Introduction

Approximately 10% of the population is diagnosed as dyslexic (Habib, 2000). Specialized testing most often reveals this disability in third grade or later, when there develops an observable differential between reading achievement and IQ (Wenar and Kerig, 2000). This late identification poses severe problems for effective remediation. At the time of diagnosis, poor readers are on a trajectory of failure that becomes increasingly difficult to reverse. Attempts at intervention must both focus on remediation of the impaired components of reading as well as extensive rehabilitation to reverse the growing experience differential.

Educators and researchers are aware of the need for early diagnosis. In response, research investigating early correlates of later reading ability/disability has burgeoned (e.g. Wagner, Torgesen, Rashotte, Hecht, Barker, Burgess, Donahue, & Garon, 1997). However, these early reading studies primarily focus on school age children (e.g. Share, Jorm, Maclean, & Matthews, 1984). To date, there are few studies focusing on the reading trajectories of children younger than preschool, and there is little consistency within the existing studies (Scarborough, 1990, 1991; Lonigan, Burgess, Anthony, & Barker, 1998; Olofsson & Niedersoe, 1999; Molfese, Molfese, & Modgline, 2001; Gathercole & Adams, 1993).

We propose that the correlates of reading develop and can be identified earlier than preschool and kindergarten. The purpose of the current project is to identify two very early correlates of later reading disability. Ideally, through early identification of reading disability, children can enter school with the aid and remediation necessary to stay on a positive developmental trajectory.

Brief Review of Dyslexia

One of the challenges of the current research in dyslexia is to determine its etiology. Dyslexia is a heterogeneous disorder. Dyslexics present with a multitude of behavioral deficits and with great

variability in individual profiles (Adams et al, 1998). However, researchers have converged on a unanimous description of dyslexia's most glaring deficit. About 80 – 90% of all reading disabled children all show a phonological deficit (Wenar & Kerig, 2000). Through comparison with both chronological age and reading age controls, studies demonstrate that while dyslexics present with a multitude of lexical and sublexical deficits, only the sublexical deficits in phonological processing show discrete impairment as opposed to simple delay (Castles, & Coltheart, 1993). Both longitudinal, training, and carefully controlled cross-sectional studies have repeatedly shown isolated phonological impairment to be the one consistent marker of reading disability (e.g. Bradley & Bryant, 1983; Gough & Turner, 1986; Liberman, Shankweiler, & Liberman, 1989 cited in Pugh et al, 2000). Behaviorally, the most common impairments are deficits in: phoneme identification, analysis and segmentation, rapid naming, and working memory tasks. While there is some debate over whether there is a single underlying phonological construct or multiple, researchers most often divide phonological processing into three distinct categories: phonological awareness (blending and segmenting of sound units), phonological working memory (storage and manipulation of sound units), and phonological rapid access (speed of processing of and access to sound units) (McBride-Chang, 1995b).

Given this convergence of deficits, researchers have struggled to identify a unitary cause of dyslexia. Four major theoretical camps proposing divergent causal models have formed over the past 50 years. On one side, researchers argue that a disruption in the phonological assembly process is the underlying cause of dyslexia (Bradley & Bryant, 1981; Bryant, Nunes, & Bindman 1998; Liberman & Shankweiler, 1985; Morais, Luytens & Alegria, 1984; cited in Galaburda, A. & G. Rosen, 2001). The other side acknowledges that dyslexics manifest a behavioral disorder in their phonological processing; however, these researchers posit that there is an underlying and lower-level deficit which accounts for this behavior. Some argue that the deficit is a sensory processing impairment, one group

positing an auditory origin, the other a visual base. Others advocate for a temporal processing deficit underlying the sensory problems (Adams, 1990; Snowling, 1987; Stanovich, 1988a, Vellutino, 1979; Wagner & Torgesen, 1987 cited in Joanisse, M.F, Manis, F.R., Keeting, P. & M.S. Seidenberg). Each of these theories has met with both success and failure, and yet no unitary causal explanation has been unveiled. Instead, the continuing supportive evidence for each of these four separate theories has lead researchers to speculate that dyslexia may be a composite of multiple deficits (Eden, 2002 lecture series). Some are calling for an interdisciplinary approach to understanding dyslexia, positing that the main impairment is phonological with some underlying sensory deficits (Eden, 2002).

