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Naming Speed, Letter-Sound Automaticity, and Acquiring Blending Skills among Students with Moderate Intellectual Disabilities

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ACCEPTANCE

This dissertation, NAMING SPEED, LETTER-SOUND AUTOMATICITY, AND ACQUIRING BLENDING SKILLS AMONG STUDENTS WITH MODERATE INTELLECTUAL DISABILITIES, by DAWN H. DAVIS, was prepared under the direction of the candidates Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University.

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ABSTRACT

NAMING SPEED, LETTER-SOUND AUTOMATICITY, AND ACQUIRING BLENDING SKILLS AMONG STUDENTS WITH MODERATE INTELLECTUAL DISABILITIES
by
Dawn H. Davis

Students with moderate intellectual disabilities (MoID) typically are not taught decoding skills because they have difficulty mastering critical blending skills. In response to this skill deficit among students with MoID, an *Initial Phonics* instructional sequence was created that included student development of rapid and automatic retrieval of taught letter-sound correspondences to a level of mastery before teaching the skill of blending. For each of 16 students with MoID (ages 6-15), mastery criterion of letter-sound automaticity phases was determined by their individual naming speed as measured by the Rapid Object Naming (RON) subtest of the *Comprehensive Test of Phonological Processing* (CTOPP). Visual analysis of graphically displayed single-case data revealed a functional relation between simultaneous prompting procedures and letter-sound correspondences, automaticity, and blending acquisition for all students. Furthermore, the use of hierarchical linear growth modeling (HLGM) revealed statistical significance for: (a) the impact of daily instruction on the development of letter-sound correspondences, automaticity, and blending in terms of average student growth per instructional session, (b) variability between student growth trajectories within automaticity and blending phases, (c) student pretest scores on RON as an explanatory variable for differences between growth trajectories within automaticity treatment phases, and (d) the extent to which the number of sessions to mastery within automaticity phases and student age predicted acquisition of blending skills. The purpose of identifying explanatory/predictor

variables was to classify cognitive predictors for students with MoID who successfully acquire blending skills.

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ABBREVIATIONS

AUTONUM	Number of sessions to mastery of automaticity of letter-sounds
CSPM	Correct Sounds Per Minute
HLGM	Hierarchical Linear Growth Modeling
MoID	Moderate Intellectual Disabilities
NRP	National Reading Panel
NS	Naming Speed
RON	Rapid Object Naming
W-AS	Word-Analysis Skills

CHAPTER 1

TEACHING STUDENTS WITH MODERATE INTELLECTUAL DISABILITIES TO READ: A REVIEW OF THE LITERATURE

We shouldn't teach great books; we should teach a love of reading.
~B.F. Skinner~

Great emphasis has been placed on learning to read in America. The federal government has supported large scale efforts, such as the Reading First initiative (National Institute for Literacy, 2001) and the National Reading Panel (NRP, 2000), for the purpose of identifying scientific, effective reading practices. In their comprehensive evaluation, the NRP (2000) identified five essential components of reading instruction: (a) phonemic awareness, (b) phonics, (c) fluency, (d) vocabulary, and (c) comprehension. These five vital components have been at the heart of the ongoing development of reading programs, and the research community has produced an extensive number of robust scientific studies concerning the relationships between these components and reading acquisition. Additionally, many research studies have provided evidence for prerequisite skills children need in order to read, such as emergent literacy skills, and effective instructional strategies for teaching these prerequisite skills (Adams, 1990; Snow, Burns, & Griffen, 1998).

However, students with developmental disabilities have not reaped the benefits of the same level of attention to reading acquisition as other populations of children, nor have they benefitted from the same intense research focus. For students with moderat intellectual disabilities (MoID) a pendulum has swung over time from a strictly functional literacy approach, which includes sight-word reading and logo reading, to an academic literacy approach that includes word-analysis skills. Yet, the precise nature and implementation of academic literacy goals is far from established for students with MoID.

Purpose

This review will examine the historic and current forms of literacy instruction provided to students with MoID. A cognitive profile approach to selecting and informing reading instruction for students with MoID will be introduced. Then, known cognitive predictors of early reading acquisition for students with MoID and for other populations of students will be reviewed, and relative contributions of cognitive subskills to early reading acquisition will be discussed. Next, a synthesis of research regarding the impact of instructional strategies on ameliorating cognitive subskills for students with MoID will be provided. Finally, future recommendations will be made that promote the development of a cognitive profile that would effectively address the contributions of cognitive subskills known to be critical for early reading acquisition, as well as the effect of instructional strategies on the development of cognitive subskills.

Historical and Current Forms of Literacy for Students with MoID

Prior to 1960's, education for students with MoID was limited to basic vocational and daily living skills. A lack of reading research for these students led to a popular misconception that they could not learn to read (Singh & Singh, 1985). But during the

1970's studies started to emerge showing that these students could learn sight-word vocabularies and that led to a subsequent inspection of curricula goals for students with MoID (Brown et al., 1979). An improved instructional approach was adopted which emphasized teaching minimal functional-communication skills, such as sight words and logo recognition, to students with MoID in order to provide them access to resources within the community. Functional literacy in the form of sight-word reading and logo reading became a primary focus as it provided a means by which students could carry out independent daily life skills. However, this functional emphasis on literacy for students in this population occurred at the exclusion of academic instruction and began to attract the concern of some educators (Cegelka & Cegelka, 1970).

Three decades later, a twofold division of literacy instruction provides different definitions of literacy that serve complementary yet distinctly different functions for individuals with MoID: (a) academic literacy which includes word-analysis skills, comprehension, and fluency, and (b) functional literacy which includes sight-word reading and the communication skills necessary to carry out daily living activities (Yesseldyke & Thurlow, 1997). Current educational policy includes an ongoing alignment of special education curricula objectives with the more academically oriented objectives of general education standards (Flowers, Wakeman, Browder & Karvonen, 2009). Furthermore, a few recent studies have included the five NRP (2000) essential components in literacy interventions for students with MoID (Browder, Ahlgrim-Delzell, Courtade, Gibbs, & Flowers, 2008; Fredrick, Davis, Waugh, & Alberto, 2010) with an emphasis on academic skills that empower students to function in society with a greater level of independence. As this review will show, these advances in policy and research are just the beginning of changes in education for students with MoID.

Prior to the recent academic focus in literacy, a comprehensive review of reading instruction studies for students with MoID was conducted by Browder, Wakeman, Spooner, Ahlgrim-Delzell, and Algozzine (2006). The review revealed that almost 90% of the studies focused on acquisition of functional sight words. Thus, sight-word instruction has remained the most commonly implemented form of reading instruction, maintaining an emphasis on a functional approach to literacy for students with MoID. Of the studies examined, only 24% included the NRP (2000) recommended comprehension component, only 10% included the decoding component, and a mere 4% taught phonemic awareness. Considering contemporary knowledge regarding the importance of the fluency component (Fuchs, Fuchs, Hosp, & Jenkins, 2001; Kame'enui & Simmons, 2001), it is surprising that only 28% of studies included fluency measures, and those primarily targeted percentage of errors and excluded rate. The skill of reading sight words is very valuable for students and will continue to be the highest level of reading for some students with MoID. But as will be shown in this review, more effective sight-word programs are needed as part of comprehensive literacy programs that include access to literature thereby teaching a broad range of early literacy skills in order to prepare students to learn to read to their fullest potential (Browder et al., 2009).

Sight-word programs can be improved upon by adding NRP (2000) recommended evidenced-based reading components such as comprehension. But sight-word instruction is not without other limitations. Research shows that sight-word programs are deficient in promoting the generalization of learned sight words to other contexts (Browder et al., 2006; Conners, 1992) and in teaching students to read connected text (Alberto, Waugh, & Fredrick, 2010). These deficiencies combined with problematic word selection greatly limit students' reading potential.

A review of sight-word instruction for students with moderate and severe disabilities by Browder and Xin (1998) revealed that sight-word activities that include the use of real materials are best for promoting reading acquisition among students with MoID. The use of real materials that represent sight words, and activities in which the actual use of sight words is demonstrated, were shown by Browder and Xin (1998) to have positive effects on reading acquisition. However, in 90% of the studies surveyed, no form of comprehension of learned sight words was demonstrated by the students or measured by the researchers (Browder et al., 2008).

Students' comprehension of learned sight words is necessary for generalization that results in functional use of the words. As indicated by Browder and Xin (1998), generalization of learned sight words involves both stimulus and response generalization. Stimulus generalization is the recognition of a sight word in any context other than the context in which it was learned. The identification of sight words has been demonstrated in a few studies (e.g., product labels in a store, signs in a restaurant) but does not necessarily mean the student comprehends the meaning of the word (Collins & Stintson, 1995; Schloss et al., 1995). Successful stimulus generalization only indicates that the student has identified the word; word identification does not indicate that by learning a new sight word the student has learned a new functional activity.

Response generalization also is necessary for demonstration of comprehension and has been measured and shown in a few studies. An academic comprehension component is included occasionally in sight-word instruction such as matching pictures to words (Gast, Doyle, Wolery, Ault, & Baklarz, 1991), or having students verbalize the meaning of a sight word (Collins & Stinson, 1995), but neither of these components teach nor measure sight-word comprehension. However, some studies have demonstrated response generalization by having students with MoID use learned sight words to prepare food successfully (Collins, Branson, & Hall, 1995), and some students with MoID have been shown to respond appropriately to product warning labels (Collins & Griffen, 1996). Recently Alberto et al. (2010) taught students with MoID to demonstrate comprehension of short sight-word phrases by manipulating real objects contained in learned sight words thereby showing response generalization. Unfortunately, these few studies are the only cases found in which a comprehension response has been measured.

Another limitation of sight-word programs is the failure to teach students to read connected text (Alberto et al., 2010). Sight-word reading is practically defined as the memorization of individual words (Browder et. al, 2006). However, Snow et al. (1998) have shown that instruction for reading individual words should be extended to include teaching students to read simple-connected text, and that reading connected text should be considered a basic component of literacy instruction.

Several studies have incorporated multiword phrases in sight-word instruction that taught the phrases as single units of information. Gast, Wolery, Morris, Doyle, and Meyer (1990) taught environmental phrases such as *fire exit* and *emergency exit*. Wolery and Ault (1992) taught connected-text names of establishments such as *Health Department* and *Festival Market*, and Cuvo and Klatt (1992) taught community connected-text phrases such as *garage sale* and *package pick-up* to students with MoID.

However, Davis, Gagné, et al. (2010) used simultaneous prompting procedures and Direct Instruction teaching methodology to teach students with MoID to read individual nouns (e.g., book, ball), then adjectives (e.g., small, red) and then connected text successfully (e.g., blue cup, big book). Alberto et al. (2010) taught students with MoID to read individual words and then environmental connected text and leisure connected text in the form of short phrases. Because the sight words were taught as individual units first, they could be recombined therefore contributing to generalization in the form of the ability to read even more connected text phrases.

Word selection is another common limitation to sight-word instruction. Sight-word lists consisting of the most frequently used words, such as The Dolch Sight-Word List (Dolch, 1936), are random, lack logical sequence, and are therefore not conducive for demonstration of comprehension. Abstract words such as before, away, and never are taught typically through rote memorization using flash cards. Easily represented nouns are not included in The Dolch Sight Word List (Dolch, 1936) rendering it almost impossible to include real materials during instruction, and very difficult to demonstrate the actual use of the sight words. The Edmark sight-word program (Austin & Boekman, 1990) is one of the most widely used sight-word programs for students. The first level consists of more abstract words from The Dolch Sight-Word List and common words from basal readers. Although nouns are included in the Edmark beginning level sight-word instruction, nouns such as airplane, boat, and clouds are impossible to manipulate physically for demonstration of functional use. Edmark includes a comprehension component that consists of matching drawings to words, but the matching activity does not provide an opportunity for demonstration of functional use. Furthermore, not every functional sight word can be anticipated and taught to students. It is not possible to predetermine which words in the English language will be functional for some students and not other students (Katims, 2000).

Sight-word lists are often used to teach decontextualized and isolated words through drill and practice procedures (Conners, 1992). This form of instruction does not provide the literacy-rich environment afforded to other populations of students. A literacy-rich environment promotes a broader focus on gaining meaning from print and teaching literacy for the purpose of communication. Studies have shown that students with intellectual disabilities lack exposure to books (Kliewer, 1998). Limiting literacy instruction to the identification of individual words from lists prevents students from acquiring the emergent literacy, phonological awareness, and comprehension skills that are typically learned from exposure to sentences, paragraphs, and interesting books and are known prerequisites for phonetic reading (Conners, 1992).

Following the comprehensive review by Browder et al. (2006), she and her colleagues developed a comprehensive reading program that emphasizes all five NRP (2000) components of effective reading instruction, around a literature core. Browder et al. (2008) designed the Early Literacy Skills Builder (ELSB) program that successfully teaches all aspects of beginning reading to students with moderate to severe disabilities. Phonological awareness, emergent literacy skills, and vocabulary are taught using shared stories between adults and students. The stories supplement sight-word instruction by teaching the sight words as vocabulary words and by providing a context for meaning. However, student's demonstration of comprehension is limited to matching words to pictures and pointing to words in order to complete sentences.

More research is needed to teach students application of words to real life situations and to teach higher-level reading such as connected text (Browder et al., 2008). Subsequently, when Alberto et al. (2010) and Davis, Gagné, et al. (2010) successfully taught connected text to students with MoID, their comprehensive sight-word instruction included the five components of reading (NRP, 2000), and importantly, students demonstrated comprehension of learned words and phrases through functional use of real objects as recommended by Browder and Xin (1998). Not only did the students in both studies identify sight words correctly, they demonstrated participation in a functional activity as a result of reading functional sight words.

The reading potential of students with MoID is limited when students are not provided with a literacy-rich environment. Browder et al. (2008) demonstrated that when an educational environment centers on a literature core, it promotes the development of the known foundational, prerequisite skills for reading acquisition such as phonological awareness, emergent literacy, and letter-sound correspondences. When these skills are taught, students are provided the opportunity to broaden their knowledge base to include phonetic, word-analysis skills. The most direct limitation of most sight-word programs is that students who have the academic potential are not taught the word-analysis skills necessary to read untaught words they encounter in the community.

Phonics instruction, while considered an academic form of literacy, includes generalizable word-analysis skills that increase the student’s probability of decoding a novel, untaught word encountered in his or her environment. These skills include phonological awareness, letter-sound correspondences, blending, and telescoping (Foorman, Francis, Shaywitz, Shaywitz, & Fletcher, 1997). Phonological awareness and letter knowledge have been shown consistently to be strong predictors of reading acquisition in young children (Ehri, 2004; Share, Jorm, MacLean, & Matthews, 1984). It is proposed in this review that phonetic skills, although categorized as academic literacy, are also functional communication skills because they allow students access to more community resources and independent living. Reading novel, functional words is pivotal in this concept of community resourcefulness. Functional words are words that are necessary for the individual in the particular context in which the words are encountered. All functional words cannot be anticipated and pretaught. In this way, phonics instruction joins academic and functional literacy, blurring the delineation between the two forms of literacy. In addition to providing the NRP (2000) decoding component of reading, perhaps the most important advantage of phonetic instruction is that it promotes a greater degree of functional independence than sight-word instruction alone.

