesigned to specifically emphasize repeated readings, listening to readings, and increasing reading opportunities by establishing designated reading periods at home and school. Other researchers have attempted to improve fluency by using strategies such as having children repeatedly read passages, listen to passages while following along with the text, phrase drills, and repeated reading of words lists that appeared in the text (Daly, Murdoch, Lillenstein, Webber, & Lentz, 2002). Reading-while-listening and repeated reading exercises are useful techniques for developing fluency.

Intervention programs have also been developed which focus on integrating fluency-based with phonological-based treatment (Wolf, 1999). For example, the Retrieval, Automaticity, Vocabulary Elaboration, Orthography (RAVE-O) program (Wolf et al., 2000) was designed as an intensive, small-group intervention for second and third grade students. The purpose of the program was to improve fluency in overt reading outcomes as well as automaticity in underlying component skills. Fluency and automaticity processes are addressed while cognitive and emotional components are also included. Children are taught cognitive strategies to assist with decoding and word-retrieval, and self-concept is reinforced by through incremental successes (Wolf et al., 2000). In the RAVE-O program, a clear distinction is made between fluency and automaticity. Fluency specifically refers to "the acquisition of smooth rates of processing speed in reading outcomes," such as word identification, word attack, and comprehension, while automaticity is defined as "a continuum in which processes are

considered automatic when they are fast, obligatory, and autonomous and require only limited use of cognitive resources" (Wolf et al., 2000, p. 377). In essence, automaticity encompasses the underlying components involved in the reading process. Hence, one target for treatment is improving automaticity for the lower level, sublexical processes needed for reading fluency and another target is promoting fluency through repeated practice and exposure to words (Wolf et al., 2000).

Teaching for automaticity suggests that, as basic decoding skills are mastered, children should be regularly exposed to familiar and decodable sight words so these words become automatically accessible. As a core sight vocabulary is acquired, children may be exposed to more irregular words in order to increase reading accuracy. Starting at an early age, it is beneficial to teach children similarities and differences between speech sounds and visual patterns across words. Children with Dysnomia would likely benefit from direct instruction in language analysis and the alphabetic code. Further, explicit instruction in segmenting and blending speech sounds as well as processing progressively larger chunks of words would also be helpful.

Another implication for practice is that a greater emphasis needs to be placed on early intervention and prevention efforts specifically for preschool and kindergarten-aged children at-risk for reading and/or writing disabilities. While efforts have been made advocating for early intervention practices, these types of services are not always widely available in the public school system except for children with more significant delays and/or impairments. Unfortunately, the more children fall behind during early elementary school, the more educators and clinicians will be moving toward a "remedial" rather than a "preventive" model of intervention.

Based on previous developmental research, early language acquisition is posited to involve multiple processes and the activation of the visual and linguistic coding processes are emphasized to facilitate the storage of words and use of language. During development, children build phonological-orthographic connections between many different patterns, sounds, and phonemes to support word identification skills. Thus, multiple processes are thought to contribute to word retrieval and naming difficulties. As information is retrieved from the lexicon more frequently, the connections involved are strengthened. Therefore, word-finding difficulties at the phonological level may reflect reduced experience with retrieving these specific lexical items. Particularly for children at-risk for developing reading difficulties, it seems important to foster these connections by building background knowledge, teaching specific comprehension strategies, and providing regular practice with reading materials that are contextually meaningful.

<div align="center">Conclusions</div>

The present study examined the nature of expressive language deficits for Dysnomic children with and without impaired reading by incorporating multiple measures of expressive language. Performance differences were specifically investigated on measures of verbal fluency, confrontation naming, and rapid naming, as well as visual and verbal sequential memory. The impact of a concurrent diagnosis of a primary attention deficit was also examined within the context of cognitive performances.

Several decades of research have consistently pointed to the strong relations between reading and serial naming tasks (see review by Bowers, Golden, Kennedy, & Young, 1994). Wolf (1984) has argued that naming and reading tasks involve shared processes that include the perception, recognition, and sequencing of visual symbols,

access and retrieval of verbal labels, attention, and articulation. In particular, previous studies have found that deficits in rapid naming and expressive fluency are associated with reading disabilities in children (Vellutino et al., 1994). Research studies have also demonstrated that early language difficulties may lead to later reading impairments, meaning that various skills associated with reading development should be considered when children display expressive language deficits.

Results of the current study indicated that a concurrent diagnosis of AD/HD does not significantly impact performance on reading-related and rapid naming tasks although significant differences were found for verbal fluency and confrontation naming performances. When examining the neurocognitive profiles of these children, some significant differences were noted also noted. General intelligence was within normal limits, yet children with both Dysnomia and Dyslexia performed significantly better on Similarities. Children with Dysnomia performed significantly better on reading-related tasks and worse on a measure of visual sequential memory. No significant differences were found between groups on measures of verbal fluency, confrontation naming, rapid naming, or verbal sequential memory, although performances were consistently below average for children in both groups.