Without assuming any established causal framework, I will review possible causes of this behavioral deficit by adopting one of the more interesting and unique perspectives in the field, the view that reading deficiency is an outgrowth of language deficiency. This approach, while often considered relevant only to the auditory deficit group, is actually more broadly implicated in the decoding process than at just the sensory level. The following review provides insights into a possible convergence between the sensory processing and phonological processing deficit models.

The impetus behind the language deficit model is obvious. The underlying commonality of phonological awareness, working memory, and rapid access, is that each involves a child's processing of phonetic units. It is a natural step to question whether the locus of impairment of reading disabled children lies specifically in the processing of speech units. This approach has led some researchers to propose that learning to read may rely on the adequacy of certain linguistic skills (Mann, 1984).

There are several ways in which speech processing may be implicated in phonological impairments and reading. The identification, manipulation and storage of phonetic information are all areas of possible impairment that could produce the delineated profile of a dyslexic. What's more, these three processes are critical components of multiple stages of the decoding process (see

Attachment A). "The speech-specific hypothesis (Liberman, 1998) proposes that the deficit is in the phonetic transform from analog neural response pattern to digital lexical/phonological representation." (Studdert-Kennedy, 2002 p6). Evidence in support of the speech-specific hypothesis has found poor readers to be impaired on speech perception but not non-speech perception tasks and verbal working memory tasks whether heard or read, but not non-verbal working memory tasks (Mody, Studdert-Kennedy, & Brady, 1997 cited in Studdert-Kennedy, 2002). However, research has had a difficult time teasing apart the unique and specific contribution of each mechanism to determine where impairment may truly lie.

Phonological impairment may stem exclusively from a deficit in identification and encoding of speech units, or impairment in speech perception. Speech is not an "acoustic alphabet" (Studdert-Kennedy, 2002). Given the degree of coarticulation within a spoken word, the ability to parse a word into its constituent phonemes relies heavily on an individual's intact categorical perception. While all infants are born with the ability to perceive the phonetic contrasts of any language (Sternberg, 2003), it is possible that there are gradations in this ability or, that with development some infants fail to tune or consolidate their phonemic categories (Kuhl, 198? cited by Chandan, 2002). Either possibility could have significant impact on later phonological manipulations particularly within a written language. The inability to accurately perceive acoustic stimuli could lead to the establishment of 'fuzzy' or underspecified' lexical representations and weak verbal short-term memory (Liberman, 1998 cited in Studdert-Kennedy, 2002). The root of impairments seen in phonological working memory and rapid naming tasks could be simply a product of poor speech perception.

The goal of researchers advocating the speech-specific hypothesis is to discover whether speech perception is a causal factor in dyslexia. Researchers have taken several different approaches to answering this; however none have converged on evidence of a causal link between speech

perception and phonological impairment in dyslexics. Multiple cross-sectional studies demonstrate correlations between an individual's speech perception (typically phonemic discrimination of consonant and vowel pairs) and phonological processing (segmentation or identification) (e.g. Tallal, 1980; Hurford, 1991; cited in McBride-Chang, 1995b). However, McBride-Chang (1996) used path analysis to show that the effects of speech perception on word reading were mediated by its bidirectional relationship with phonological processing skills, emphasizing the lack of a causal link to reading. What's more, some studies have found that reading-disabled children suffer from impaired speech perception (e.g. Brady, Shankweiler, & Mann, 1983; cited in McBride-Chang, 1995b), while other studies have found no difference in speech perception between impaired and normal readers (Pennington, Van Orden, Smith, Green, & Haith, 1990; Snowling, Goulandris, Bowlbey & Howell, 1986 cited in McBride-Chang, 1995b). One of causes for divergence may be that the current research is riddled methodological inconsistencies, particularly the inability to tease apart the contribution of perceiving phonemic contrast versus storage of the phonemic information (McBride-Chang, 1995b)