Although students with MoID may benefit from phonics instruction, the question that remains is whether or not they have the cognitive potential to learn phonetic skills and if so, what is the best way to teach these skills? Early evidence has shown that students with mental retardation, even moderate to severe levels, can learn phonetic decoding strategies (Bracey, Maggs, & Morath, 1975; Cossu, Rossini, & Marshall, 1993; Hoogeven, Smeets, & Lancioni, 1989; Katims, 1996; Nietupski, Williams, & York, 1979). Bracey et al. (1975) demonstrated long ago that children with MoID can learn phonetic decoding skills through the use of *Distar Reading* (Engelmann & Bruner, 1969), which is a Direct Instruction program that provides explicit, systematic presentation of material to be learned and mastery of skills before new skills are introduced. Before the study began none of the students could decode or sound out any words. Students learned letter-sound correspondences, then blended sounds into words, and spelled words successfully using their letter-sound correspondences. Results from another early study by Nietupski et al. (1979), revealed that students could learn letter-sound correspondences through explicit instruction although not specifically a Direct Instruction program. Word-analysis skills were broken down into subsets of skills and each subset skill was taught to mastery before introducing the next subset skill. Five out of six students were able to master letter-sound correspondences for consonants, letter-sound correspondences for vowels, vowel (V) and consonant (C) combinations, and CVC combinations.

Other studies have provided preliminary evidence that students who have MoID can learn generalizable word-analysis skills such as letter-sound correspondences and blending (Cossu et al., 1993; Hoogeven et al., 1989; Katims, 1996). Yet, in a comprehensive review between 1990 and 2002, Joseph and Seery (2004) only found seven reading programs that provided any type of phonics instruction for students with any level of mental retardation. Almost all of the students had a mild cognitive delay; only one student included in the review was diagnosed as having a MoID.

Since Joseph and Seery's (2004) review, more research has shown the potential of students with MoID to learn phonetic decoding strategies. Flores, Shippen, Alberto, and Crowe (2004) conducted a study in which six elementary students with MoID were taught phonetic decoding through the use of explicit instruction. The authors implemented modified sequences and formats of the SRA Direct Instruction program, *Corrective Reading: Word-Attack Basics, Decoding A* (Engelmann, Becker, Hanner, & Johnson, 1980). In their study, five of the students were successful in learning letter-sound correspondences, blending, and sounding out. All but one student mastered the four sounds taught and were able to blend the sounds slowly on both instructional and generalization words. All of the students exhibited difficulty with telescoping (blending sounds quickly), and only one student was able to generalize blending to novel CVC words. These results substantiated findings by Conners (1992) and Katims (2000), and set precedence for further examination of the use of Direct Instruction programs to teach phonetic decoding to students with MoID.

Recent evidence of the effectiveness of Direct Instruction programs with this population has been provided by Bradford, Shippen, Alberto, Houchins, and Flores (2006) who found that middle school students with MoID were capable of learning word-analysis skills. The students were successful in identifying letter-sound correspondences and blending letter-sound correspondences into words. In only six months the students learned to read sentences and short passages at approximately a second grade level. The students accomplished these skills through the use of the Direct Instruction program, *Corrective Reading* (Engelmann et al., 1980).

More recent research has provided evidence of the effectiveness of Direct Instruction in teaching reading skills to students with MoID. Browder et al. (2008) reviewed the Direct Instruction early literacy programs Reading Mastery (Engelmann & Bruner, 2003) and Language for Learning (Engelmann & Osburn, 1999), and taught segmenting and letter-sound correspondences to students with moderate and severe disabilities using the model, lead, test Direct Instruction teaching strategy. Also, two studies produced successful results using Direct Instruction teaching methodology along with time delay and simultaneous prompting as instructional procedures (Cohen, Heller, Alberto, & Fredrick, 2008; Waugh, Fredrick, Alberto, 2009). Cohen et al. taught five students with MoID decoding and word-reading strategies using constant time delay. Students demonstrated segmenting by sounding out words slowly and telescoping by blending the words quickly thereby successfully demonstrating word reading. Three students with mild to moderate disabilities learned letter-sound correspondences and attempted to apply blending skills to previously learned sight words (Waugh et al., 2009). But, similar to students in the Flores et al. (2004) study, the students had difficulty with telescoping. One student was unable to generalize the blending skill to novel, untaught words, and two students were able to generalize blending to one untaught word but could not telescope.

However, more recently an *Initial Phonics* instructional sequence based on simultaneous-prompting procedures and Direct Instruction teaching methodology was effective in teaching blending skills to students with MoID (Fredrick et al., 2010). To increase the probability that students with MoID would learn blending skills, Alberto and Fredrick (2007) developed an *Initial Phonics* instructional sequence in which students were taught prerequisite decoding skills such as phonological awareness, emergent literacy skills, and vocabulary through the use of shared, interactive storybooks and word-play activities. Students mastered automaticity with letter-sound correspondences before being introduced to blending and demonstrated mastery of blending skills by reading untaught words made up of previously learned letter sounds. Additionally, students were allowed many opportunities to practice applying sublexical word-analysis skills before advancing to lexical word-analysis skills. The *Initial Phonics* instructional sequence appears to be a promising new and comprehensive approach for teaching students with MoID word-analysis skills within a literacy-rich context.

This review shows that some students who have MoID can be taught decoding skills, and it appears that Direct Instruction is an effective teaching methodology for that purpose. However, students were shown to learn to read at different levels and some showed difficulty in particular areas. Some students were able to read short sentences and passages successfully (Bradford et al., 2006). Other students learned decoding skills at the word level by demonstrating mastery of letter-sound correspondences and subsequently blending the letter-sounds successfully (Cohen et al., 2008; Waugh et al., 2009). However, some of the students struggled to learn to decode at the word level (Cohen et al., 2008; Flores et al., 2006; Waugh et al.) as is evidenced by the fact that they learned letter-sound correspondences yet demonstrated difficulty in the areas of blending, telescoping, and generalization.

Thus, the existing literature indicates two groups of students in the moderate IQ range (40-55) who have demonstrated different reading potentials. Through the use of Direct Instruction programs that are readily available, one group has been shown to learn to read connected text in the form of complete sentences and short paragraphs (Bradford et al., 2006). Although seldom used to teach students with MoID, the mainstream DI programs such as Reading Mastery (Engelmann & Bruner, 2003) and Corrective Reading (Engelmann et al., 1980) are readily available for use with students with MoID, are utilized commonly by general and special education teachers, and contain the five essential components of effective instruction. Another group with MoID has been shown to learn to read at the word level or short-phrase level, but some of the students have difficulty with decoding subskills (Cohen et al., 2008; Flores et al., 2006; Waugh et al., 2009). This second group, that struggles with basic decoding skills, and for whom there is a dearth of effective reading programs, suggest the need for research that discovers untapped learning potential. Attention is now being directed to the need for effective instruction for this group, and as revealed in this review, promising new instructional approaches are beginning to emerge. Browder et al. (2008) has shown that students with MoID can learn emergent and beginning literacy skills and Fredrick et al. (2010) has demonstrated that students who might otherwise struggle with basic decoding skills at the word level can learn decoding skills by providing effective instructional strategies that addresses areas of student difficulty. Both of the new reading programs incorporate the five essential components of instruction (NRP, 2000) within the context of a comprehensive curriculum designed around a literature core.

The first group of students with MoID who have been shown to benefit from available Direct Instruction reading programs, and the second group of students with MoID who have been shown to benefit from emerging, intensive reading programs, do not appear to be distinguishable by higher and lower IQ scores in the moderate range (40-55). Rather, there may be specific underlying cognitive processes necessary for these levels of reading that students may or may not possess, or the cognitive processes may not function efficiently, or in proper coordination. Another new and important area of research on reading for students with MoID involves the exploration of cognitive subskills for this population. A few researchers have begun to explore the supporting cognitive processes in students with MoID and how they relate to different aspects of reading acquisition (Browder et al., 2008; Cohen et al., 2008; Conners et al., 2001; Davis, Fredrick, Gagné, & Waugh, 2010) for the purpose of designing effective literacy programs.

Developing a Cognitive Profile for Selecting and Informing Reading Instruction

In order to provide the most effective sight-word or phonetic instruction to students for whom reading presents the greatest challenge, there are factors that need to be accounted for in addition to providing the NRP (2000) recommended components of reading instruction for general education. Systematic research for the purpose of identifying underlying cognitive processes and how they relate to literacy for students with MoID is lacking in the literature and is necessary in order to provide a foundation for evidence-based curricula for teaching reading to children with significant cognitive delays. If relationships between reading skills and supporting cognitive processes for students are understood more clearly, educators will be in a position to actively develop the cognitive processes that reading skills may build upon thereby advancing the literacy potential for students with MoID. Studies could contribute collectively to a cognitive profile for students with MoID for the purpose of cultivating a knowledge base for effective literacy instruction. Further, a profile of cognitive skills for students with MoID would be useful in identifying the initial instructional level of reading for students who have been in an education system but have not received a fully developed reading curriculum. An alternative would be for educators to make reading content decisions based upon other factors such as age (e.g., younger students receive sight-word instruction while older students are provided instruction in phonetic skills). But the dilemma with age-based curricula decisions is that some older students with MoID do not have the cognitive potential to learn phonetic skills and some younger students may be able to start learning more than sight words in early elementary school. For that reason, making informed decisions based upon cognitive functioning would be a less discriminatory method for curriculum selection. Likewise the use of IQ level, which is the current method of selecting the type of reading instruction for students, presents the same disadvantage. A selection approach that includes a cognitive profile could be used as a fine grained, dynamic method for the selection and implementation of reading instruction, thus providing students with MoID access to reading instruction based upon their individual cognitive potential.

The current system of identifying types of reading instruction for students is an outdated and arbitrary one. IQ cut offs, which vary considerably for individuals by test and administration, typically determine whether a student will receive the opportunity to learn decoding strategies, or will at best receive some form of sight-word instruction that may consist of isolated word lists taught through rote memorization (Katims, 2000). Some classrooms for students with mild intellectual delays incorporate phonetic instruction, but as already discussed in this review, once students are placed in a classroom for moderate disabilities, they are not afforded the same opportunity. Thus, if a particular student's IQ is five points lower than another's, then chances are high that the former student will be placed in a classroom next door with fewer academic goals regardless of cognitive potential. Another disadvantage with subsuming reading ability of students with MoID under a single IQ criterion is that the complex and various critical skills of reading are ignored when, in fact, tapping into these various skills can promote reading acquisition for a very heterogeneous group of learners. It is proposed in this review that a cognitive profile approach to selection of reading placement, in lieu of the arbitrary IQ criterion, would be more precise, fair, informed, and current.

In the ten years since the five essential components of reading instruction were identified (NRP, 2000) other skills and underlying cognitive processes necessary for supporting reading skills for students who are typically developing, students with learning difficulties, and some students with mild intellectual disabilities (MID) have been investigated heavily (Katzir et al., 2006; Kirby, Georgiou, Martinussen, & Parrila, 2010; Lervâg & Hulme, 2009; Parrila, Kirby, & McQuarrie, 2004). Studies for the purpose of identifying early, cognitive predictors of reading acquisition were conducted in response to the problematic IQ-achievement discrepancy formula that most schools used to identify students with reading disabilities (Speece, Mills, Ritchey, & Hillman, 2003). The discrepancy model was inefficient for remediation because, typically, a discrepancy large enough to qualify a student for special remediation services was not apparent until the student was in school for a few years and had experienced much reading failure. Researchers began to find early skill predictors for use in identifying kindergarten and first grade students who were at risk for reading difficulties and could be placed in early intervention in an effort to prevent later reading difficulties (Fuchs et al., 2001; Torgesen, Wagner, Roshette, Burgress, & Hecht, 1997).

In a similar manner, a cognitive profile of skills and subskills found necessary for earliest reading acquisition for average readers and readers with difficulties could replace the current IQ cut-off criterion used to select reading instruction for students with MoID. In addition, a profile of cognitive skills may be used to increase students' reading potential by addressing students' underlying skill deficits shown to be necessary for reading. This is very important because the identification of optimal levels of reading for students will promote greater levels of independent functioning among students with MoID. According to Katims (2000), students with MoID have the potential to become increasingly literate, and Browder (2006) indicates that educators should not limit reading potential of students due to a significant cognitive disability.

Reading is a multidimensional, multicomponent, complex activity about which much has been produced in the literature (Fuchs et al., 2001; Katzir et al., 2006; Kirby et al., 2010; Lervâg & Hulme, 2009; Parrila et al., 2004; Torgesen et al., 1997). The development of a cognitive profile could begin with an examination of the most basic processes that have been found to be predictive of reading acquisition for other populations of students, and then investigate the predictor skills in relation to reading acquisition for students with MoID.

As has been shown in this review, many students with MoID can learn letter-sound correspondences and some experience difficulty with blending letter sounds to form single words (Cohen et al., 2008). Additionally, most sight-word instruction for students with MoID lacks procedures for teaching comprehension and connected text (Alberto et al., 2010). The underlying cognitive skills that support the ability to perform word-analysis skills such as letter-sound correspondences, blending, telescoping, and generalizing blending skills, and the underlying cognitive skills necessary for developing comprehension of individual sight words as well as connected text have been shown to be an area that needs to be developed for students with MoID who struggle with these skills (Fredrick et al., 2010). To complicate the task at hand further, students with MoID have not had the same quantity of print exposure and literacy-rich environments as many students who have progressed through a typical trajectory of reading acquisition. Therefore students have not had the opportunity to develop prerequisite skills for reading that are acquired through print exposure and a literacy-rich environment. This literature review will explore what is known about these essential underlying processes, how the processes interrelate, and how proficient individuals must be in these processes for optimal sight-word reading and decoding of novel words to develop. Then research can be designed to determine how to transfer this information to designing effective reading instruction for students with MoID.

Known Predictors of Early Reading Acquisition

Cognitive subskills found to be most closely related to the earliest stages of phonetic decoding and sight-word reading will be described. The subskills include: emergent literacy skills, phonological memory, phonological awareness, decoding, orthographic processing, naming speed (NS) as measured by rapid automatized naming (RAN), and fluency/automaticity. Next, theoretical models will be reviewed that represent different combinations of the earliest reading predictors and their respective influences on reading. Some models conceptualize the development of these skills in a linear fashion, some provide evidence for a circular, integrated model, and some models provide evidence of independent and discrete skills.

Emergent literacy. Emergent literacy includes print and word-awareness skills. Through exposure to connected text students learn to identify individual words and sentences, and to understand that text is read from left to right. Word-awareness skills include the understanding that words are made of letters and that sentences are made of words (Adams, 1990; Whitehurst & Lonigan, 2001). Mastery of these skills has been shown to predict early reading acquisition (Whitehurst & Lonigan, 1998).

Phonological memory. Phonological memory is known also as short-term memory and refers to the capacity to hold units of information, specifically phonological information, in working memory. It has been shown to be an important component of reading performance (Jorm, 1983; Mann & Liberman, 1984; Swanson & Ashbaker, 2000; Swanson & Berninger, 1995; Swanson, Cooney, McNamara, & Wong, 2004; Swanson, Zheng, & Jerman, 2009) and blending skills in particular.

