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### A Proposed Theoretical Model of Literacy Learning Using Multisensory Structured Language Instruction (MSLI)

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A PROPOSED THEORETICAL MODEL OF LITERACY LEARNING USING  
MULTISENSORY STRUCTURED LANGUAGE INSTRUCTION (MSLI)

A Dissertation

Presented to the Faculty of  
Antioch University Seattle  
Seattle, WA

In Partial Fulfillment  
of the Requirements of the Degree  
Doctor of Psychology

By

Judith E. Rusinko, M.A., M.Ed.

October 2011

A PROPOSED THEORETICAL MODEL OF LITERACY LEARNING USING  
MULTISENSORY STRUCTURED LANGUAGE INSTRUCTION (MSLI)

This dissertation, by Judith E. Rusinko, has  
been approved by the committee members signed below  
who recommend that it be accepted by the faculty of  
Antioch University Seattle at Seattle, WA in  
partial fulfillment of requirements for the degree of  
DOCTOR OF PSYCHOLOGY

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12 October 2011

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Date

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## ABSTRACT

### A PROPOSED THEORETICAL MODEL OF LITERACY LEARNING USING MULTISENSORY STRUCTURED LANGUAGE INSTRUCTION (MSLI)

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Multisensory Structured Language Instruction has been used for decades by clinicians and practitioners as an intervention for teaching students with dyslexia. Multisensory Structured Language Instruction uses the integration of multiple senses (visual, auditory, and kinesthetic/tactile) simultaneously to teach literacy. Although the anecdotal evidence for Multisensory Structured Language Instruction is strong, there is a lack of empirical evidence to support its effectiveness. In addition, Multisensory Structured Language Instruction includes the foundational skills recommended by the National Reading Panel (2000), but the use of multiple senses to teach these skills has not been thoroughly studied.

This theoretical dissertation focused on one element of Multisensory Structured Language Instruction that has not been adequately explored in the literature. A vast amount of brain imaging research demonstrates how the brain reads and writes and how a brain with dyslexia works differently from a typically developing brain. However, this research has mainly focused on the visual and auditory elements of learning to read. The kinesthetic modality has not been explored with respect to language learning disorders. This theoretical dissertation

specifically examines the kinesthetic modality and offers a hypothesis as to why incorporating this modality into intervention may help some students with dyslexia.

A literature review in the areas of dyslexia, Multisensory Structured Language Instruction, executive functioning, phonological awareness, attention, and learning disabilities was used to construct a theoretical model to explain the use of the kinesthetic modality for dyslexia intervention. Results are twofold: that Multisensory Structured Language Instruction is effective in teaching students with dyslexia because its pedagogy is grounded in methods supported by learning theory; and that use of the kinesthetic modality is useful for students who exhibit specific deficits in rapid automatic naming, a processing deficit underlying many students' reading difficulties. The use of the kinesthetic modality improves rapid naming via attention and uses the teacher as a surrogate central executive. An intervention model was also constructed to triage students who would benefit from this intervention. Students with a single deficit in phonological processing only are treated with linguistically based interventions, while students with double-deficits in both phonological processing and rapid naming benefit from the addition of the kinesthetic modality. The electronic version of this dissertation is accessible at the OhioLink ETD Center, <http://www.ohiolink.edu/etd>.

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## **Background**

Reading is one of the most difficult skills to acquire in an individual's lifetime. It is a complex task that does not develop naturally. In other words, if children were not directly taught to read, they would not learn to read independently or as a matter of developmental course. Reading enlists specific areas of the brain for processing language and also utilizes cognitive reserves to "crack the code," therefore making it a cognitive-linguistic task (Birsh, 2005). Each child's processing skills are unique, with a range of strengths and weaknesses. It is because of this individuality that children will learn to read in different ways. What works for one child may not work for another.

Reading is therefore dependent on language and cognitive development, but it is also dependent on the quality of instruction. This instruction is complex. Teachers make judgments every day about what to teach, how to teach, and whom to teach, but many do not make these decisions based on training, a solid grasp of current research, or evidence-based practices. Not every intervention works for every child, and not all teachers have received adequate training opportunities to bring evidence-based interventions into their classrooms.