A final approach to determining the causal relationship between speech perception, phonological processing and reading ability is through longitudinal studies. Most longitudinal studies concentrate on the effects of speech perception on phonological processing and reading in children between the ages of 4 – 6 years (e.g. Joanisse, Manis, Keeting, Seidenberg, 2000). While there is evidence of language specific impairment in children who later become poor readers, such as deficits in receptive and expressive vocabulary, speech discrimination abilities, syntactic awareness, comprehension and production (cited in Scarborough, 1990), most of these factors fail to produce unique variance when controlling for prior reading ability except for specific phonological processing skills (Burgess, 2002). One possible explanation is "… that greater variability in speech perception

will emerge in younger children and infants in whom speech skills are changing more rapidly." (McBride-Chang, p1852) which could produce the necessary causal connection.

Scarborough (1990, 1991) provided definitive evidence against the speech perception hypothesis in her study looking at very early predictors of later reading disability. Scarborough (1990, 1991) collected measures of oral language proficiency in three groups of 30- month-old children taken from a mix of families, some with a history of dyslexia and others with no history of reading impairment. The subjects were given a language battery measuring language comprehension and production at equal intervals over a three year period. The measures were designed to tap vocabulary recognition, naming vocabulary, speech discrimination, a child's productive syntax, MLUs, phonological production, and lexical diversity. The results showed that only phonological production and syntactic complexity in the two- and three-year-old children were significantly correlated with later phonological awareness and early reading ability. This study provides clear longitudinal evidence that speech perception is not causally implicated in later reading disability.

A second possible language impairment may be a deficit in verbal working memory. Limits on either the long-term storage of phonetic information or on the short term working memory space, may produce the phonological impairments noted in dyslexics. According to Baddeley's (1999) tripartite model, verbal working memory constitutes a storage mechanism for acoustically coded information. The acoustic nature of this mechanisms has been reinforced by research demonstrating that subjects have more difficulty storing information that is acoustically similar than semantically or visually similar information (Baddeley, 1999; Conrad, 1964 cited in Sternberg, 2004). Mann and colleagues produced a variety of studies investigating the role of phonological working memory in impaired readers. Overall, they found that poor readers performed worse on acoustic memory tasks than good readers, but performed equally as well on nonverbal memory tasks. What's more, on the verbal

memory tasks, good readers were significantly more influenced by acoustic confusability than poor readers (Mann, 1984). This performance differential suggests that the verbal working memories of impaired readers are different than non-impaired readers, however is not clear whether this is a result of poorer phonetic representations or of a more rapid rate of decay.

Although there is evidence for a difference in working memory between impaired and nonimpaired readers, it is unclear whether this a causal factor in dyslexia. Working memory or the ability to manipulate and store phonetic representations is implicated in many levels of the decoding process, and often in concert with other mechanisms (see Attachment A). For this reason, it has proven difficult to determine the individual contribution of this process to decoding and later reading ability.

A third possible language impairment may be limitations in the speed with which an individual is able to process phonetic units. "The efficiency with which children are able to retrieve phonological codes associated with individual phonemes, word segments, or entire words should influence the degree to which phonological information is useful in decoding print words." (Baddley, 1986; Wolf, 1991 cited in Wagner, Torgesen, and Rashotte, p6). While there has been consistent support for the importance of rapid naming ability in later reading it is unclear still whether this is a general speed of processing factor, or whether it is specific to language (Wolf, O'Rourke, Gidney, Lovett, Cirino, & Morris, 2002; Bowers & Newby-Clark, 2002). If specific to language, there are two stages in the decoding process at which processing speed may be related to reading disability. In the phonemic recoding stage, it may be that the phonetic representations that need to be called up are either more poorly represented (degraded) or are more poorly organized, or it may be that an individual's speed of processing linguistic material is limited. On the other hand, it may in the last stage of decoding where

retrieval of a lexical entry is slowed either due to speed of processing limitations or due to the organization of the mental lexicon.