Phonological awareness. Phonemic awareness refers to the understanding that words are divided into parts and the parts are blended together to form words. It is one of the strongest predictors of the first two years of reading acquisition (Ehri, 2004; Share et al., 1984). In order to correctly pronounce words, one must be able to divide and recombine the parts of words. (Goswami & Bryant, 1990; Parrila et al., 2004; Scarborough, 1998; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993).

Decoding. Decoding is also called phonological processing and involves the ability to make grapheme-phoneme correspondences to identify individual sound units in words and then to blend the units together to sound-out words. Decoding is comprised of word-analysis skills that include letter-sound correspondences and blending (NRP, 2000).

Orthographic processing. Orthographic processing is also known as unitization and involves recognizing visual aspects rather than phonemic aspects of words to decode. It differs from phonological decoding in the size and number of letter units translated from print to speech. Phonological decoding involves translating at the phoneme level, and orthographic processing involves translating larger units, or "chunks" made up of more than one phoneme (Ehri, 1987).

An example of phonological decoding is reading the word "sat" as "/s/-/a/-/t/". In contrast, if the word "sat" is read while relying on an orthographic lexicon it would be read as "/s/-/at/" with "/at/" functioning as a rime or cluster translated by sight rather than two distinct phonemes "/a/-/t/". Orthographic knowledge is composed of the repertoire of syllables and rimes stored in a lexicon and it is also referred to as an alphabetic system by Ehri (2005).

Naming speed and rapid automatized naming. Geschwind (1965) hypothesized that a child's ability to name colors is a valid indicator of future reading ability. His assertion was that the cognitive act of putting a verbal label on a visual stimulus is involved in the visual domain, and the more quickly a reader can associate the verbal representation of a printed phoneme and articulate it, the less decay and confusion will occur leading to more efficient blending of the phonemes. His hypothesis that reading involves this process was predictive of future naming speed (NS) constructs.

Subsequent research by Denckla (1972) led to findings that the speed with which children retrieved color names, rather than the accuracy of retrieval, differentiated children with reading difficulties, average readers, and children with learning disabilities. After this finding, Denckla and Rudel (1974) designed the Rapid Automatized Naming (RAN) test as a method of measuring naming speed (NS) in children. Four subtypes of RAN tests are Rapid Color Naming (RCN), Rapid Object Naming (RON), Rapid Digit Naming (RDN), and Rapid Letter Naming (RLN). For each subtest a student names, as quickly and accurately as possible, an array of 50 stimuli of the respective symbol that is displayed on a page. Rapid Automatized Naming speed subtests are typically discussed in terms of their predictive utility in reading acquisition (Holland, McIntosh, & Huffman, 2004; Katzir et al., 2006; Torgesen et al., 1997; Wolf & Bowers, 1999). RAN subtests involving alphanumeric stimuli (i.e., letters and digits) have been more highly correlated with reading tasks (Compton, 2000; 2003; Wolf, Bally, & Morris, 1986), yet nonalphanumeric RAN subtests (i.e., colors and objects) have been shown to be useful with students who have not learned letters and/or numbers well enough to be highly familiar with the stimuli (Lervag & Hulme, 2009). Additionally, Scarborough (1998) examined 14 studies and found the two types of stimuli to be similar in utility.

Naming speed of verbal information has been shown to provide unique predictive utility to early reading acquisition among readers who are typically developing and readers who are struggling (Parrila et al., 2004). Naming speed is implicated as a unique contributor to early reading independent of phonological awareness (Catts, Gillispie, Leonard, Kail, & Miller, 2002; Kirby, Parrila, & Pfeiffer, 2003; Lovett, Steinbach, & Frijters, 2000; Torgesen et al., 1997; Wolf & Bowers, 1999; Wolf et al., 2009) to the extent that NS alone may distinguish between readers who are typically developing and readers who are struggling (Wolff, Michel, & Ovrut, 1990).

Fluency and automaticity. Automaticity is a mechanism of fluency (Wolf & Katzir-Cohen, 2001), although fluency involves additional skills such as prosody during rapid and accurate reading of connected text. Also, one can develop automatic recognition of singular phonetic units such as letters, sounds, and words, but fluency traditionally refers to accuracy and speed of connected text at the passage level (Speece et al., 2003).

Oral reading fluency (ORF) is often used as an indicator of overall reading competence (Fuchs et al., 2001). It is the speed and accuracy with which an individual translates written language into spoken language. Oral reading fluency is a powerful high-order indicator of reading competence and the exploration of its related components can lead researchers along a continuum of layered and sometimes overlapping cognitive skills.

According to LaBerge and Samuels (1974), automaticity is often used as a model to help conceptualize ORF as an overall reading competence indicator. The authors state that the execution of a complex set of skills such as reading requires very efficient and fast coordination of many component skills. If each component skill requires attentional processes, then the efficient execution of the skills will be impeded by overloading cognitive resources. But, if components are executed automatically, without the need for conscious attention, then efficient coordination of complex skills will be possible.

Meyer and Felton (1999) reconceptualized reading fluency by introducing the idea of sublexical fluency and suggested that a breakdown can occur at the sublexical, lexical, sentence, or higher-integration levels. Kame'enui and Simmons (2001) showed that there are three levels of fluency (e.g. sublexical, lexical, and connected text) and that the skills involved in each level are built upon each other. Ritchey and Speece (2006) state that lower-level fluency skills such as phonological awareness, letter-name, and letter-sound knowledge are sublexical skills which are the building blocks of the earliest stages of decoding. Richey and Speece go on to say that early literacy development may be enhanced by sublexical fluency and that letter-sound fluency in particular may be a supporting mechanism of early word reading. Sometimes researchers refer to letter-naming fluency or word-identification fluency that involves singular sound or word units (Katzir et al., 2006), but more accurate terms would be letter-naming automaticity, or word identification automaticity (Wolf & Katzir-Cohen, 2001).

Theoretical Models of Early Reading Acquisition

In an attempt to explain causes of reading difficulties that are independent of IQ, theoretical views of reading have emerged. Different theories relate certain cognitive skills to reading. The following is a review of theories that demonstrate cognitive skill deficits that impede reading acquisition, or cognitive processes that have been shown to be related to or to predict reading. The literature reveals layers of prerequisite reading skills that support higher-order skills, and as each layer is examined, evidence for some more lower-level prerequisite skills are revealed.

Automation theory. The automaticity model of reading was established by LaBerge and Samuels (1974). Automaticity involves four properties: speed, effortlessness, autonomy, and lack of conscious awareness (Hasher & Zacks, 1979; Shiffrin & Schneider, 1977). Performance that exhibits all of these properties can be considered “automatic.”

Speed is important to automaticity because an increase in speed, which is also a decrease in reaction time, is distinctive to automaticity. According to a power law (Logan, 1988), as practice time increases, reaction time decreases until an irreducible floor is reached. The power law is important because it implies that there is no specific speed criterion for automaticity, that it is relative.

Automatic processing is effortless. Posner and Boies (1971) investigated this criterion and indicated that effortlessness exists when an individual can perform a task while engaged in an automatic one. An everyday example of this is talking while riding a bike which requires that two tasks be done simultaneously without interference. In order for this to happen, one of them must be automatic.

Automatic processing is also autonomous (Zbrodoff & Logan, 1986). This means that it occurs without intention. Nonautonomous processing requires deliberation and cannot occur without intention. This is demonstrated by the classic Stroop effect (Stroop, 1935) in which participants who were to name the color of ink in which words were written could not inhibit themselves from reading the words rather than naming the ink color as they were instructed to do (e.g., BLUE written in red). The skill of naming ink color was not autonomous because participants had to deliberately make themselves stop reading the word and attend to the color.

Automatic processing does not occur in consciousness. This is evidenced by a semantic priming paradigm in which the presentation of a priming word (e.g., "DOCTOR") speeds responses to a target word (e.g., "NURSE"; Meyer & Schvaneveldt, 1971). The semantic priming paradigm is based on the premise that this can occur without an individual being aware of the stimulus that elicited the response.

LaBerge and Samuels (1974) indicated that automaticity affects the rate of reading acquisition by suggesting that letter encoding had to become automatic before word reading could become automatic. Schneider and Shiffron, (1977) looked at the relationship between the amount of consistent practice and the degree of automaticity. They found that consistency was indeed essential and that automaticity did not develop when tasks were inconsistent; furthermore, the degree of automaticity depended upon the amount of consistency. Finally, Cohen, Dunbar, and McClelland (1990) theorized that the most important mechanism underlying automaticity is the strengthening of connections between stimuli and responses. Practice makes these connections stronger and performances subsequently faster and less effortful.

Theory of automatic sight-word reading. Sight-word reading is commonly called word reading or word identification, and is demonstrated when students see a word and immediately identify it without sounding out individual units. This is considered the most efficient type of reading words within connected text (Ehri, 1992). LaBerge and Samuels (1974) showed that when students automatically recognized a word and its meaning, no attention or effort needed to be paid to decoding individual letters, leading to seamless reading without pauses between sounds (Ehri & Wilce, 1983).

Ehri (1992) describes how automatic sight-word reading development depends entirely upon a connection-forming process. She indicates that sight-word reading speed is dependent upon grapheme-phoneme connections. Automatic, or fluent, sight-word reading is accomplished after complete connections are made between visually detected graphemes and phonemes detected in pronunciations. When words are read as single units with no pauses between sounds it is known as unitization. Ehri (1992) goes on to show that a well-developed vocabulary adds a contextual dimension, or meaning, that forms another connection to sight words thereby aiding in automatic retrieval. Furthermore, as a sight-word vocabulary builds, unknown words can be read through a process called analogizing (Goswami, 1986). Analogizing is demonstrated when students encounter the word "nurse" for the first time and recognizes it because they already know the word "purse."

Ehri (2005) expands on sight-word reading theory and suggests that grapheme-phoneme connections form a mnemonic that helps in memory. These connections form an understanding of the alphabetic system, also known as orthography, and act as glue that binds letters in printed words to pronunciations and meanings. The key to building a sight-word vocabulary is the healthy development of an alphabetic mapping system which is dependent upon knowing major grapheme-phoneme correspondences that are eventually consolidated into larger units serve as a foundation for sight-word reading. According to schemata theory, alphabetic schemata fit with graphophonemic relations. In this way, readers build an increasingly larger lexicon of automatically identified word chunks and words, or orthography, which is used to read other words. Children who do not have as many letter-sound connections formed to a level of automaticity will memorize a sight word based upon select visual features creating a large load on memory. For example, they might remember the word “look” as two eyes in the middle, or “dog” as having a tail on the end. Ehri (2005) explains that some children have difficulty in forming an automatic alphabetic mapping system or well-developed orthographic knowledge, and therefore need much more practice learning sight words.

Phonological-core deficit view. For years, a core deficit in phonological processing, which is rooted in language development, was the prevailing explanation for problems with the development of word-recognition skills (Catts, 1996; Foorman et al., 1997; Kamhi & Catts, 1989; Perfetti, 1985; Stanovich, 1988; Torgesen et al., 1994; Vellutino & Scanlon, 1987). In this view, the locus of reading difficulties is the lack of phonological sensitivity which makes learning grapheme-phoneme correspondences very difficult. Within this framework, a phonological deficit is considered to be an impaired ability to decode nonsense words which requires the ability to apply grapheme-phoneme correspondences without the support of contextual cues (Stanovich, 1988). Researchers posit that a phonological-core deficit is responsible for later difficulties with word recognition, which in turn is responsible for reading disabilities (Ehri, 1992; Foorman et al., 1997).

Double-deficit hypothesis. Another well-known componential view is the double-deficit hypothesis (DDH; Wolf & Bowers, 1999). A major tenet of the DDH is that there are various pathways to the breakdown of reading. This view incorporates the phonological-core view and extends it to include difficulties with NS, also known as rapid automatized naming (RAN). Wolf and Bowers (1999) showed that RAN predicted reading ability over and above phonological processing and subsequently contended that the two subskills are distinct entities that can be categorized separately.

Synthesis of Components of Early Reading Acquisition

The commonality among the theories of reading acquisition is that components of reading are complex and must be integrated well in order to function optimally. Teasing apart the roles of components and skills such as automatic sight-word reading, orthographic knowledge, phonological processing, NS, and fluency at the sublexical, lexical, and connected text levels has inspired many different studies, and proven to be a daunting task. The relative contributions of each component to stages of reading development will be summarized below with an emphasis on lower-level components because they relate more closely to reading acquisition for students with MoID.

A preponderance of literature has shown that emergent literacy, phonological awareness, and phonological memory are skills necessary for supporting the earliest stages of reading acquisition. Sometimes NS, as measured by RAN subtests, has been shown to predict decoding acquisition (Compton, 2003), and automaticity of sublexical fluency skills such as letter-sound correspondences has been implicated as facilitating decoding and sight-word acquisition (Ritchey & Speece, 2006). Moreover, during the alphabetical, or phonological, phase of reading acquisition (Ehri & McCormick, 1998) fluent retrieval of individual letter-sounds has been shown to be critical for forming a later lexical orthography that consists of combinations of phonemes that grow in size and eventually develop into automatically retrievable words. Otherwise students memorize sight words based strictly on visual characteristics alone (Ehri, 1997, 2005). Additionally, a strong vocabulary supplements automatic retrieval of sight words by adding a contextual dimension to the underlying cognitive connections. Intuitively, children learn more easily sight words that exist in their vocabulary, and Goswami (1986) has shown that even if an exact sight word does not exist in a student's repertoire, similarly structured unknown words can be identified through the process of analogizing.

Studies have not shown that foundational sublexical skills including phonological awareness, letter-name knowledge, and letter-sound knowledge are directly related to accurate reading, instead they have indicated that these skills provide students with knowledge that facilitates the use of graphophonemic associations necessary for reading development (Compton, 2003; Ehri, 1992; Kirby et al., 2010). But of the sublexical skills, NS of alphanumeric stimuli has been shown to be a cognitive subskill that plays an important role. A bidirectional relationship has been found between RAN of digits and decoding acquisition among first-grade students (Compton, 2003); NS of digits predicted decoding acquisition, and NS growth was facilitated by decoding acquisition.

Furthermore, NS has been correlated with or been shown to predict almost every aspect of reading within a normal course of reading development (Ehri & McCormick, 1998) including word vs. nonword reading (Cirino, Israilian, Morris, & Morris, 2005) and comprehension (Arnell, Joanisse, Klein, Busseri, & Tannock, 2009) over and above other well-established predictors such as phonological awareness, verbal IQ, and orthographic processing (Georgiou, Parrila, Kirby, & Stephensen, 2008). Yet, studies also have shown that the relationships between NS, phonological processing (decoding skills), and orthographic processing are complex (Holland et al., 2004).

Ehri (1992) suggested that phonological and orthographic knowledge (alphabetic mapping) develop simultaneously; Bruck, (1992) found that phonological and orthographic processes develop at the same time until third grade, when phonological processing plateaus developmentally, but orthographic processing continues to develop. It also has been shown that the development of orthographic knowledge is supported by phonemic awareness, which supports phonological decoding (Ehri, 2005). Other studies have shown that the development of phonological processing precedes and overlaps orthographic knowledge at points and is necessary for proper development of orthography (Cassar & Treiman, 1997). Although these studies have demonstrated a clear relationship between phonological and orthographic processing, the relationships among orthographic processing, phonological processing, and NS are less clear.