Dyslexia is a specific learning disability affecting reading ability. It accounts for nearly 80% of all learning disabilities and affects between 5 and 17% of the population in the United States (Shaywitz, 1998). In 2005, 37.5% of all fourth graders, 29% of eighth graders, and 28.8% of twelfth graders scored below the basic level in reading on the National Assessment of Educational Progress (NAEP) (National Center for Education Statistics, 2005). Boys are identified more often than are girls because they tend to exhibit behavioral problems that capture the attention of parents and teachers (Shaywitz, 2003).

As a result of historically low reading scores in the United States and the No Child Left Behind Act of 2001 (NCLB), the Reading First state grant program was started to promote scientifically based research in the area of reading instruction, from kindergarten through third grade. NCLB mandated that assistance be given to schools, with the goal of having all children reading by the end of the third grade. Reading First required yearly assessments for accountability and targeted children who were not reading at grade level or struggling to meet reading standards put forth by NCLB. It provided funds for evidenced-based professional development for teachers. The United States Department of Education implemented this legislation and funds reading research to improve reading nationally.

Initially, research primarily focused on learning how the “reading brain” works in normally functioning children and adults, but research has also come to include what is happening in the brains of those diagnosed with dyslexia. As of 2004, National Institute of Child Health and Human Development studies included 42,000 participants, both poor and advanced readers (Lyon & Chhabra, 2004). The two best overall sources of reading research remain the National Research Council (Snow, Burns, & Griffin, 1998) and the National Reading Panel (National Institute of Child Health and Human Development, 2000). Both came to a consensus on the critical components of effective reading instruction. The ways in which these critical areas are taught became the foundation of the Reading First state grants.

### **Overview of Multisensory Structured Language Instruction (MSLI)**

Multisensory Structured Language Instruction (MSLI), one method of intervention, has been used for decades by clinicians and practitioners as an intervention for teaching students with dyslexia. MSLI has its roots in the work of Dr. Samuel Orton, Helen Keller, Grace Fernald, and others from the early 20th century. These pioneers based their work on careful observation,

without the benefit of today's brain imaging technology. They developed and practiced a formula for successful intervention with students who were struggling to read, and they continued to refine that practice.

Birsh (2005) cited McIntyre and Pickering (1995) when outlining MSLI's principles of instruction. First, the mode of instruction must be *multisensory*, using two or more senses simultaneously, with students practicing and repeating information. The acronym VAKT (visual, auditory, kinesthetic, and tactile) is the hallmark of this system. Second, instruction must be *systematic* and *cumulative*, with material starting off with the most basic building blocks of language and systematically progressing from there. Third, students must be taught completely through *direct instruction*, in an explicit manner that takes nothing for granted. Fourth, *diagnostic teaching* must be used in a prescriptive manner in order to individualize teaching, therefore teaching is based on careful and continual assessment of the student's needs. Last, *synthetic and analytic instruction* must be utilized together to teach students how the parts of language go together to form a whole - and how the whole of the language can be broken down into smaller components. The content of instruction, separate from the pedagogy described above, includes phonology and phonological awareness; sound-symbol association; syllable instruction; morphology; syntax; and semantics (International Multisensory Structured Language Education Council, 2011).

Today, MSLI is used with clinical success across the globe, and an international society of practitioners called The International Dyslexia Association (IDA) is dedicated to helping students with dyslexia. Entire schools and their curricula are built on MSLI. Although modern day MSLI includes the foundational skills recommended by the NRP (phonemic awareness, phonics, fluency, vocabulary, and comprehension), the hallmark of MSLI, which is the method

of using multiple senses simultaneously to teach these reading skills, has not been adequately researched. Even the IDA admits, “There is no substantial body of scientific research supporting the efficacy of the multisensory component in structured-language reading instruction” (International Dyslexia Association, 2011, p. 1).

### **Problem Statement**

Scientifically based research has given us a wealth of information about reading and how the brain learns to read. It has also helped us to understand the dyslexic brain, including where and how the reading process breaks down. But there is a scarcity of research on MSLI, and much of what has been published cannot be classified as scientifically based research. While some studies have focused on the pedagogy of MSLI, that is, the sequential, structured nature of the system, these studies have not focused on the multisensory component of this approach, broken down the modes of transmission of MSLI (visual, auditory, kinesthetic, and tactile) or compared unisensory to multisensory methodology.