The rapid naming argument relies on the assumption that individuals (and children in particular) are storing their phonemic information in an organized manner. There is some behavioral evidence demonstrating the primacy of lexical organization even in young children. Nelson (1996) argued that there are three developmental stages to word learning (Backsheider & Shatz, 2001). First, children learn word to world mappings. Only once they've mastered this, can children move onto word to concept mappings. And finally, word to word mappings. Shatz and Backsheider (2001) provided evidence that this hierarchy may not be rigidly established in children's word learning. They argued that children learning language develop word-word mappings in addition to word-world mappings. They posited that children actually are hierarchically organizing their lexicon while developing it; and this early structuring of the lexicon creates the template upon which later knowledge develops (Shatz & Backscheider, 2001). If this is true, one possible task for the child is lexical organization. If lexical organization is a feature of word learning, children unable to successfully organize their mental lexicons may show slower access rates.

The speed of processing variable is involved in several stages of the decoding process in collaboration with other mechanisms. For this reason, it has been difficult to identify the degree of predictive power this measure has for later reading ability. Some researchers argue that rapid naming is only implicated in a subset of dyslexics (Wolf, O'Rourke, Gidney, Lovett, Cirino, & Morris, 2002), arguing for adopting a dual-deficit approach to understanding the etiology of dyslexia. Given the complicated role of rapid naming in decoding and dyslexia, it is not surprising that to date, no research has been able to identify whether it plays a causal role in reading disability.

The speech-specific hypothesis argues that impairments in identification, manipulation and storage of phonetic units, processes that are integral in the decoding process, are implicated in reading disability. Impairments in any of these areas could produce the observed behavioral deficits in phonological awareness, working memory, and speed of processing. However, to date, the research on the possibility of an underlying speech impairment is inconclusive. First, there is evidence that the ability to discriminate phonemes is not a causal factor in reading disability. Second, it is unclear whether phonological working memory and rapid processing play a causal role in reading impairment. Part of the reason may be that each of these skills is implicated at multiple levels within the decoding model and often in concert with other processes, and therefore the unique variance contributed by either mechanism is difficult to tease apart. Research needs to continue to investigate the unique role that these two processes may play in the decoding process.

One process that differentiates speech processing from reading is the process of phonological recoding, or of mapping specific phonemes onto visual symbols. This process requires two steps. First, it demands the recall of appropriate phonetic matches. In order to do this an individual must perceive phonemic distinctions and somehow accurately store these distinctions. The second step requires an individual to map the specific phonemic unit to the appropriate letter. Many researchers posit that this alone is the locus of impairment in dyslexics. These theorists propose that the underlying core dysfunction in dyslexia **is** a disruption in the phonological assembly process (Bradley & Bryan, 1983; Gough & Turner, 1986; Liberman, Shankweiler, & Liberman, 1989 cited in Pugh et al, 2000). Namely, the development and subsequent automatization of the grapheme to phoneme mapping is impaired (Coltheart, Curtis, Atkins, & Haller, 1993). However, while this is specific to reading, this decoding process implicates both speech specific abilities such as phonetic representation

and storage as well as reading specific mechanisms, the mapping of letters to sounds. Therefore, it may be necessary to view this as a reading specific impairment with possible speech specific causes.

I propose that dyslexia is a multi-faceted disorder with several underlying impairments. Research has suggested that possible candidates for impairment are an individual's ability to represent, store and manipulate the units of speech and their ability to map these units onto abstract symbols. These are all abilities that develop and can be identified earlier that preschool. I propose to investigate the development of two of these factors, phonemic coding and mental lexical development in children younger than preschool.