The pervasive nature of speed of processing requirements for NS tasks make NS a strong contender for a moderator variable between phonological processing and reading, and between orthographic processing and reading outcomes. This is supported by findings by Holland et al. (2004) which show NS as a predictor of phonological processing and orthographic processing. Holland et al. (2004) reported that phonological and orthographic performance appears to depend upon how fast the reader can identify and name visual stimuli.

Torgesen, Wagner, Roshette, Burgress, and Hecht (1997) found that NS did not predict orthographic processing once phonological processing was controlled. Manis, Doi, and Bhadha (2000) found that NS better predicted orthographic processing than phonological ability. Holland et al. (2004) provided evidence that NS predicted both phonological processing and orthographic processing. According to these different findings NS, phonological processing, and orthographic processing need to be investigated further. Clearly these skills influence each other in some way, and they might develop in a certain order, even overlap at times.

Finally, fluency and automaticity appear to be overarching skills that operate as important mechanisms in supporting other basic and higher-level reading skills. The development of accuracy *and* automaticity is very important to cognitive processes such as orthographic processing and phonological processing that underlie reading at the letter, word, and connected text levels (Logan, 1997; Ritchey & Speece, 2006; Wolf & Katzir-Cohen, 2001).

Studies Examining Predictors of Reading Acquisition for Students with MoID

Some researchers have examined the cognitive skills of students with MoID (Cohen et al., 2008; Conners et al., 2001). Their findings could serve as the beginning of a knowledge base regarding the relationships between cognitive skills and different aspects of reading acquisition for this population. Researchers have examined cognitive skills in terms of preassessment and postassessment differences (Browder et al., 2008) and terms of the predictive utility of certain cognitive skills, and the possible explanatory variables for variability found among students' reading acquisition (Davis, Fredrick, et al., 2010; Davis, Gagne et al., 2010). Additionally, certain cognitive skills have been shown to be associated with student growth rates in reading acquisition (Davis, Fredrick, et al., 2010; Davis, Gagne, et al., 2010).

Siegel (1992) and Stanovich and Siegel (1994) found that students with and without reading disabilities do not differ in reading ability based on IQ, but differ based upon underlying reading processes. Conners, Atwell, Rosenquist, and Sligh (2001) examined language skills, phonological awareness, and phonological memory among students who had mild to moderate intellectual disabilities and either higher or lower decoding abilities. Conners et al. (2001) found that the students who were better at decoding were older, had higher language abilities, and higher phonological memory abilities specifically in the area of the rehearsal process of working memory. According to Baddeley's (1986) theory of working memory, the refresher component of the phonological loop keeps bits of information active in working memory and therefore available for use (Baddeley & Gathercole, 1992). When age was covaried out, the students who differed on decoding could only be distinguished by their rehearsal processing ability. The authors reasoned that when intelligence is significantly compromised, the refresher component of phonological coding is vital for decoding successfully. However, phonological awareness which is one of the strongest reading predictors among other populations of students did not differ among the students with higher and lower decoding ability. This could be an indication that, while some reading prerequisite skills may play a consistent role in reading acquisition among other populations of students, the role of other prerequisite skills such as phonological awareness may not transfer to this largely unexplored population with much lower IQs. Nevertheless, the phonological processing component played a more important role than IQ in decoding acquisition in the Conners et al. study.

Cohen et al. (2008) also examined the roles of phonological memory and phonological awareness in acquisition of decoding skills among students with MoID. They found that these cognitive subskills were more highly associated with the execution of word-analysis tasks than with IQ. The oldest student, who had the highest phonological memory score and lowest IQ, demonstrated the fastest decoding acquisition. A student who was among the slowest learners had the highest IQ and lowest phonological memory score. The students with the highest phonological awareness and phonological memory ability appeared to benefit from their higher abilities as demonstrated with faster decoding acquisition. However, students with lower phonological abilities still learned to decode, just at a slower rate. These findings are consistent with findings reported by Stanovich (1985) which revealed that some students with intellectual disabilities who have low decoding ability can benefit from intensive remediation in skill deficits and a lack of decoding ability may not be not due to low IQ. Instead, Stanovich (1985) suggested that low decoding ability could be due to an absence of intensive instruction for supporting skills. Subsequently, other studies have examined the effects of intensive intervention on literacy skills such as decoding (Fredrick et al., 2010; Browder et al., 2008)

Browder et al. (2008) found significant differences between pretest and posttest assessments of receptive vocabulary, emergent literacy skills, phonological awareness, and memory for sentences for students with moderate and severe intellectual disabilities who participated in the Early Literacy Skills Builder (ELSB) program consisting of comprehensive sight-word and phonetic instruction. The data provide further support for findings by Stanovich (1985) who indicated that reading skill deficits may exist for students with intellectual disabilities not because they cannot learn, but because the students have remained largely untrained in reading skills.

Davis et al. (2010) also investigated vocabulary along with emergent literacy and phonological awareness skills among students with MoID who participated in the sight-word instructional sequence of the comprehensive Integrated Literacy reading program (Alberto & Fredrick, 2007). Hierarchical linear growth modeling (HLGM) was used to explore cognitive predictors other than IQ in student sight-word acquisition. All students' IQs were in the moderate range (40-55) and all students mastered sight-word acquisition individually. As a collective group the students demonstrated, on average, statistically significant growth in reading per instructional session. An examination of possible predictor variables showed that pretest scores on receptive vocabulary predicted the variance found among students' initial baseline scores, indicating that students with higher vocabularies knew more sight words before instruction began.

Davis, Gagne, et al. (2010) also found that the average sight-word reading score increased significantly per instructional session, but there was a significant amount of variance found among students' growth rates, indicating that the rates at which all students reached mastery were significantly different from one another. Thus, although the students had similar IQs, their learning rates for sight words varied significantly from one another. Davis, Gagne, et al. (2010) examined student pretest scores on the Print

Knowledge (TPK) subtest of the Test of Preschool Emergent Literacy (TOPEL; Lonigan, Wagner, & Torgesen, 2007) as a possible predictor of sight-word acquisition other than IQ. The TPK is a measure of emergent literacy skills and some phonological awareness skills. They found that the higher the students scored on the TPK pretest the more sight words students learned per instructional session, meaning that higher levels of emergent literacy and phonological awareness ability facilitated faster growth in sight-word acquisition. In sum, vocabulary, emergent literacy, and phonological awareness predicted students' sight-word reading acquisition more than IQ, and is evidenced further by the fact that each of these subskills explained a unique and statistically significant portion of the variance among sight-word learning.

Letter-sound automaticity and NS among students with MoID are other factors of reading acquisition for students with MoID that have been examined recently. Based on previous findings reported by Flores et al. (2004) and Waugh et. al. (2009), Fredrick et al. (2010) proposed that students with MoID have difficulty with blending due to a lack of automaticity with the letter-sound correspondences. To address this concern, students were taught to retrieve learned letter sounds to a rate of automaticity (Fredrick et al., 2010) before attempting to blend the sounds into words. The automaticity mastery criterion for each student was the student's NS on the Rapid Object Naming (RON) subtest of the *Comprehensive Test of Phonological Processing* (CTOPP; Wagner, Torgesen, & Rashotte, 1999). All of the students who participated in the instructional sequence were successful in learning letter-sound correspondences and blending to mastery criteria. These findings are promising and shed insight towards effective components of reading instruction for students with MoID.

Davis et al. (2010) explored the relationships between NS, automaticity of learned letter-sounds, and blending among students who learned phonetic skills as a result of participating in the *Initial Phonics* instructional sequence (Fredrick et al., 2010). Naming speed is a cognitive subskill that has only been investigated recently among students with MoID, although it is one of the most investigated cognitive subskills among other populations of students (Manis et al., 2000; Parrila et al., 2004; Scarborough, 1998; Torgesen et al., 1997;). Hierarchical linear growth modeling was used again to examine NS as a potential predictor of blending acquisition, other than IQ, for students with MoID. It was found that NS pretest scores did not predict blending acquisition rates to a significant extent. However, the number of instructional sessions to mastery of letter-sound automaticity did predict students' blending acquisition rates. The longer students took to attain mastery of letter-sound naming, the longer it took them to acquire subsequent blending mastery suggesting to an undefined degree, that students who are slower developing automaticity of letter-sounds will be slower developing blending skills. This is a possible indication that a shared cognitive subskill is involved in the execution of both types of phonetic skills.

Bowers and Ishaik (2003) reported that weakness in NS might inhibit the ability to develop phonological awareness skills, establish representations of letter strings in memory, or develop orthographic representations. The inhibited development of these skills could impede overall reading development (Cunningham, Perry, Stanovich, & Share, 2002). Bowers and Ishaik (2003) also suggested that existing reading programs were unlikely to address enough of these underlying skills as students may need extensive training to overcome these obstacles in lower-level processes.

Findings reported by Fredrick et al. (2010) addressed the assertion by Bowers and Ishaik (2003) regarding reading programs being insufficient for remediating NS deficits. During Automaticity Phases of the single-case study by Fredrick et al. (2010) all students improved their NS to a predetermined point of mastery as a result of intensive practice in letter-sound naming. Their findings were in contrast to findings reported by Kirby et al. (2010) in which practice did not improve accuracy or rate of NS. Also, the single-case findings were in contrast to findings by de Jong and Vrielink (2004) that showed no improvements in naming speed or word reading after training in serial letter-sound naming for first-grade students who develop typically. However, neither de Jong and Vrielink nor Kirby et al. included students with MoID in their studies, and practice with NS was neither as systematic nor as intensive as the daily practice to a mastery criterion implemented by Fredrick et al. (2010).

Davis et al. (2010) also investigated the student characteristic AGE among students who participated in the *Initial Phonics* (Fredrick et al., 2010) instructional sequence. These data supported findings from previous studies showing that older students learned decoding skills faster than younger students (Cohen et al., 2008; Conners et al., 2001) regardless of IQ. In the study reported by Davis et al. (2010), middle-school students with MoID mastered blending skills twice as fast as early-elementary age students with MoID. This shows that younger students can acquire the same amount of decoding skills as older students, but they may require a longer amount of time in which to do so. This may be due to the fact that younger students have experienced less exposure to literature and may not have cognitive skills that are as advanced as older students with IQs in the same range.

Reviews of sight-word instruction for students with MoID (Browder et al., 2006; Joseph & Seery, 2004) have indicated that most sight-word programs for students with MoID have not been developed with the conventional view of sight-word development (Ehri, 2005) in mind. Students with MoID rarely, if ever, possess strong phonological and orthographic processing skills prior to the onset of sight-word instruction because they have not been taught these skills within literacy curricula. Very few students who begin sight-word instruction have been taught letter-sound correspondences and therefore have not had the opportunity to develop an alphabetic-mapping system. Nor do students with MoID often have expansive vocabularies from which they can make supportive connections, leading to the conclusion that the students are relying on memorizing the visual aspects of sight words, which is an enormous load on memory (Ehri, 2005).

Browder et al. (2008) ascertained that student gains in vocabulary and language skills were due to the communication aspect of the shared-stories component of the Early Literacy Skills Builder program. According to theories of reading development (Manis et al., 2000; Parrila et al., 2004; Wagner et al., 1993), the language-based communication within the shared-stories component and the phonological awareness activities were contributors to students' success with sight-word learning and phonetic segmenting during participation in the ELSB program.

Interactive storybook reading was used as well within the *Integrated Literacy* (Alberto & Fredrick, 2007) sight-word and phonics instructional sequences. To promote emergent literacy skills, phonological awareness, and vocabulary, the researchers wrote storybooks with a controlled vocabulary. The storybooks contained all of the blending words or sight words that were to be taught. The teachers began class each day with an interactive storybook session during which the students played with puppets and objects from the stories while the teacher read the storybooks and then asked the students comprehension and language-expansion questions. The purpose of the controlled vocabulary in the storybooks was to ensure that the blending words and sight words to be learned were in the students' receptive vocabulary by the time they received instruction for reading those words. In addition, word-play games were designed so that students could practice breaking words apart into sounds and then putting them back together again. The promotion of phonological awareness probably supported blending success in the *Initial Phonics* instructional sequence. It is also likely that phonological awareness skills supported students in learning sight words and served as a foundation for building orthographic knowledge.

Browder et al. (2008) addressed another important aspect of reading instruction for students with MoID. In addition to the obvious need for literacy instruction that incorporates language-skills strategies concurrently with phonological awareness and emergent literacy, many students within this population are nonvocal and do not have the ability to respond vocally as is required for most reading instruction. Browder et al. (2008) adapted all response requirements for students who were nonvocal. During sight-word and phonetic segmenting tasks, distracter arrays were presented that included several choices for answers. Correct answers were selected by students in the form of pointing or gesturing with any part of the body including eye gazes towards the correct answer.

Students who have limited or no ability to respond vocally comprise a large subgroup of the population of students with MoID; therefore adapting traditional responding so that students who are nonvocal can participate is critical to their development of literacy skills. Davis, Fredrick, Waugh, Gama, and Alberto (2009) recognized this as well. A student who was nonvocal and participated in the *Initial Phonics* instructional sequence (Fredrick et al., 2010) was provided distracter arrays (Heller, Fredrick, Tumlin, & Brineman, 2002) in which she could point to the correct answer. The teacher sounded out a blending word slowly, and then the student pointed to the segmented word that the teacher vocalized. Error analysis of answer choices revealed which sound the student was having difficulty with. This was a beneficial procedure because then the teacher knew which sounds to continue to teach to the student. The distracter array procedure was effective as the student reached mastery of all letter-sound correspondences, blending, and generalization of the blending skill to untaught words.

Reviews have shown that often comprehension is neither taught nor measured during reading instruction for students with MoID (Browder et al., 2008). Comprehension was taught within the ELSB program (Browder et al.); and comprehension was taught and measured within the sight-word and *Initial Phonics* components of *Integrated Literacy* (Alberto & Fredrick, 2007). During the ELSB program students matched words to illustrations and filled in missing sight-words as strategies to teach comprehension of sight words. Within *Integrated Literacy* students were taught motor demonstrations of comprehension with sight words and blending words within the respective instructional sequence. Students demonstrated comprehension of learned words and phrases through functional use of real objects as recommended by Browder and Xin (1998). Not only did the students in both instructional sequences identify sight words and blend words correctly, they demonstrated participation in a functional activity as a result of engaging in a functional reading skill. Motor demonstration of read words also helps promote lexical retrieval by forming semantic connections to the visual aspects of a sight word or blending word. It has been recommended that reading instruction for students with MoID contain a semantic component by which students learn not only how to decode words, but also that the words have meaning (Conners, 1992; Ehri, 2005).

Synthesis of Research on Cognitive Skills and Reading Intervention for Students with MoID

Although literacy for students with MoID is in nascent stages of development there are several new promising approaches that have emerged (Alberto & Fredrick, 2007; Browder et al., 2008). They incorporate the five essential components of reading recommended by NRA (2000), address cognitive skills such as NS, and the most common predictors of reading acquisition such as phonological awareness, emergent literacy, and vocabulary. In addition, they incorporate instructional strategies based upon Direct Instruction that has been shown to be effective in teaching students with MoID (Bradford et al., 2006; Conners, 1992).