The No Child Left Behind Act of 2001 requires schools employ “a learning system or program of reading instruction based on scientifically based reading research” (NCLB1202 [c][7][A]). The act defines scientifically based reading research as research that “applies systematic, rigorous, and objective procedures to obtain valid knowledge relevant to reading development, reading instruction, and reading difficulties” (NCLB1208 [6][A]). Rose and Zirkel (2007) reviewed special education case law, analyzing all published MSLI decisions from the original passage of the Individuals with Disabilities in Education Act in 1975 through 2005. The rationale for the study was that parents and advocacy groups recommend MSLI, but public education does not always adopt it as a reading methodology. This discrepancy between parental expectations and school district programming has led to increased litigation under IDEA.

Rose and Zirkel (2007) found 64 cases reviewed by the courts, with 77% in the past 10 years alone, and with courts ruling in favor of school districts at a rate of 75%. The 2004 reauthorization of IDEA states that intervention must be based on “peer reviewed research” and “scientifically based research,” which benefits parents and increases litigation. Problems with MSLI studies, such as lack of methodological rigor and poor data analysis, have skewed what little work has been completed in this field away from these notions of peer review and scientifically based research, therefore leading the courts to rule in favor of the school districts rather than parents. Rose and Zirkel list these issues as: the small number of studies, in general; failure to use rigorous, systematic, and objective methodology; inappropriate data analysis (use of grade equivalents, not controlling for pretest differences); lack of operational definitions of MSLI procedures; wide variation in treatment intensity, duration, and group size; and variety among subjects’ severity of disability, age, and grade level.

Another study by Ritchey and Goeke (2006) cited similar problems with research on MSLI, such as the small number of subjects, inadequate outcome measures, a lack of outcomes actually measured, variation in the populations studied, lack of identification of the subjects’ degree of disability, variation in instructional time, omission of details regarding the procedures used to ensure equivalence of the treatment groups, and fidelity of instruction across treatment groups. Not cited by either of these studies is the fact that these studies do not focus on the effectiveness of specific multisensory components of the MSLI methodology, or the relative effectiveness of one sensory modality over another.

Of particular concern is the lack of methodological rigor across many studies. Both Rose and Zirkel (2007) and Ritchey and Goeke (2006) address this issue in the literature. Many of the studies were not included in these reviews due to lack of methodological rigor such as poor

sampling procedures and assignment to treatment or control group not being randomized.

Reliance on grade equivalents and failure to control for pretest differences were cited by both studies as cause for exclusion from their reviews. A lack of inferential statistics was also noted as a leading cause for exclusion, and if inferential statistics were used, significant differences between pre- and post tests, not between treatment and control groups, were found, therefore calling into question causality between treatment and effect. Finally, a lack of operational definitions of treatment procedures means that these studies cannot be replicated and calls into question treatment fidelity across groups and across time.

Torgeson (2004) reviewed 25 years of intervention research that targeted the five components of reading most important in teaching struggling readers. Results were that *explicitness* and *intensity of instruction* were most salient. Explicitness was defined as repetitive, direct instruction and intensity was defined as highly structured, sequential activities (with time for practice and close monitoring) that are not usually available in general education classrooms. There was no mention of multisensory intervention. This dissertation will suggest a theory that MSLI may work with some students, but not necessarily every student struggling with dyslexia.

### **Purpose and Scope**

The purpose of this theoretical dissertation is to provide a conceptual model for the efficacy of MSLI. This dissertation will consider the multisensory (use of more than one sense simultaneously) but not pedagogical (sequential, structured literacy instruction) components of MSLI, supporting or refuting the use of multisensory strategies as a means of intervention for dyslexia. Although proponents of MSLI point to clinical or anecdotal evidence for the efficacy of MSLI, there is still a dearth of specific, peer reviewed, scientifically based research regarding the use of multiple senses.

This dissertation offers a theoretical model and hypotheses to be tested and refined through future research. The intention of this dissertation is to provide a theory for the practice of MSLI as an intervention for dyslexia. The theory will allow future empirical research to support or refute classroom use of MSLI with clearly defined pedagogical methodology. These teaching methods will be referenced throughout the theory and outlined in an intervention model.