In the current study, we trace the development of these two aspects of the phonological processing deficit in a longitudinal follow-up study of two-year-olds. Shatz and colleagues (1996, 1999, 2001) investigated the underlying lexical structure in two-year-old children. Although their experiments were tailored to investigate early word learning behavior, their study design is uniquely suited to looking at the phonological processing skills of two-year old children as well. We measure the early reading skills of these same two-year-olds at five to seven years of age in order to determine the predictivity of the early two-year old behaviors for later reading ability.

Word to Word Study of Two-year-olds

Shatz and Backscheider completed a series of experiments demonstrating word-word knowledge for color terms and letter and number names (Shatz & Backscheider, 1993; Shatz et al, 1996, Shatz et al, 1999; Shatz and Backsheider, 2001). These experiments show that children between the ages of 19 – 22 months demonstrate the ability to distinguish the appropriate categorical knowledge, while still not knowing the appropriate content specifics. Thus, when asked what color a certain item was, these children were able to designate the appropriate category, but would give the incorrect response. For example, more children would answer 'yellow', when asked 'what color is the

car?' about a blue car, than expected by chance. Thus, children seem to a certain extent to rely on categorical knowledge to constrain if not guide their responses for color knowledge.

All these experiments demonstrate that children have a certain level of word-word lexical knowledge in the absence of the relevant content knowledge. This evidence suggests that an important step in learning language is simultaneously organizing while augmenting their lexicons. However, for our current purpose there is more to the design than simply the demonstration of early word categorizing ability. The study of both letters and numbers also measured children's ability to map meaning to abstract symbols, a fundamental underpinning of phonological mapping.

There were two different task designs between Study 1 and Study 2. In Study 1, children were asked either, "What letter is this?" or "What number is this?" with the presentation of a visual stimulus. Thus, they receive a lexical cue of the categorical membership of the presented stimulus. In the second condition, the children were presented with the visual stimulus and simply asked, "What is this?", without any lexical cue to category membership. The second condition teases apart the contribution of mapping meaning to abstract symbols from the child's propensity to organize his/her lexicon.

The results from these two studies allow children to be categorized on both their early lexical organization and their ability to map meaning onto abstract symbols at two-years of age. Children's ability to map meaning onto abstract symbols may be an early precursor of their ability to learn to read. The process of assigning phonemic meaning to letters is the external representation of a process that is deeply embedded within decoding. This study is uniquely suited to measure both children's lexical organization, but also their ability to perform the requisite phonological recoding independent of the reading process. We retested these children when they first began to read to see if there is any correlation with their early word learning ability.

This study is important on several different levels. For one, if there is a correlation between early language learning and later reading performance, then this could be used as an early indicator of dyslexia. Thus, intervention measures could be applied earlier and with potentially with greater impact. Secondly, if there is a positive correlation, it needs to be determined what aspect of the task is reflecting a deficit.

Hypothesis:

Our global hypothesis posits that there is a connection between the two-year olds' performance on the word-to-word mapping studies and later reading ability. This global classification can be divided into specific hypotheses based on the results from the two-year-old word study. There are three classifications of performance on the two-year old word to word mapping study: results that are 1.) category and content correct; 2.) category correct, content incorrect; 3.) category and content incorrect. The different categories of performance each present different theoretical implications, or hypotheses to be tested. Children performing in Group 1 and Group 2 are clearly organizing their mental lexicons. Therefore, a comparison between these two groups and the children in group three can tap the aspect of mental lexical organization hypothesized to underlie a child's rapid naming abilities. Second, a comparison of these groups within each study and across the two studies provides a way to investigate the mapping abilities of these two-year-olds. In Study 1, the children are given a lexical cue to the category membership of the symbol they are presented. Group 1 children in Study 1 are able to identify the stimulus appropriately. They clearly have mapped the abstract visual symbol presented to its appropriate phonemic marker. There are two possible causes underlying Group 2's behavior. In Group 2, the children may have responded with a category correct item because they were cued by the question (which provided the lexical cue of category membership) in which case, their performance could be independent of mapping between a visual stimulus and auditory category.