Integrated Literacy (Alberto & Fredrick, 2007) is a comprehensive approach to reading that incorporates instructional sequences specifically for the development of sight-word and phonetic reading to fairly proficient levels. The instructional sequences provide intensive instruction so that students may learn to read connected text in the form of functional short phrases (e.g., phonics component) and complete sentences (e.g., sight-word component). The ELSB (Browder et al., 2008) program provides a combination of sight-word and phonetic instructional strategies at a very basic level, in order to prepare students for any type of reading instruction. Both *Integrated Literacy* and ELSB incorporate instructional strategies for promoting prerequisite skills for reading acquisition that include phonological awareness, emergent literacy, and vocabulary.

A unique aspect of the ELSB program is that it incorporates sight-word and phonetic instruction together while simultaneously teaching prerequisite skills such as vocabulary, emergent literacy, and phonological awareness. Although the program does not teach either sight words or phonetic reading in great depth, it provides students with foundational skills that have been found to be predictive of learning acquisition during effective reading instruction. This foundation is taught within the context of a literacy-rich environment in which students are exposed to many types of books and engaged in communication around shared stories. In the review conducted by Browder et al. (2006), prior to the ELSB program, no reading program was found for students with MoID that contained access to literature.

A unique aspect of the sight-word and initial phonics components of *Integrated Literacy* is the ongoing emphasis on not just accuracy, but automaticity of skills. Research has emphasized the importance of reaching automatic retrieval of sublexical units such as letter sounds and letter names (Richey & Speece, 2006; Speece et al., 2003). But the actual practice of developing automaticity as an instructional aid is not seen in reading programs (Browder et al., 2006). Conrad and Levy (2007) and Wolf, et al. (2009) indicated that students who have slower NS might need multicomponent interventions for the purpose of increasing fluency and automaticity. Attention to automaticity of learned letter sounds appeared to facilitate lexical access of words and sounds as demonstrated by students' successful participation in the *Initial Phonics* instructional sequences (Fredrick et al., 2010).

Implications for Future Research in Developing a Cognitive Profile

Research has only begun to inform reading instruction for students with MoID. A useful cognitive profile would address ability levels of skills such as phonological awareness, emergent literacy skills, NS, phonological working memory, and vocabulary for successful reading acquisition. A useful cognitive profile would also assess the effects of a comprehensive reading program on the development of these skills. This could be accomplished by comparing pretest and posttest scores. Pretest scores could be compared to subsequent reading acquisition. Likewise, examining the effects of a comprehensive reading instruction program on posttest scores would inform educators of the effectiveness of instructional strategies on the development of these cognitive skills.

Additional research exploring phonological awareness, emergent literacy skills, NS, phonological working memory, and vocabulary as possible predictors of subsequent reading acquisition would inform educators of how proficient students may need to be prior to reading instruction in order to be successful. A cognitive profile could be developed that includes minimum ability levels that are associated with successful sight-word and phonics acquisition. For example, in a study by Levy, Bourassa, and Horn (1999), students with slow NS responded to sight-word instruction much more slowly than students with faster NS, possibly due to the load on orthographic processing required for whole-word learning. It would be beneficial for future studies to examine pretest NS scores as a possible explanatory variable for variance among students' learning rates.

Because so few students with MoID have been taught phonetic skills, it is not known how much repetition is required for learning. It would be helpful to know how many opportunities for students to respond are required for successful acquisition of phonetic skills. Daily data collected from the *Integrated Literacy* instructional sequences could be analyzed in an attempt to determine how long it takes students with MoID to master these skills.

The main question regarding automaticity of letter-sounds is whether or not it is a prerequisite skill for blending for students with MoID. The research presented in this review does not identify cause and effect relationships (Fredrick et al., 2010; Davis, Fredrick et al., 2010). A conclusion cannot be extrapolated from the data because all students mastered automaticity and all students mastered blending. If some students had not mastered or attempted automaticity and subsequently did not master blending then there might be some evidence supporting automaticity of letter-sounds as a prerequisite for blending. Future research could compare blending acquisition of student who receive the letter-sound naming intervention and students who do not. Yet, the reviewed research does provide evidence that consistent practice that increases associations between the visual stimulus and response does increase naming speed to a statistically significant extent in this population of students (Davis, Fredrick, et al.).

Compton (2003) indicated a bidirectional relationship between naming letter sounds and decoding ability. Naming of letter sounds improved the rate of decoding acquisition, and previous decoding skill was associated with faster initial NS for students. Research regarding other bidirectional relationships between factors such as the phonological memory rehearsal process and the skill of blending would be very beneficial to establishing a cognitive profile. It is not known what minimal working memory capacity is required for successful decoding. Also, while practicing the skill of decoding requires students to hold units of phonological information in working memory, the effects of practicing decoding on phonological memory are not known.

Interactive storybook reading has been emphasized by Browder et al. (2008) and Fredrick et al. (2010) as promoting prerequisite language and reading skills that contributed to successful learning of sight words and blending skills. Kliewer and Biklen (2001) indicated that storybook reading that involves social engagement improves communication for students with MoID and suggested that future research could directly assess the effects of story reading on language and emergent literacy skills. Perhaps studies could focus on direct measurement of the effects of interactive storybook activities on language development, prerequisite skills such as phonological awareness, and actual reading acquisition. This an important area of investigation as educators strive to create reading programs around a true literacy core.

In sum, more research is needed examining expected growth trajectories in blending skills and sight-word reading as a function of participation in comprehensive reading programs. It would be helpful to examine students pretest scores on phonological awareness, vocabulary, phonological memory, and NS skills as predictors of reading potential, and also the corresponding posttest scores as indicators of the effect that a comprehensive reading program has on these skills. A cognitive profile of this type would be beneficial to teaching students with MoID to read at their optimal, individual level. Ultimately, a cognitive profile of specific skill functioning of students with MoID can be developed to replace the outdated, arbitrary IQ cut off criterion that currently exists.

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CHAPTER 2

NAMING SPEED, LETTER-SOUND AUTOMATICITY, AND ACQUIRING BLENDING SKILLS AMONG STUDENTS WITH MODERATE INTELLECTUAL DISABILITIES

Great emphasis has been placed on learning to read in America. The federal government has supported large scale efforts such as the Reading First initiative (National Institute for Literacy, 2001) and the National Reading Panel (NRP, 2000), for the purpose of identifying scientific evidence of effective reading practices. In their comprehensive evaluation of reading, the NRP (2000) identified five essential components of reading instruction: (a) phonemic awareness, (b) phonics, (c) fluency, (d) vocabulary, and (c) comprehension. These five components have been at the heart of the ongoing development of reading programs, and the research community has produced many scientific studies concerning the relationships between these components of reading instruction and children's acquisition of reading (Berne & Blachowicz, 2008; Ehri, 2005; Fuchs, Fuchs, Hosp, & Jenkins, 2001; Schwanenflugel et al., 2006).

Reading instruction for students with intellectual disabilities has not received the amount of attention or the intensity of research that it has for other populations of children. Yet, current educational trends emphasize academic literacy for this population of students as demonstrated by the ongoing alignment of special education curricula objectives with those of general education standards (Browder et al., 2007). For students with moderate intellectual disabilities (MoID), this represents a shift from a strictly functional literacy approach that includes sight-words and logo recognition, to an academic literacy approach that includes phonetic skills.

Research on teaching phonetic skills to students with MoID is sparse. When Joseph and Seery (2004) reviewed all forms of literacy instruction provided to students with all levels of intellectual disabilities they found only seven studies in which phonics instruction was provided, and of those studies, only one participant was diagnosed as MoID. More recently, Browder, Wakeman, Spooner, Ahlgrim-Delzell, and Algozzine (2006) reported that almost 90% of research studies examining reading instruction for students with moderate and severe disabilities (MSD) focused on acquisition of functional sight words.

However, the Institute of Education Sciences (IES) recognizes the importance of identifying effective phonetic instruction for students with MoID. Preliminary grant findings from IES Grant #R324A070144 (Alberto & Fredrick, 1997) have shown that an *Initial Phonics* instructional sequence based on simultaneous prompting procedures and Direct Instruction teaching methodology is effective in teaching blending skills to students with MoID (Fredrick, Davis, Waugh, Gama, & Alberto, 2010). To increase the probability that students with MoID would learn blending skills, Alberto and Fredrick (2007) developed an *Initial Phonics* instructional sequence in which students mastered automaticity with letter-sound correspondences before attempting to learn blending skills.

Early reading research with students with MoID indicated that they can learn word-analysis skills (Bracey, Maggs, & Morath, 1975; Conners, 1992; Cossu, Rossini, & Marshall, 1993), and this finding is supported in more recent research (Bradford, Shippen, Alberto, Houchins, & Flores, 2006; Browder, Ahlgrim-Delzell, Spooner, Mims,

& Baker, 2009; Cohen, Heller, Alberto, & Fredrick, 2008; Hoogeveen, Smeets, & Lancioni, 1989; Katims, 1996, 2000). Although there is evidence that this population can learn word-analysis skills, there is also evidence that blending and telescoping are particularly difficult skills for students with MoID (Flores, Shippen, Alberto, & Crowe, 2004; Waugh, Fredrick, & Alberto, 2009). Yet very few researchers have attempted to identify the cognitive subskills necessary to support word-analysis skills such as blending with students with MoID.

Cohen et al. (2008) and Conners, Atwell, Rosenquist, and Sligh (2001) examined the roles of phonological memory and phonological awareness in acquisition of word-analysis skills among students with MoID. They found that these cognitive subskills were more highly associated than IQ with the execution of word-analysis tasks. These findings are consistent with the body of research involving typical readers and students with reading disabilities which shows phonological awareness as a key predictor of early reading acquisition (Goswami & Bryant, 1990; Parrila, Kirby, & McQuarrie, 2004; Scarborough, 1998; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993) and short-term memory capacity as an important component to reading performance (Jorm, 1983; Mann & Liberman, 1984; Swanson & Ashbaker, 2000; Swanson & Berninger, 1995; Swanson, Cooney, McNamara, & Wong, 2004; Swanson, Zheng, & Jerman, 2009).

In an effort to understand better the supporting cognitive subskills necessary for successful word-analysis tasks within phonics instruction, Alberto and Fredrick (2007) measured phonological memory and phonological awareness along with naming speed (NS) in their population of students with MoID. Naming speed of verbal information has been shown to provide unique predictive utility to early reading acquisition among readers who are typically developing and readers who are struggling (Parrila et al., 2004). Naming speed is implicated as a unique contributor to early reading independent of phonological awareness (Catts, Gillispie, Leonard, Kail, & Miller, 2002; Kirby, Parrila, & Pfeiffer, 2003; Lovett, Steinbach, & Frijters, 2000; Torgesen et al., 1997; Wolf & Bowers, 1999; Wolf et al., 2002) to the extent that NS alone may distinguish between readers who are typically developing and readers who are struggling (Wolff, Michel, & Ovrut, 1990).

Naming-speed, also known as rapid automatized naming (RAN), has been implicated as a source of reading disabilities in a prevailing componential view of reading known as the double-deficit hypothesis (DDH; Wolf & Bowers, 1999). The DDH also includes a phonological-core deficit which is considered to be a lack of phonological sensitivity which makes learning grapheme-phoneme correspondences very difficult (Catts, 1996; Foorman, Francis, Shaywitz, Shaywitz, & Fletcher, 1997; Kamhi & Catts, 1989; Perfetti, 1985; Stanovich, 1988; Torgesen, 1994; Vellutino & Scanlon, 1987). Wolf and Bowers (1999) showed that RAN predicted reading ability over and above phonological ability and therefore contended that the two deficits are distinct entities. Research on the role of phonological awareness and NS is very limited for students with MoID (Cohen et al., 2008; Conners et al., 2001) with NS being the least examined cognitive subskill (Davis, Fredrick, Gagne, & Waugh, 2010). Thus, this study explored the relationship between NS and automaticity of letter-sounds, and NS as a predictor of acquisition of the skill of blending for students with MoID.

Decades ago, Geschwind (1965) reported that RAN involves providing a verbal name to a visual stimulus when naming a letter's sound or a word's pronunciation from writing. Simply stated, the quicker a reader can associate the verbal representation of a printed phoneme and articulate it, the less decay and confusion occurs, leading to more efficient blending of the phonemes. This is supported by the more recent findings of Holland, McIntosh, and Huffman (2004) which show RAN as a predictor of phonological performance because the latter appears to depend upon how fast the reader can identify and name visual stimuli.

Fredrick et al., (2010) measured the NS of their participants by administering the Rapid Object Naming (RON) subtest of the *Comprehensive Test of Phonological Processing* (CTOPP; Wagner, Torgesen, & Rashotte, 1999) to their students prior to the onset of *Initial Phonics* instruction. Further, they used the measure as an individualized mastery criterion for the development of automaticity of letter sounds. Before beginning a subsequent blending phase each student practiced accurate and rapid retrieval of learned letter sounds until his or her correct sounds per minute (CSPM) matched his or her performance on the RON pretest.

The concept of automatic retrieval of letter sounds is based upon LaBerge and Samuels' (1974) automaticity theory of reading. That is, the execution of a complex set of skills such as reading requires very efficient and fast coordination of many component skills. If each component skill required attentional processes, then the efficient execution of the skills would be impeded by overloading cognitive resources. But, if components were executed automatically, without the need for conscious attention, then efficient coordination of more complex skills would be more likely.

LaBerge and Samuels (1974) emphasized that automaticity impacts the rate of reading acquisition, and Shiffron and Schneider (1977) pointed out a relationship between amount of consistent practice and the degree of automaticity. They found that consistency was imperative to the extent that automaticity did not develop when tasks were inconsistent; moreover, the degree of automaticity depended upon the amount of consistency. Finally, Cohen, Dunbar, and McClelland (1990) theorized that the most important mechanism underlying automaticity is the strengthening of connections between stimuli and responses. Practice makes these connections stronger and performances are subsequently faster and less effortful. Taken together, these findings strongly support incorporating formal, systematic development of automaticity within reading instruction.

Automaticity is a mechanism of fluency, although fluency involves additional skills such as prosody during rapid and accurate reading of connected text. One can develop automatic recognition of singular phonetic units such as letter sounds and words, but fluency typically refers to accuracy and speed of connected text at the passage level. Sometimes researchers refer to letter-naming fluency or word-identification fluency that involves singular sound or word units (Katzir et al., 2006), but more accurate terms would be letter-naming automaticity or word-identification automaticity (Wolf & Katzir-Cohen, 2001).

Meyer and Felton (1999) drew attention to the development of letter-sound automaticity when they suggested that a fluency breakdown can occur at the sublexical, lexical, sentence, or higher integration levels. Fluency at lexical, sentence, or higher levels often is examined but sublexical skills that operate below the lexical level are examined less often. Ritchey and Speece (2006) underscored phonological awareness, letter-name, and letter-sound knowledge as sublexical skills that are the building blocks of the earliest stages of decoding. They acknowledged that early literacy development may be enhanced by sublexical fluency and that letter-sound fluency in particular may be a supporting mechanism of early word reading (Richey & Speece, 2006). Ehri (1992) recognized that sublexical skills provide students with knowledge that facilitates the use of the graphophonemic associations necessary for reading.