Because there is currently no model to explain how MSLI works, the investigator offers a model of one modality within MSLI and proposes a theory as to why this modality works with some students with dyslexia. The model created in this dissertation will generate hypotheses that can be tested through future research. Research may be stimulated through several avenues: the replication or support for the theory as a whole; refutation or support of elements of the model; evaluation of the model; expansion or revision of the model; or deletion from or addition to the model. It is the investigator's hope that this model will contribute to the evolution of the model.

This dissertation will focus on one element of MSLI - the kinesthetic modality that has not been adequately explored in modern research. A vast amount of brain-imaging research exists that demonstrates how a brain reads and writes and how a dyslexic brain works differently from a typically developing brain. However, this research has mainly focused on the visual and auditory elements of learning to read. The kinesthetic-tactile modality included in Fernald and Keller's (1921) VAKT model has not been adequately explored with respect to language-learning disorders. Although this dissertation will consider the visual and auditory elements of learning to read, it will include this information in light of the kinesthetic modality. This dissertation will focus primarily on the kinesthetic domain and its interaction with the visual and auditory domains.

## Definitions

The field of reading research has a technical language all its own. This section will define key terms and provide explanation of those terms to the novice. Although many terms, including the words *dyslexia* and *phonics*, have made their way into our everyday conversation, these terms must be operationally defined for the purpose of this theoretical dissertation.

Learning to read is a cognitive and linguistic task and is not a skill that is learned over the normal course of development. Findings of the National Reading Panel's meta-analysis of reading research tell us that instruction must be direct, systematic, explicit in content, and address foundational skills (*phonemic awareness, phonics, fluency, vocabulary, and comprehension*) (NICHD, 2000), which will be defined below. Since that time, experts in the field have added *spelling* (Moats, 2006) and *automaticity* (Berninger & Amtmann, 2004) to the list. As brain imaging technology has evolved, it has helped identify reading pathways, therefore broadening our understanding of how the brain acquires literacy skills and how it processes language. However, sound empirical research on treatment and instructional practices has not kept pace with efforts to define dyslexia and its possible causes.

The five components of reading mentioned above have been the focus of most reading research in the recent past. *Phonemic awareness*, in particular, has been highlighted as playing a central role in learning to read. It is defined as "the ability to notice, think about and work with the individual sounds in spoken words" (Partnership for Reading, 2006, p. 1). Without phonemic awareness skills and the ability to manipulate individual sound bites within words, beginning readers are at high risk of falling behind (Birsh, 2005). In kindergarten, phonemic awareness is the single best predictor of reading success in first and second grade (Torgeson, Wagner, & Roshotte, 1994). *Phonics*, however, differs from phonemic awareness. It is the relationship



between letters or letter combinations of written language (which are called graphemes) and the sounds of language (called phonemes). This is often referred to as sound-symbol correspondence. It connects spoken language with written symbols, relating alphabetic symbols on the page to the sounds of language. The NRP found that systematic and explicit instruction in phonics provided the most significant gains in reading and had the greatest impact in the early elementary grades (NICHD, 2000).

*Vocabulary* is the understanding of the meaning of words, corresponding strongly to comprehension (NICHD, 2000). If a student does not understand the meaning of a word, comprehension suffers. *Fluency* is “the ability to read text accurately and quickly...to recognize words...and gain meaning from the text” (Partnership for Reading, 2006). Without fluency, students remain slow and their reading is labored. Their effort is spent on decoding single words or even phonemes and their comprehension suffers (Snow et al., 1998). Ultimately, comprehension is the goal of reading, which is defined simply as “making sense of what we read” (Birsh, 2005, p. 563). *Comprehension* depends on all of the aforementioned “prerequisite” skills and also depends on good word reading, verbal reasoning, and world knowledge. Word reading involves reading words as whole chunks, rather than slowly decoding its smaller phonemes. Verbal reasoning involves making sense of how words go together to create a larger meaning than each word would independently and world knowledge is often referred to as “prior knowledge,” or an individual’s experience with the topic or content prior to reading. Again, the NRP recommends direct instruction for comprehension, particularly instruction in cognitive strategies, in order to help students understand and remember what was read (NICHD, 2000). Metacognitive strategies, or teaching students to understand their own thinking and learning, are particularly helpful with comprehension.