Future research efforts should continue to address the underlying connection between reading and rapid naming processes. Using a neuropsychological approach with children allows researchers to assess multiple domains of cognitive functioning and gain a better understanding of the specific mechanisms involved with rapid naming and reading. Incorporating neuroimaging procedures and longitudinal research designs may further help to pinpoint where cognitive processes are breaking down for a child with

language and/or reading deficits. Assessment practices are needed which are sensitive to and focused on determining the underlying cause of reading problems and clinicians should focus on evaluating different subsystems of reading in a comprehensive manner.

Establishing a more comprehensive diagnostic protocol of the processes involved with Dysnomia will enhance the understanding of successful versus deficient word retrieval abilities in children. In addition, gaining a more complete understanding of the processes involved with word retrieval and naming tasks will assist clinicians by allowing a more accurate and precise localization of the "cognitive processes that cause the difficulty and will address the question of whether word-finding difficulties can be viewed as an isolated difficulty or a by-product of other language disabilities" (Messer & Dockrell, 2006, p. 310). Due to the correlation between academic underachievement and self-esteem, social-emotional factors should also be included in the assessment. Treatment approaches targeting reading fluency and automaticity may be particularly helpful for children with Dysnomia, in addition to intervention programs which integrate fluency-based with phonological-based treatment.

Dysnomia is a developmental condition characterized by deficits and strengths that require a comprehensive battery of neuropsychological measures for accurate diagnosis. Gaining a better understanding of the unique nature of Dysnomia in school-aged children will allow clinicians to more adequately determine where to target educational interventions. Psychologists are in a unique position to administer comprehensive evaluations of children with expressive language and/or reading difficulties, examine multiple cognitive subcomponents underlying these processes, and make appropriate treatment recommendations. By continuing to explore these specific

questions and gaps in the existing research literature, we can begin to better understand

the nature of expressive language deficits in children and, thus, tailor interventions for

these children before difficulties become more long-standing and impairing.

APPENDIX A:

PEDIATRIC PSYCHOLOGY NORMS

PEDIATRIC PSYCHOLOGY NORMS

Word Fluency (WF)

Age (years)	Female		Male	
	x	SD	x	SD
6	4.6	5.0	4.1	4.1
7	16.0	7.3	14.1	6.5
8	23.1	5.7	22.5	7.7
9	25.0	7.3	22.6	6.4
10	27.4	7.1	23.8	8.2
11	31.1	6.8	28.2	8.1
12	32.0	6.8	29.4	8.1

Boston Naming Test (BNT)

Age (grade)	Total	
	x	SD
5.5 (K)	29.6	5.78
6.5 (1st)	29.0	5.55
7.5 (2nd)	37.0	4.15
8.5 (3rd)	38.4	2.94
9.5 (4th)	41.6	3.56
10.5 (5th)	43.2	4.07
12 and over	55.7	4.42

Rapid Automatized Naming (RAN)

Colors

Age (years)	Female		Male	
	x	SD	x	SD
6	57.0	17.0	59.0	17.0
7	52.4	8.8	56.3	10.9
8	49.0	11.7	54.7	6.9
9	40.4	6.9	46.5	11.4
10	41.4	5.9	42.3	8.2
11	35.0	7.0	35.0	7.0
12	32.0	6.96	32.0	6.96

Objects

Age (years)	x	SD
6	71.0	21.0
7	70.0	24.2
8	62.0	12.6
9	48.0	10.7
10	50.0	10.8
11	36.0	6.9
12	35.0	7.0

Numbers

Age (years)	x	SD
6	45.0	16.0
7	34.0	6.8
8	31.0	5.8
9	26.0	8.6
10	24.0	3.5
11	21.0	7.0
12	19.0	6.8

Letters

Age (years)	x	SD
6	43.0	19.0
7	33.0	6.3
8	31.0	6.9
9	25.0	5.1
10	24.0	2.9
11	22.0	6.9
12	21.0	7.0

Color Span

Trial 1 (Visual/Visual)

	Female		Male	
Age (years)	x	SD	x	SD
6	4.4	1.4	4.3	1.3
7	5.6	0.9	5.5	1.0
8	6.1	1.8	6.0	1.7
9	7.4	1.5	6.8	1.6
10	8.1	1.8	7.6	1.8
11	9.4	1.1	8.7	2.0
12	10.1	1.6	10.2	1.7

Trial 4 (Verbal/Verbal)

	Female		Male	
Age (years)	x	SD	x	SD
6	4.3	1.5	4.4	1.1
7	6.1	1.6	5.8	1.4
8	6.7	1.4	6.4	1.7
9	7.6	1.1	6.9	1.2
10	7.9	1.0	7.7	1.5
11	9.1	1.8	8.8	1.5
12	9.2	1.4	8.9	1.7

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