Study Purpose

Findings from earlier research indicate that students with MoID for whom a phonics approach to reading was not successful exhibited difficulty with blending skills (Flores et al., 2004; Waugh et al., 2009). These findings helped to shape the *Initial Phonics* program developed through the IES research project (Grant #R324A070144) by Alberto and Fredrick (2007). The purpose of this study was to analyze single-case data from the Letter-Sound, Automaticity, and Blending Phases of the *Initial Phonics* program through the use of two types of research methods. Visual analysis was used to examine the effects of the *Initial Phonics* sequence on the acquisition of letter-sound correspondences and on the skill of blending. Visual analysis was used also to examine the effects of practice of letter-sound naming on student performance during automaticity phases.

In an effort to identify the cognitive subskills necessary to execute the word-analysis skills required of students in the *Initial Phonics* program, this study examined student pretest scores on the RON as a possible explanatory variable for differences in students' automaticity and blending acquisition rates. This was done via hierarchical linear growth modeling (HGLM) based upon procedures developed by Davis, Gagné, Haardörfer , Waugh, Fredrick, and Alberto (2010), thereby augmenting traditional visual analysis of the single-case data. This analysis allowed the investigator to: (a) explore the single-case data for predictor variables, and (b) quantify and test statistically student reading acquisition depicted in single-case graphic displays.

The following research questions were addressed. What effect does the *Initial Phonics* sequence have on student acquisition of letter-sound correspondences and the skill of blending? What effect does systematic practice of letter-sound naming have on student acquisition of automaticity? Do students vary in their rates of acquisition of letter-sounds and blending skills? If so, to what extent does RON explain variance among acquisition rates? Does the number of sessions to mastery of automaticity of sounds account for variance among blending growth rates?

Methods

Participants

Sixteen students diagnosed with MoID participated in the *Initial Phonics* program in order to provide extended instruction around the development, analysis, and practice of blending skills. All students' IQs were in the 40 – 55 range and they were between 6 and 15 years old. Seven students were boys and nine were girls; seven students were African American, six Caucasian, and three Hispanic. The students were served in ten different self-contained special education classrooms for students with MoID, in eight different schools, across four school districts. Students were selected who had relatively high verbal skills as determined by teacher recommendation and researcher interaction with potential participants, performed successfully in their current sight-word reading programs, and did not have behaviors that would interfere with 15 minutes of continuous instruction.

Teacher Training

Teachers were trained prior to beginning the instruction with students. The investigator presented the overall program to teachers and modeled instructional steps for them. Then the teachers practiced implementing the instructional procedures by role playing with the investigator until they could follow program steps with 100% accuracy.

Assessment

Students in this population who struggle with a phonics approach have difficulty with blending sounds into CVC words (Flores et al., 2004; Waugh et. al., 2009). It was proposed that difficultly with blending could be due to a lack of automaticity with the sounds. To address this concern, naming speed (NS) data were collected for each student by administering the Rapid Object Naming (RON) subtest of the *Comprehensive Test of Phonological Processing* (CTOPP; Wagner et al., 1999) as a measure of information processing rates.

NS can be measured by asking students to name as quickly and accurately as they can an array of stimuli such as colors (Rapid Color Naming), letters (Rapid Letter Naming), digits (Rapid Digit Naming), or objects (Rapid Object Naming) that are pictured on a page. Colors, letters, and digits are often learned in school and many students with MoID have not been taught colors, letters, and digits so the RON subtest was selected for use because it utilizes pictures of everyday common objects such as ball, star, and chair.

Rapid Object Naming was administered individually in private testing areas of students' schools by the investigator prior to the onset of instruction. Raw scores were used because no standardized assessments have been developed to measure processing speed for this population.

Designs

Single-case design. A nonconcurrent multiple baseline with an embedded changing criterion design was used to demonstrate a functional relation for all 16 participants. The dependent variable (DV) was the number of correctly read sounds during the Letter-Sound Phase and the number of correctly read words during the Blending Phase. The independent variable (IV) for those phases was the *Initial Phonics* program. The DV during the Automaticity Phase was the number correctly read sounds per minute (CSPM), and the IV was practice reading an array of previously learned letter-sound correspondences. The multiple baseline design was selected in order to demonstrate replication across students. Functional relations were determined by replication across tiers of the multiple baselines. The results from the visual analysis provided a necessary detailed inspection of the data to ascertain the effectiveness of the intervention.

The participants were grouped by age within three groups. The purpose of this grouping was to compare easily the performance of students in the same IQ range, but of different ages and with different prior school experiences. Group 1 was comprised of six students who were 6 - 9 years old and represented an early elementary group. Group 2 was comprised of five students who were 10 - 12 years old and represented an older elementary group. Group 3 was comprised of five students who were 13 - 15 years old and represented a middle school group. Each group's range of scores, grand mean score, and mean number of sessions to mastery were depicted on a separate table.

Each age-group's data were graphically displayed on a separate 3-tier multiple baseline across students. For the sake of space, a representative sample of three students from each age group was selected for graphic display here. However, functional relations were determined using the data performance of the entire group of 16 students.

Hierarchical linear modeling. An advantage of hierarchical linear growth modeling (HLGM) is that it takes into account student growth rates and trajectories. This type of multi-level modeling allowed predictions to be made regarding person-level characteristics that might influence changes in growth. This was of interest because a goal was to find cognitive subskills that predict growth in blending among a population of students who vary quite a bit in cognitive abilities. This is also why repeated measures ANOVA was not implemented. The difference among mean scores is not a meaningful measure with such heterogeneous groups. The purpose of this study was not to identify groups of students who are similar with respect to certain characteristics, who would be expected to learn blending skills; the purpose was to identify cognitive skills that are systematically related to blending-acquisition vectors.

A two-level HLGM analysis was conducted. The first hierarchical linear growth model, which included all 16 participants, quantified and statistically tested aggregate measures of growth within all treatment phases, Word-Analysis Skills (W-A S) values at the beginning of the study, and the variance across participants on each of these measures. This model contained four *time* variables that were represented by daily probe sessions: Time during Baseline, Time during Letter-Sounds, Time during Automaticity, and Time during Blending. Time/sessions for each phase were used as predictors of the outcome variable W-A S. In the unconditional model, the slope for each treatment phase (Baseline, Letter-Sounds, Automaticity, and Blending) represented the growth during its corresponding predictor's phase.

For the second model, student-level RON scores were entered to quantify and test statistically the extent to which student RON pretest scores explained differences in growth rates (slopes) within the Automaticity and Blending Phases. The number of probe sessions to mastery (AUTONUM) within student Automaticity Phases was entered into the second model to explore whether AUTONUM explained differences among Blending slopes. Student Age was examined as a possible explanatory variable for variance among Blending slopes.

Initial Phonics Instructional Sequence

Data through four phases of the first sound set of the *Initial Phonics* program (Fredrick, et al. 2010) were analyzed. Each student reached mastery for a phase before beginning a subsequent phase. The mastery criterion for each Letter-Sound and Blending Phase was 80% correct for two out of the last three probe sessions. Mastery criterion for each Automaticity Phase was 100% of each students' RON pretest rate for two consecutive probe sessions.

Baseline phase. All sounds and words to be taught were presented to each student on white index cards to ascertain if students had learned them prior to the intervention. Baseline stimuli included four letter-sound correspondences and four blending words.

Letter-sound correspondence phase. Letter-sound correspondences for /a/ /m/ /t/ /s/ were taught. The four letter sounds were each presented twice for a total of eight presentations per probe session. Mastery criterion (80%) was 6 correct responses.

Automaticity phase. Automaticity of letter sounds /a/ /m/ /t/ /s was developed. The investigator created automaticity charts consisting of the previously mastered letter sounds in random order and in the same format as objects on RON charts. Students practiced naming the sounds as fast as they could for one minute until their naming rate matched their own RON pretest rate. Only after students reached this level of automaticity was the skill of blending introduced.

Blending phase. During the Blending Phase, students attempted to blend the words /sam/, /mat/, /at/, and /am/. Blending was operationally defined as holding each sound in the blending word for two seconds without stopping in between sounds. This is called "saying the word slowly" and is a Direct Instruction technique (Engelmann, Carnine, & Johnson, 1988) used as an indicator that the student has actually manipulated and blended sounds rather than having memorized the word as a sight word. Then, the student was asked to telescope, or "say the word fast" in order to practice the correct pronunciation of the word. The four words were each presented twice for a total of eight presentations per probe session. Mastery criterion (80%) was 6 correct responses.

Daily Instructional Sequence

Simultaneous prompting procedures were used to teach letter-sound correspondences and blending skills. Learning was measured before each teaching session through the use of daily probes, described below. The daily instructional sequence consisted of a series of steps in the following order: storybook activities, probes, and a teaching session.

Storybook. The researchers wrote storybooks with a controlled vocabulary. That is, storybooks contained all of the blending words that were being taught. The teachers began class each day with an interactive storybook session during which the students played with puppets and objects from the stories while the teacher read the storybooks and asked the students comprehension and language-expansion questions. The purpose of the controlled vocabulary in the storybooks was to ensure that the blending words to be learned were in the students' receptive vocabulary by the time they received blending instruction for those words. No data were collected on storybook activities.

Probe sessions. The teachers conducted one probe session prior to each daily teaching session in order to evaluate how much information the students retained from previous teaching sessions. Probes sessions were conducted with individual students and were the source of daily data collection. Teachers recorded the number of correct and incorrect responses of each student on data-collection sheets. The student was presented with a sound or word card and asked to touch the card as a joint-attention prompt. Then the teacher asked *What sound?* For correct student responses the teacher praised the student and repeated the correct response (i.e., *Good reading, the sound is* __.). For incorrect student responses the teacher provided the student with the correct response (i.e., *No, the sound is* ___.). The same procedures were followed for word cards, and only correct responses counted toward mastery for that particular phase.

Teaching sessions. After each probe session, teachers conducted a teaching session in either a 1:1 or small-group format during which simultaneous prompting procedures were used and no data were collected. After a sound or word card was presented and the student touched the card, the teacher provided the controlling prompt simultaneously with the instructional cue (i.e., *The sound is* ___. *What sound?)* and then modeled for the students by providing the correct response. The teacher then provided the controlling prompt simultaneously with the instructional cue and asked the students to respond with her as a lead step. Finally, the teacher provided the controlling prompt simultaneously with the instructional cue and asked individual students to respond. These steps were repeated for all sound cards and word cards until students responded correctly and independently.

Data-Collection Procedures

All reading performance data were recorded by teachers while they implemented probe sessions. Teachers were provided data-collection sheets on which they recorded correct and incorrect student responses. The investigator monitored this process by observing teachers recording data, providing ongoing feedback, and answering teacher questions for a minimum of one instructional sequence per week.

Procedural fidelity data. To measure procedural fidelity each week, teachers and the investigator used video cameras to record at least one instructional sequence that included a probe session and a teaching session. This equated to approximately 20% of instructional sequences. The investigator viewed the tapes while comparing procedures to a behavior checklist. The total number of teacher behaviors observed during the session was divided by the total number of teacher behaviors on the behavior checklist and multiplied by 100%. Procedural fidelity for teacher implementation ranged from 91% to 100% with a mean of 96%.

Interobserver agreement data. The researcher observed sessions on video while simultaneously recording correct and incorrect student responses. Data was compared to data collected by the primary data collector, the teacher. Interobserver agreement was calculated using point-by-point agreement. The total number of agreements was divided by the total number of agreements plus disagreements and multiplied by 100%. Interobserver agreement was calculated for 20% of probe sessions and ranged from 93% to 100% with a mean of 95%.

Social validity data. Teachers were provided with a social validity rating scale to complete at the end of the study. They were asked to answer questions pertaining to the usefulness of the study in determining appropriate instruction for their students, ease of implementation, relevance to curriculum development for students with MoID, how important they felt phonics instruction was for their students, and how likely they would be to continue to develop word-analysis skills and automaticity with their students. Teachers rated their responses on a 1 to 5 likert-type scale with 1 indicating strongly disagree and 5 indicating strongly agree for a maximum positive score of 20 (see Appendix). Each teacher reported a maximum positive score of 20.

Results

Graphic Display of Learning

All 16 participants were divided into three groups by age. The data are reported by group in Table 1 showing range of scores for each phase, mean score for each phase, and average number of sessions to mastery for all phases except the Baseline Phase. Visual analysis was conducted for all 16 participants; however, due to space limitations graphic presentation of data was provided for a sample of three participants from Group 1

Table 1. *Phase ranges of scores, mean scores, and average number of sessions to mastery for Groups 1, 2, and 3.*

	Group 1 ages (6-9) n=6	**Group 2** ages (10-12) n=5	**Group 3** ages (13-15) n=5
Baseline Phase			
Range of Scores	0 - 2	1 - 8	1 - 7
Phase Mean	.55	5.1	2.3
Letter-Sound Phase			
Range of Scores	0 – 8	0 – 8	7 – 8
Phase Mean	7.6	6	7.6
Average Sessions to Mastery	4.3	4.1	2.1
Automaticity Phase			
Range of Scores	12 – 42	10 – 42	28 – 48
Mean Mastery Criterion (RON)	27.1	25.6	38.5
Phase Mean	28.2	31.9	40.4
Average Sessions to Mastery	9.5	6.1	3.5
Blending Phase			
Range of Scores	0 – 8	0 – 8	0 – 8
Phase Mean	3.5	6.2	6.9
Average Sessions to Mastery	11.6	5.6	5.6

(ages 6-9), three participants from Group 2 (ages 10-12), and three participants from Group 3 (ages 13-15). The data for each group sample are displayed in a three-tier nonconcurrent multiple baseline design across students with an embedded changing criterion, depicting the number of correct W-A S and correct sounds per minute. The sample from each group provided a detailed view of students' daily reading performance during Baseline, Letter-Sounds, Automaticity, and Blending Phases. Dashed lines across each phase indicated interim criterion for that phase and the number in parentheses was the actual number of correct words or sounds needed for mastery. The means and averages reported below are based on when individual students met mastery. Because of small group mastery criterion some students remained in phases beyond mastery.

As seen in Figure 1, Taniesha, Megan, and Eli demonstrated mastery of each phase. Baseline data were collected for each student until the data were stable with no data point varying more than 50% above or below the mean. Baseline data ranged from 0-1, with a mean of .33. Letter-Sound data ranged from 0-8 correct sounds, with a mean of 5.3, and an average of five sessions to mastery. Automaticity data ranged from 13- 42 CSPM, with a mean of 26.4, an average mastery criterion of 31 CSPM, and an average of 10 sessions to mastery. Blending data ranged from 0-8 correctly blended words, with a mean of three correct words, and an average of 14.2 sessions to mastery.