## Multisensory Structured Language Instruction (MSLI)

Multisensory Structured Language Instruction (MSLI) has a long history of use for students with dyslexia. However, it is important to separate pedagogy from multisensory strategies. Birsh (2006) wrote:

*Multisensory teaching and learning is a form of direct instruction of the phonologic, morphemic, semantic and syntactic layers of language. Multisensory strategies simultaneously involve visual, auditory, tactile-kinesthetic sensory systems, and/or articulatory-motor components while linking listening, speaking, reading, and writing; this means it directly involves students in seeing, hearing, saying, and writing during instruction. (p. 15)*

She added that the power of these strategies lies in pairing the multisensory strategies with a structured language curriculum. For example, a complete lesson incorporates what a student hears, sees, says, and feels in the body, while at the same time follows a carefully sequenced approach to the structure of language. Students handle manipulatives such as color-coded blocks and felt letters, utilize textured surfaces like sandpaper letters and playdough, and accumulate new knowledge based on prior knowledge, daily review, and practice.

What is meant by *carefully sequenced*? What is the importance of this sequence? Birsh (2006) explained that programs based on this approach start with the basic building blocks of written language “a sequence that addresses phonemic awareness, sound-symbol relationships, phonics, syllable types, structural analysis, spelling, fluency, vocabulary, comprehension, composition, and handwriting” (p. 16). Therefore, the sequence comes from the structure of English language itself, beginning with the smallest bites of information and building up to larger concepts of composition and comprehension. This structure addresses how our language is constructed.

Birsh (2005) loosely defined multisensory instruction as “a generic term for any learning activity that uses two or more sensory modalities simultaneously to take in or express

information” (p. 11). When thinking of learning to read, it is entirely feasible to envision the simultaneous use of two senses to receive or express information. For example, when adults read to children, the child is using the auditory system to listen to the adult, while at the same time using the visual system to follow along with the words on the page.

### **The Kinesthetic-Tactile Modality**

The kinesthetic-tactile modality is more difficult to conceptualize. Merriam-Webster defines kinesthesia as “a sense mediated by receptors located in muscles, tendons, and joints and stimulated by bodily movements and tensions” ([www.merriam-webster.com/dictionary/kinesthesia](http://www.merriam-webster.com/dictionary/kinesthesia)). Birsh (2005) defined kinesthesia as a sensory experience that is stimulated by “both bodily movements and tensions” (p. 570) and applies kinesthesia to MSLI as “pertaining to the student’s feeling of letter shapes while moving parts of the body throughout space” (p. 570). Birsh noted that using the kinesthetic modality is useful as a memory aid. She calls “kinesthetic memory” a “voluntary motor sequence that is recalled by the student after repeated practice and training” (p. 570), citing an example of daily writing of letter shapes while associating them with the name and sounds represented by each.

Maria Montessori (1964) provided a rationale for these modalities of input and expression when she cited the tenacity of muscle memory in the process of learning. When a movement is repeated it is remembered, which allows for that movement to be recalled later without conscious effort. Playing a musical instrument, skiing, riding a bicycle, and typing are all examples. Grace Fernald and Helen Keller (1921) believed that children with nonspecific neurological impairments (such as dyslexia) benefit from compensatory, or “bypass” techniques. These techniques were also used effectively with brain injured children. Fernald emphasized the need for the tactile in word learning and reported higher and more rapid learning rates when

finger tracing was used rather than a pencil. She oftentimes used the work of Husband (1928) and Miles (1928) on maze learning to support what she knew to work with her students.