However, a second possibility is that they showed a highly refined mapping ability. Group 2 children may be mapping the visual stimulus to it superordinate lexical marker or category, while still not having the specific marker necessary. This suggests that children are simultaneously organizing their mental lexicons and the visual referents, a highly sophisticated possibility. Unfortunately, the children in Group 2 of Study 1 do not provide a means for distinguishing between these two possibilities. However, Study 2 provides a way to tease apart this confound. Children in Group 3, are clearly failing to both organize and map effectively. In Study 2, children receive no lexical cue of category membership. Children in Group 1 of Study 2, are clearly mapping an abstract symbol onto its specific phonemic counterpart. Children in Group 2, are clearly mapping an abstract symbol onto the category of the appropriate phonemic counterpart, before actually knowing the specific phonemic mappings. Children in Group 3 are failing both tasks of mapping and organizing.

A comparison between performance on reading measures of Group 1 and Group 3 children for both studies will address the global hypothesis of whether there is continuity between word learning behaviors at two years of age and later reading abilities. A comparison of the Group 2 children in both studies will help address the specific hypotheses about the relationship between a child's mental lexical organization and mapping abilities and his/her later reading abilities.

We propose the that group membership will be correlated in the following ways:

Group 1: We hypothesize that these children will be performing at a developmentally advanced level.

Group 2: We hypothesize that these children may either be on a slower developmental trajectory or may have specific mapping impairments.

Group 3: We hypothesize that these children may be either slower developmentally or developmentally impaired.

Current Study

The study conducted is a prospective study correlating language learning at two years of age with later reading specific abilities. Our interests lie in the correlation between children manifesting difficulty both with the task at two years of age and with the later precursors to reading and reading-specific measures. Thus, the study will look at the development of reading impairment.

There are two goals embedded in the design. The first goal is to determine what aspect of the phonological assembly route is breaking down. To date, researchers have avoided decomposing the phonological process to this degree, and thus this is an important step in producing clearer and less methodologically compromised research. The second goal is to provide a reliable correlate of dyslexia for earlier intervention. The prospective study we designed attempts to tease apart the contributions of the differing aspects of phonological assembly and language learning.

See Attachment B for Methods.

Conclusions

The correlates of reading develop and can be identified earlier than preschool. The current study is designed to test this hypothesis by investigating two potential underlying mechanisms of reading in two year old children. There are several limitations to the current design. First, the most obvious problem is the limited sample size. Second, the number of measures collected will also reduce the power of the current design. A final limitation is in the methods where there may have been inconsistencies in administration due to different experimental techniques, location of testing, and general experimental error. Regardless, this study is innovative in several ways. First, it is one of the few studies proposing to disentangle the specific processes contributing to the impaired phonological processing profile of a dyslexic. It is also unique in that it is tracking the development of reading abilities in two-year-old children.

Attachment B

Method

Participants

A total of forty of the original sixty two year old children participated in the current study of early predictors of reading. The mean age was X years (range = 5.0 – 6.11 years); X were in kindergarten and X were in first grade. Testing started in the August of 2002 and ended December, 2002. The group had equal distribution of gender. Socio-economic status was not assessed, but subjects were recruited from university-affiliated and private day-care centers serving primarily academic and middle-class families. No questions were asked about ethnic or racial identity, but participants were presumably representative of a large Midwestern university community. All participants were native English speakers except for one, whose data was removed for the purpose of analysis. Because of subsequent diagnosis of Asperger's syndrome, data from one of the original children tested was not included in the analysis. A total of 38 children were included in the present analyses.

Procedure

Children were tested individually by trained experimenters in a quiet private testing area either in their home or in the child lab at the University of Michigan. The testing took an hour to complete and was administered in a single sitting.

Tasks

In the current study, we administered a battery of pre and early reading measures designed to assess multiple components of a child's developing reading abilities. Participants engaged in a series of tasks measuring letter, sound, and word identification skills, skills that are strong predictors of later reading

fluency (e.g. Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997). See Attachment B for write up of measures.