As seen in Figure 2, Jenny, Brandon, and Leon demonstrated mastery of each phase. Baseline data were collected for each student until the data were stable with no data point varying more than 50% above or below the mean. Baseline data ranged from 1-6, with an average of 2.7. Letter-Sound data ranged from 0-8 correct sounds, with an average of 5.1, and an average of 6.2 sessions to mastery. Automaticity data ranged from

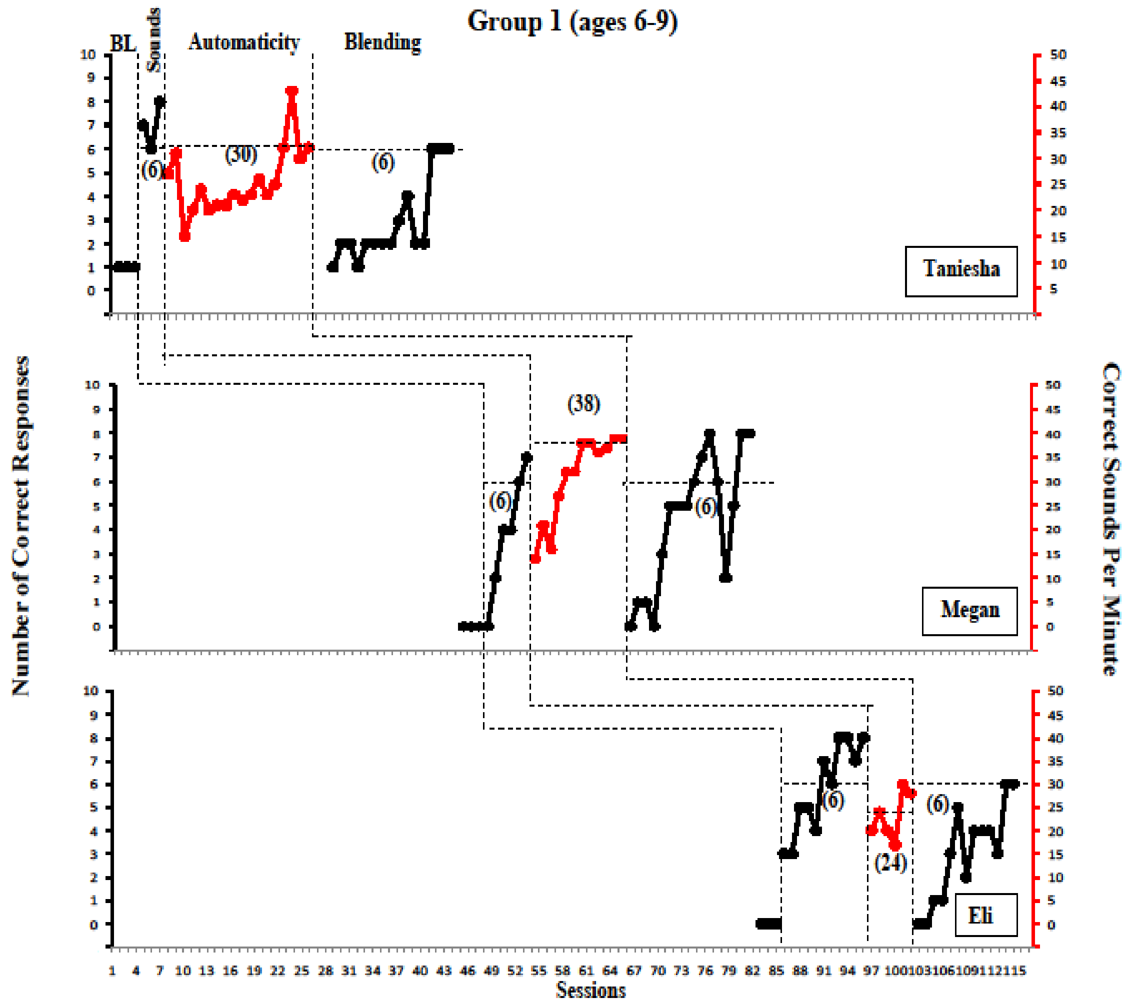

Figure 1. A Multiple Baseline design across three student s with an embedded Changing Criterion depicting number of correct W-AS. The red data paths correspond with the secondary axis and depict rate of correct sounds per minute within Automaticity phases.

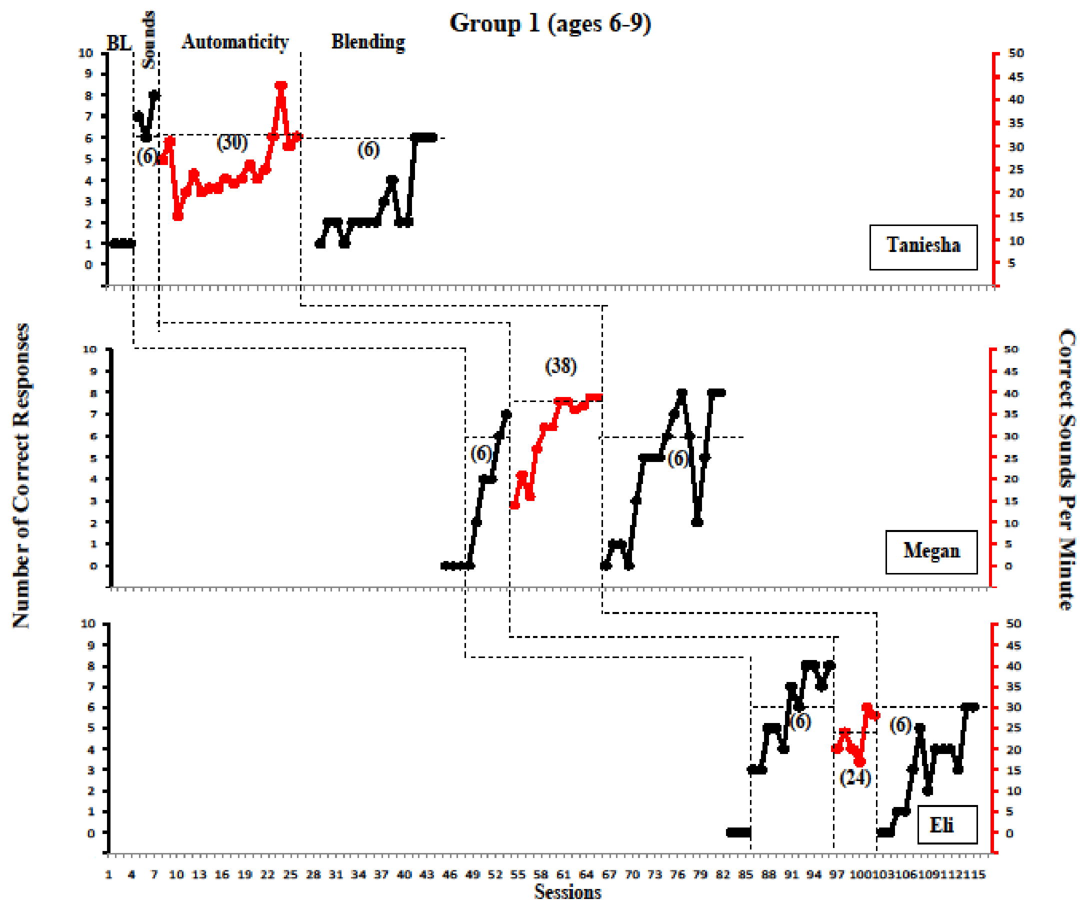

Figure 1. A Multiple Baseline design across three student s with an embedded Changing Criterion depicting number of correct W-AS. The red data paths correspond with the secondary axis and depict rate of correct sounds per minute within Automaticity phases.

10 - 47 CSPM, with an average of 30.8 correct sounds per minute, with an average mastery criterion of 25.3 CSPM, and an average of 11 sessions to mastery. Blending data ranged from 0-8 correctly blended words, with an average of 5.2 correct words, and an average of 8.2 sessions to mastery.

As seen in Figure 3, Janette, April, and Jasmine demonstrated mastery of each phase. Baseline data were collected for each student until the data were stable with no data point varying more than 50% above or below the mean. Baseline data ranged from 1 - 4, with an average of 2.6. Letter-Sound data ranged from 7 - 8 correct sounds, with an average of 7.3, and an average of 2.3 sessions to mastery. Automaticity data ranged from 28 - 46 CSPM, with an average of 37.8 correct sounds per minute, an average mastery criterion of 35 CSPM, and an average of 4.1 sessions to mastery. Blending data ranged from 3 - 8 correctly blended words, with a mean of 6.4 correct words, and an average of 5.7 sessions to mastery.

For all three groups, a functional relation between the *Initial Phonics* intervention and W-A S was evidenced by a pattern of increase in learning that occurred during intervention phases, as compared to baseline performance, and was then replicated across students.

Hierarchical Linear Growth Modeling

The results from visual analysis provided a detailed inspection of the data for each student that depicts the effectiveness of the *Initial Phonics* intervention for students with MoID. Hierarchical linear growth modeling results are depicted on Table 2. The first hierarchical linear growth model, which included all 16 participants, was used to quantify and test statistically aggregate measures of within-phase growth, W-A S values at the

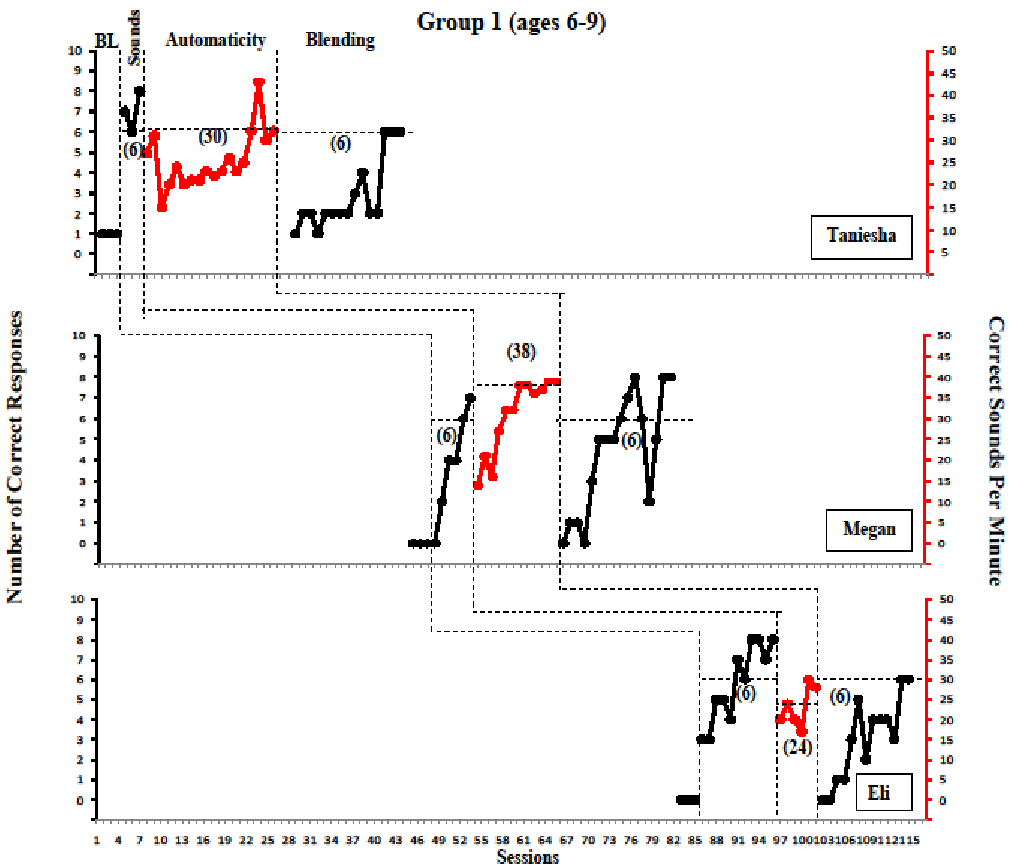

Figure 1. A Multiple Baseline design across three student s with an embedded Changing Criterion depicting number of correct W-AS. The red data paths correspond with the secondary axis and depict rate of correct sounds per minute within Automaticity phases.

Table 2. *HLGM findings*.

Hierarchical Linear Growth Modeling

Unconditional Model: Fixed and Random Effects

Baseline Phase

B00 = 2.5464, $t(15) = 3.300$, $p < .05$

B10 = 0.0638, $t(15) = 0.176$, $p > .05$

$\tau_{00} = 4.59633$, $\chi^2(15) = 16.52443$, $p > .05$

$\tau_{11} = 0.03891$, $\chi^2(15) = 0.19993$, $p > .05$

Letter-Sound Phase

B20 = 0.6989, $t(15) = 4.589$, $p < .001$

$\tau_{22} = 0.07957$, $\chi^2(15) = 9.39578$, $p > .05$

Automaticity Phase

B30 = 2.3026, $t(15) = 2.548$, $p < .05$

$\tau_{33} = 9.31687$, $\chi^2(15) = 752.29483$, $p < .001$

Blending Phase

B40 = .4028, $t(15) = 5.776$, $p < .001$

$\tau_{44} = 0.00880$, $\chi^2(15) = 23.27919$, $p < .05$

Fully Conditional Model: Fixed and Random Effects

Automaticity Phase

B31 (RON) = -0.3767, $t(14) = -5.354$, $p < .001$

$\tau_{33} = 30.59108$, $\chi^2(14) = 2268.85097$, $p < .001$

Blending Phase

B41 (RON) = 0.0018, $t(12) = 0.209$, $p > .05$

B42 (AUTONUM) = -0.0728, $t(12) = -4.645$, $p < .001$

B43 (AGE) = -0.2713, $t(12) = -5.581$, $p < .001$

$\tau_{44} = 0.59525$, $\chi^2(12) = 111.76443$, $p < .001$

beginning of the study, and the variance across participants on each of these measures. A second hierarchical model was used to quantify and to test statistically the extent to which student characteristics explained differences in average growth rates during the intervention phases.

The Baseline Phase intercept was statistically significant, $t(15) = 3.300$, $p < .05$, indicating that the average W-A S score at the beginning of the study was significantly different from zero. The average change in W-A S scores during the Baseline Phase was not statistically significant, $t(15) = 0.176$, $p > .05$. As shown on Table 1, the older students knew a few letter-sounds prior to the onset of instruction, but, none of the students' W-A S scores increased during the Baseline Phase indicating that no simultaneous exposure to literature was resulting in the learning of W-A S. There was no significant variance among the students in their initial scores, $\tau_{00} = 4.59633$, $\chi^2(15) = 16.52443$, $p > .05$; neither did the change in scores during baseline vary significantly across the participants, $\tau_{11} = 0.03891$, $\chi^2(15) = 0.19993$, $p > .05$. So the finding of no change, on average, during the Baseline Phase also was consistent across the participants.

During the Letter-Sounds Phase, W-A S scores significantly improved, $t(15) = 4.589$, $p < .001$, increasing, on average, by 0.6989 words per session, and the variance of the individual growth rates was not statistically significant, $\tau_{22} = 0.07957$, $\chi^2(15) = 9.39578$, $p > .05$. These results indicate that after no learning occurred during the Baseline Phase, W-A S scores increased after treatment began and there were, on average, significant gains with each session. The nonsignificant variability among W-A S scores indicates that letter-sound learning across students grew at a steady rate or in a similar pattern.

Growth rates during the Automaticity Phase were statistically significant, $t(15) = 2.548$, $p < .05$, with W-A S scores increasing, on average, by 2.3026 units per session, meaning that the intervention during the Automaticity Phase led to an average increase of 2.3 correct sounds per minute with each session. There was statistically significant variance in the growth rate, $\tau_{33} = 9.31687$, $\chi^2(15) = 752.29483$, $p < .001$, during the Automaticity Phase.

Statistically significant growth was found during the Blending Phase, $t(15) = 5.776$, $p < .001$. Successful blending of words increased, on average, by .4028 words per probe session. Significant variability was found among Blending Phase slopes, $\tau_{44} = 0.00880$, $\chi^2(15) = 23.27919$, $p < .05$.