## **Dyslexia**

In 2003, the International Dyslexia Association (IDA) and the National Institute of Child Health and Human Development (NICHD) adopted the following definition of dyslexia (Lyon, Shaywitz, & Shaywitz, 2003):

*Dyslexia is a specific learning disability [emphasis added] that is neurobiological in origin [emphasis added]. It is characterized by difficulties with accurate and/or fluent word recognition [emphasis added] and by poor spelling [emphasis added] and decoding abilities [emphasis added]. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction [emphasis added]. Secondary consequences [emphasis added] may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge. (p. 2)*

The key elements of the definition are in italics and will be discussed here. First, dyslexia is a specific learning disability, meaning that it affects reading specifically. It is neurobiological in origin, in that it is both biologically and neurologically based. It is not caused by poverty, speech or hearing impairments, developmental delays, or learning English as a second language, although those elements may increase the risk of school failure (Snow et al., 1998). Difficulties with accurate and/or fluent word recognition are a hallmark of dyslexia, which present as a student showing obvious difficulty with reading words in text by sight at the same rate and with as little difficulty as their age peers. A student may stumble or guess at words and may resort to sounding out words. This results in inaccuracy and a slow rate. Poor spelling and decoding abilities are indicators of difficulty with ‘breaking the code’ of language and its representational symbol system. These difficulties cannot be attributed to other cognitive abilities or the provision of effective classroom instruction, and, oftentimes, secondary consequences impact an individual over the lifespan.

## Historical Background

Multisensory Structured Language Instruction (MSLI) has been used by clinicians and practitioners as an intervention for teaching students with dyslexia for decades. MSLI has its roots in the work of Dr. Samuel Orton, Helen Keller, Grace Fernald, and others from the early 20th century. These pioneers based their work on careful observation, without the benefit of today's brain imaging technology. They developed and practiced a formula for successful intervention with students who were struggling to read and they continued to refine that practice. Today, MSLI is used with clinical success across the globe, an international society of practitioners is dedicated to helping students with dyslexia and entire schools and their curricula are built on it.

Countless teachers, special educators, and clinicians use the MSLI approach based on Fernald's work. In her seminal work, *Remedial Techniques in Basic School Subjects*, Fernald (1943) referred to the work of early Greek and Roman scholars, who recommended use of "multisensory pathways." Early Mesopotamian scribes in 2300 BCE learned literacy skills by tracing signs in stone tablets and reproducing those symbols from memory (Manguel, 1996). Richardson (1989) spoke of these early scholars, including Plato, who in the 3rd century BCE provided models for tracing letters, and Horace, who in 65 BCE encouraged his students to make letters from pastry. Around 2 BCE, Seneca held and directed a child's fingers while tracing letters and Quintillion used the technique of following the form of letters with a pen engraved in ivory tablets in CE 68 (Henry & Hooks, 2006). Fernald also described the use of the kinesthetic modality by Charlemagne in the 8th century and Locke in the 7th century.

In modern times, Maria Montessori (1964) wrote of the necessity of the kinesthetic pathway to be developed prior to children learning to write: "I exercised mechanically the

psycho-motor paths, and fixed the muscular memory of each letter” (p. 263). As children wrote, she reinforced the association of the visual and “muscular-tactile sensation” with the sound of the letter and she is credited with being the first to introduce sandpaper letters in order to increase tactile-kinesthetic sensation. She would methodically introduce a sound and letter, trace it while modeling the action and guide the student’s index finger over the sandpaper letter.

In 1917 a Scottish ophthalmologist, Dr. James Hinshelwood, was the first to recommend a specific intervention for dyslexia in his monograph entitled *Congenital Word Blindness*. He recommended the use of the “Alphabetic Method” in conjunction with a multisensory approach in order to appeal to “as many cerebral centers as possible” (Richardson, 1989). Not long afterward, Grace Fernald and Helen Keller (1921) recommended that a child should either trace or say a word many times while looking at the word in writing, then say it as (s)he writes it from memory:

Lip and hand kinaesthetic elements seem to be the essential link between the visual cue and the various associations that give a word meaning. In other words, it seems to be necessary for the child to develop a certain kinaesthetic background before he can apperceive the visual sensations for which the printed words form the stimulus. Even the associations between the spoken and the printed word seem not to be fixed without the kinaesthetic links. (p. 41)

This suggested that teaching methods neglected these kinesthetic factors and took for granted that the visual cue is sufficient to make associations between the symbol and meaning.