Letter knowledge is one of the strongest, most consistent predictors of later reading ability in preschool through first grade children. Both the accuracy and speed of letter naming and letter sound knowledge contribute significant unique variance to the child's developing phonological processing skills and his/her later reading ability (e.g.).

Alphabet Letter Name Knowledge. Children's knowledge of the names of the letters of the alphabet was assessed for all 26 uppercase letters. The child was required to name the letter as it was presented in a random order on a flashcard. A maximum score of 26 points was possible for the task. Speed measures were collected as well as accuracy.

Alphabet Letter Sound Knowledge. Children's knowledge of the sounds of the letters of the alphabet was assessed for 25 uppercase letters ('X' was removed based on theoretical considerations). The child was told, "This next task is like the one we just completed, but this time you are going to tell me the sound the letter makes. If a letter makes two different sounds, just tell me one of the sounds." The child then was required to name the sound of the letter as it was presented in a random order on a flashcard. A maximum score of 25 points was possible for the task. Speed measures were collected as well as accuracy.

The Comprehensive Test of Phonological Processing (CTOPP) assesses phonological awareness, phonological memory, and rapid naming. A deficit in one or more of these kinds of phonological processing skills is viewed as the most common cause of reading disabilities.

CTOPP- Children phonological processing skills were assessed using Wagner, Torgesen & Rashotte's (1997) Comprehensive Test of Phonological Processing (CTOPP). There are seven subtests: elision,

rapid color naming, blending words, sound matching, rapid object naming, memory for digits and nonword repetition.

- Elision: measures children's ability to segment the initial, final or middle phoneme.
- Rapid Color Naming: measures the speed with which a child can name the colors of a series of different colored blocks printed on a page. The colors represented are six randomly arranged colors (blue, red, green, black, yellow, brown). This is a traditional measure of a child's rate of processing, and may asses the operation of a precise timing mechanism that is important for the developing knowledge of common letter patterns in printed words (Bowers & Wolf, 1993; Wolf, 1991)
- Blending Words: measures children's ability to blend phonemes to produce words of increasing complexity.
- Sound Matching: measures the extent to which an individual can match sounds. The first part requires an individual to find the picture with an initial sound matching the initial sound of the template. The second section requires the individual to find the picture with a final sound matching the final sound of the template.
- Rapid Object Naming: measures a child's speed of naming objects. Six different randomly arranged drawings (pencil, star, fish, chair, boat, key) are used.
- Memory for Digits: Measures the child's ability to repeat a series of numbers that range in length from 2 to 8 digits.
- Nonword repetition: measures a child's ability to repeat nonwords that range in length from 3 – 15 sounds.

The Woodcock Johnson Achievement Battery- Revised (Woodcock and Mather, 1989) was administered as a measure of word reading ability in order to control for reading differences (due to

age and experience differences) and to provide a different measure of reading outcomes. Subjects were administered the Letter-Word, Fluency, and Comprehension subtests which make up a reading composite.

- Letter-Word: requires the identification of letters and words.
- Passage Comprehension: uses a cloze procedure requiring the child to read sentences with words missing, and to supply the appropriate word to best satisfy the demands of the sentence.
- Fluency: is a three minute timed test requiring a child to read a series of sentences making statements. For each sentence, the child must circle 'yes' or 'no' to verify the validity of the sentence.

Block Design: We administered the block design subtest of the Wechsler Preschool and Primary Scales of Intelligence - Revised (WWPSI- III) (Wechsler, 1989) as a measure of nonverbal IQ to control for nonverbal IQ differences.

Parent Questionnaire: The parent was asked to complete a questionnaire designed to assess both the socioeconomic status of the household and the child's home literacy environment. Both SES and home literacy are significant factors in a child's later reading ability (X)

Child's literacy exposure: was a section designed to assess, the amount of reading in the home, number of books available, frequency of library visits, amount of TV watched, the amount of reading instruction within the home, and the type of reading instruction within the classroom.

SES: was measured using a composite of degree of educational attainment in home, profession, and number of years in job based on Holingshead's X (X).

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