The level-2 predictors were statistically significant in three out of four equations. A significant and negative relationship was found between RON and growth during Automaticity Phase, $t(14) = -5.354$, $p < .001$. Holding the other predictors constant, for each point higher students scored on the RON pretest, their correct sounds per minute (CSPM) increased by 0.3767 *fewer* sounds. This finding is logical because students who began the program with faster retrieval capabilities did not have as much room for growth to mastery. After accounting for the influence of RON scores on automaticity variance, a significant amount of variance still remained among students' slopes, $\tau_{33} = 30.59108$, $\chi^2(14) = 2268.85097$, $p < .001$.

RON did not significantly predict Blending Phase growth rates, $t(12) = 0.209$, $p > .05$. A significant and negative relationship was found between AUTONUM and blending acquisition, $t(12) = -4.645$, $p < .001$. Holding the other predictors constant, for each session longer it took students to reach automaticity mastery, they successfully blended, on average, 0.0728 *fewer* words per probe session. One interpretation of this finding is that the longer it took students to reach mastery in the Automaticity Phase the longer it took them to acquire Blending skills, suggesting to an undefined degree, that students who are slower developing automaticity of letter-sounds will be slower developing Blending skills. This is a possible indication that a shared cognitive subskill is involved in the execution of both types of W-A S.

Student AGE significantly predicted blending growth to a negative extent, $t(12) = -5.581$, $p < .001$. Holding all other predictors constant, for each year older in AGE, students successfully blended, on average, 0.2713 *fewer* words per probe session. The older students demonstrated less learning per session but as can be seen on Table 1, they knew some items at baseline. Although no statistically significant variance was detected at the initial baseline session, the single-case data show that they started out at higher levels and therefore had few words to learn before reaching mastery. Statistically significant variance remained among blending slopes, $\tau_{44} = 0.59525$, $\chi^2(12) = 111.76443$, $p < .001$, even though AUTONUM and AGE predicted a significant amount of variance among students' blending slopes.

Discussion

This study investigated the effectiveness of an *Initial Phonics* reading program (Fredrick et al., 2010) in teaching word-analysis skills (W-A S) to students who have moderate intellectual disabilities (MoID). Word-analysis skills included letter-sound correspondences, automaticity of letter-sounds, and blending of learned letter-sounds into words. The *Initial Phonics* program implemented simultaneous-prompting procedures that have been shown to be successful in teaching this population of students (Gibson &

Schuster, 1992), and the program's scope and sequence of content was based upon Direct Instruction teaching methodology that, too, has been shown to be an effective approach for students with MoID (Bracey et al., 1975). Historically, sight-word instruction has been the dominant form of literacy instruction provided to students with MoID (Browder et al., 2006). While sight-word instruction is a valuable form of instruction, it has continued peremptorily as the most common form of literacy for students with MoID despite research findings which suggest that students with MoID have the potential to learn phonetic skills. Some studies have shown that students can learn phonetic skills such as letter-sound correspondences and blending (Browder et al., 2009; Cohen et al., 2008), but, some students with MoID have been shown to have specific difficulty with the skill of blending learned letter-sounds (Flores et al., 2004; Waugh et al., 2009).

The current single-case study investigated the *Initial Phonics* program, a large, systematic, and successful effort to teach generalizable, phonetic literacy skills to students with MoID (Fredrick et al., 2010). Through visual analysis and HLGM analyses of the single-case data the primary research question was supported: The *Initial Phonics* instructional sequence was an effective approach for teaching students with MoID letter-sound correspondences and blending the letter-sounds into words. As shown on Table 2, statistically significant growth was found per probe session, on average, within the Letter-Sound and Blending Phases. After obtaining a stable baseline during the Baseline Phase, all students reached mastery in the subsequent Letter-Sound and Blending Phases. Visual analysis of the single-case data revealed a functional relation between all participants' learning performance and the *Initial Phonics* intervention. This was demonstrated in the replication of an increase in learning when and only when the treatment was introduced, and then was replicated across students in the multiple baseline portion of the design.

The single-case data were divided into three age groups for the purpose of comparing learning performance of early elementary, late elementary, and middle school students (see Table 1). This was an important comparison due to the fact that students of such a wide-age range have varying prior experiences with letter-sounds and words, and with sight-word instruction. Through sight-word instruction, the students might have developed some of the alphabetic principal by exposure to whole words. However, students' history of sight-word instruction was not available for the students so age was examined as a proxy variable. Generally speaking, older students have been exposed to more academic instruction. Baseline data revealed that before intervention began the youngest student group knew a range of 0 – 2 items, the older elementary students knew a range of 0-7 items, and the middle school students knew a range of 0 – 8 items. HLGM analyses supported these data by showing a significant baseline intercept (initial baseline session). Although, the average student score at the beginning of the Baseline Phase was statistically significant, indicating that before the intervention was introduced all students' initial knowledge of Word-Analysis Skills (W-A S) was statistically different from zero, average growth during the Baseline Phase was not statistically significant indicating that their knowledge of W-A S did not change during the Baseline Phase.

All students, regardless of age, learned letter-sound correspondences to mastery at a swift and consistent rate. As can be seen on Table 1, students in Group 3 who were the oldest and knew more letter sounds at initial baseline reached mastery in an average of 2.1 sessions. Although that is approximately half the number of sessions it took younger students in Groups 1 and 2 to reach mastery, all of the students mastered letter-sound correspondences in relatively few sessions. HLGM analyses did not reveal statistically significant variance among growth rates of all the students meaning that they were all fairly consistent in learning, and, on average, the students had statistically significant growth of .7 letter-sounds per probe session.

As demonstrated on the single-case graphs, all students mastered the skill of blending, and they did so at a statistically significant rate per probe session. They averaged an impressive increase of .4 blending words per daily probe. Significant variability was found among their growth rates meaning that blending acquisition was not as consistent across students as letter-sound acquisition. The differences can be seen on Table 1. Older students in Groups 2 and 3 reached mastery in half the number of sessions as the youngest in Group 1. Also, the mean score during the Blending Phase was twice as high for the oldest students as compared to the youngest students. This would result in younger students with flatter, longer learning performance slopes and older students with steeper, shorter slopes. Therefore, it is important to note that even though the youngest to oldest students reached the same learning potential in this study, younger students will likely require more instructional sessions to master the same skill.

The development of letter-sound automaticity was a unique factor in this study. It was theorized that the reason previous students were not successful in blending was because they had not reached a point of automatic retrieval of learned letter-sound correspondences before attempting to blend sounds into words. Letter-sound automaticity is not often taught to any population of students, and prior to this study, there was no research examining the effects of letter-sound automaticity on blending. Visual analysis of graphed data showed all students reaching mastery within Automaticity Phases, and HLGM analysis of Automaticity Phase data indicated that, on average, students' growth rates increased at a statistically significant 2.3 letter-sounds per probe session. Similar to blending, significant variability was found among growth rates indicating that although they all reached mastery they varied in their learning performance. As seen on Table 1, Group 2 reached mastery in twice the average number of sessions as Group 3; and the youngest students in Group 1 took three times the average number of sessions as the oldest students in Group 3.

The main inquiry regarding automaticity of letter-sounds was whether or not it is a prerequisite skill for blending with students with MoID. Aside from the fact that this research was not designed to identify cause and effect relationships, this conclusion cannot be extrapolated from the data because all students mastered automaticity and all students mastered blending. If some students had not mastered or attempted automaticity and subsequently did not master blending then there might be some evidence supporting automaticity of letter-sounds as a prerequisite for blending. But, unlike previous studies in which some or none of the participants successfully blended, all of the participants learned the skill of blending and they all spent time developing automaticity of letter-sounds before attempting to blend.

Research has emphasized the importance of reaching automatic retrieval of sublexical units such as letter sounds and letter names (Richey & Speece, 2006; Speece, Mills, Ritchey, & Hillman, 2003). But the actual practice of developing automaticity as an instructional aid is not seen in reading programs (Browder et al., 2006). Conrad and Levy (2007) and Wolf, et al. (2009) have indicated that students who have slower NS might need multicomponent interventions for the purpose of increasing fluency and automaticity. Attention to automaticity of learned letter sounds appeared to facilitate lexical access of words and sounds as demonstrated by students' successful participation in the *Initial Phonics* instructional sequences (Fredrick et al., 2010). This finding supports findings by Compton (2003) that showed letter-sound naming to improve decoding acquisition.

Additionally, the data suggest that consistent practice of naming letter sounds, as was part of the *Initial Phonics* procedures (Fredrick et al., 2010), increased associations between the visual stimuli and responses and resulted in a statistically significant increase in naming speed for the participants in this study. All students improved their NS to a predetermined point of mastery as a result of intensive training in letter-sound naming speed. These findings are in contrast to findings reported by Kirby, Georgiou, Martinussen, & Parrila, (2010) in which practice with NS did not improve accuracy or rate. Also, the single-case findings were in contrast to findings by de Jong and Vrielink (2004) that showed no improvements in naming speed or word reading after training in serial letter-sound naming for first-grade students who develop typically. However, neither Kirby et al. nor de Jong and Vrielink included students with MoID in their studies, and practice with NS was neither as systematic nor as intensive as the daily practice to a mastery criterion implemented by Fredrick et al. (2010).

This study extends previous research on the role that cognitive skills play in the development of phonetic skills among students with MoID. The use of HLGM allowed for the examination of the predictive qualities of student characteristics such as age, naming speed as measured by RON, and automaticity acquisition rates that might have influenced the statistically significant variability found among automaticity and blending growth rates. All of the participants' intelligence quotients were in the same moderate range (40-55); however, statistically significant differences were found among their acquisitions of W-A S. The cognitive predictors in this study accounted for a statistically significant portion of the variance in acquisition of W-A S. This supports previous studies that found cognitive subskills to be associated with the execution of word-analysis tasks (Cohen et al. 2008). The previous studies examined IQ directly and found higher correlations between cognitive subskills and word-analysis tasks (Conners et al., 2001).

Students' RON pretest score was used in two ways. First, it was used as an individual mastery criterion for students in the Automaticity Phase. While not having a previous study to reference, students were expected to retrieve and verbalize the names of graphemes at the rate they could name common objects as demonstrated on the RON task. It would seem more appropriate to set mastery at students' naming speed on tasks that contain phonological items such as Rapid Digit Naming (RDN) and Rapid Letter Naming (RLN) as criterion for retrieving and naming phonological information. But very few of the participants were familiar enough with letters and digits to obtain a pretest score on RDN or RLN. Even considering the extra cognitive step required for phonological recoding (Chua, 1999), student RON rate was the best estimation of how fast students could learn to name letter-sound correspondences. Compton (2000) found no difference between types of stimuli used as a measure of NS. Rapid Object Naming was just as effective in measuring NS as RLN.

Students' RON pretest score was used also as a potential explanatory variable for differences among learning rates in the Automaticity Phase. As shown on Table 1, the oldest group that also had the highest average RON pretest score, mastered automaticity of letter-sounds in the fewest number of sessions. They accomplished this while having higher average mastery criteria as well. HLGM analyses of level-two data indicated that for each point higher students scored on RON, their automaticity acquisition decreased, on average, by .4 correct sounds per minute, per probe session. This is consistent with Table 1 which shows that the students who scored highest on RON acquired automaticity in the fewest sessions, but also started at a higher level that was closer to their mastery criteria. Thus, they required less rate increase in naming speed to reach mastery, and they accomplished it in fewer sessions.

The number of sessions to mastery of automaticity of letter-sounds (AUTONUM) was entered into the HLGM level-two equation as another possible predictor variable that might account for the significant amount of variance found among blending growth rates. A negative relationship was found between AUTONUM and blending acquisition. For each session longer students spent reaching mastery during the Automaticity Phase, their blending acquisition decreased, on average, by .07 words per probe session. This can be seen on Table 1. Group 1 had the highest average number of sessions to mastery during the Automaticity Phase and they had the lowest mean score during the Blending Phase. So the youngest students took the longest to reach mastery of automaticity and learned the least per blending session.

The current study held conjecture that student AGE would be a valid predictor of blending acquisition due to cognitive maturation and to differences in amount of prior exposure to print and sight-word instruction. AGE predicted blending acquisition to a statistically significant and negative extent. At first inspection the finding that each year increase in AGE resulted in an average decrease of .3 in blending acquisition was surprising. But as seen in Table 1, the oldest students knew more at baseline so they started at a higher level, they had less to learn, and they did so in fewer than half the number of sessions required by the youngest group. Lastly, a statistically significant amount of variance remained among the students' blending scores even after accounting for the influence of AUTONUM and AGE, indicating that another factor might explain variance among student blending acquisition.

This single-case study was conducted on a relatively large scale. Data were collected over three school years, in eight different schools, in four school districts, and the intervention was implemented by 10 different teachers. Rarely are longitudinal data collected with such a high frequency of observations. Typically, individuals' daily response to treatment is not recorded in longitudinal studies employing statistical analyses; and, it is uncommon to determine statistical significance along with functional relations within single-case studies. However, this large single-case study and advances in statistical analyses allowed for the flexible use of research methodologies in examination of the data. This resulted in a report of detailed, individual behavior patterns as well as average group behavior patterns, and in the exploration of outside influences on average group performance.

These findings support previous research on acquisition of phonetic skills for students with MoID, and extend previous findings to include evidence for the effectiveness of simultaneous prompting as part of an *Initial Phonics* program that successfully teaches letter-sound correspondences, promotes the development of letter-sound automaticity, and results in student mastery of blending skills. The effectiveness of the *Initial Phonics* program is reported in terms of functional relations, statistical significance, differences in learning among age groups with differing amounts of prior knowledge, and incremental growth in phonetic skills per instructional session. HLGM results indicate a systematic relationship between the time students spend acquiring automaticity and blending acquisition by showing that the longer students take to master automaticity the less their blending increases per session. This finding supports the assertion by Ritchey and Speece (2006) and Ehri (1992) that sublexical fluency at the letter-sound level may be a supporting mechanism of early word reading.

Results pertaining to letter-sound automaticity are limited to the design of this study in which all students reached mastery of automaticity and blending. Future research could attempt to examine further the relationship between automaticity of sounds and blending by designing a study in which some students are required to reach letter-sound automaticity and some are not, and then comparing the attempts of both groups to blend learned letter-sounds. Such a design would be helpful in establishing the role of letter-sound automaticity. Also, future studies could attempt to establish automaticity rates that are required for blending, or a rate of letter-sound automaticity at which blending becomes less effortful and students are more likely to blend successfully. Replications of this research that include AGE as a predictor of the Baseline Phase intercept, and possibly the inclusion of prior sight-word instruction data would be beneficial as well. Finally, and most importantly, this study provides evidence that supports the inclusion of phonetic instruction in MoID literacy curricula and an effective teaching approach with which to do so.

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Appendix A

Initial Phonics Social Validity Questionnaire (administered to teachers)

Please indicate the extent to which you agree with each statement on a 1 – 5 scale. 1 being strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree.

1. This instructional sequence was an effective method to teach word-analysis skills to my students.

   1 2 3 4 5

2. The procedures were easy to implement with my students.

   1 2 3 4 5

3. I will incorporate these procedures into my students' IEP goals.

   1 2 3 4 5

4. Phonetic skills are important for my students with MoID to learn.

   1 2 3 4 5

5. I will recommend this phonics instruction to other teachers.

   1 2 3 4 5