Utilizing a multisensory method of instruction anchored in the kinesthetic sense, Fernald established the first clinic for remedial literacy instruction at UCLA in 1921. After years of research and practice, Fernald pioneered the VAKT method, otherwise known as the Fernald method, and documented it in her publication *Remedial Techniques in Basic School Subjects* in 1943. The VAKT method was used at her UCLA Clinic School and in experimental public school classrooms.

American physician Dr. Samuel Orton (1925) supported the ideas of Fernald and Keller, but added therapeutic emphasis on learning the phonetic system:

...the logical training for these children would be that of extremely thorough repetitive drill on the fundamentals of phonic associations with letter forms both visually presented and reproduced in writing, until the correct associations were built up and the permanent elision of the reversed images and reversals in direction was assured. (p. 614)

Marion Monroe joined Dr. Orton as a research associate in his mobile clinic in Iowa, designed methods based on Orton's hypotheses and the Fernald approach, and used kinesthetic tracing techniques and sound blending with great success. Using visual, auditory, and kinesthetic pathways in reading instruction, she developed her approach further at a residential facility for delinquent boys with mental retardation (Hallahan & Mercer, 2003).

Dr. Orton left Iowa in 1927, returned to Ohio for one year and then moved to New York City, where he met Anna Gillingham, a psychologist at New York's Ethical Cultural School. Dr. Orton asked her to systematically organize instruction based on his neurological hypotheses. While carefully structured, Dr. Orton did not wish for a programmed model of instruction, but instead wanted one that would be flexible enough to be adapted to individual needs. Gillingham and colleague Bessie Stillman insisted that children with reading difficulties could not learn to read by sight word methods alone, noting that their technique was based upon how a letter or word looked visually and sounded aurally, and how the speech organs or the hand felt when producing it (Gillingham & Stillman, 1956). As a result, they pioneered what today is called the language triangle (Auditory-Visual-Kinesthetic) (Figure 1).

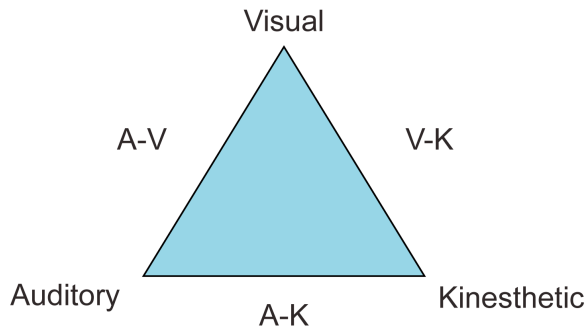


Figure 1. Gillingham and Stillman's Language Triangle

Gillingham and Stillman (1956) also insisted on correct letter formation. Many children with dyslexia transpose letters within words or reverse letters; therefore these students needed to be explicitly taught how to form the letters. Gillingham and Stillman's (1956) "b" and "d" model of handwriting directionality (Figure 2) hangs in many classrooms today.

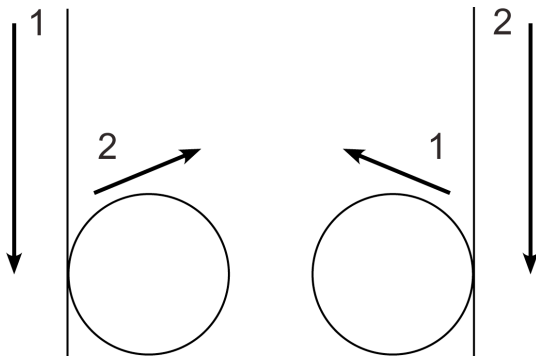


Figure 2. Gillingham and Stillman's Model of Handwriting Directionality.

After Dr. Orton's passing, his widow, June Orton, continued her husband's legacy. She described two basic principles for intervention: simultaneous association of visual, auditory, and kinesthetic stimuli of language and breaking language down into manageable units that the child can manage, depending on the disability. Only then can a child be taught to join units together into larger and more complex units (Orton, 1966). In 1966, June Orton coined the term *Orton-*



*Gillingham Approach* when she wrote a chapter entitled *The Orton-Gillingham Approach in the Disabled Reader: Education of the Dyslexic Child*. Soon after, other offshoots of this approach followed. For example, Beth Slingerland met Gillingham and Stillman in 1935. Slingerland understood the need to train classroom teachers and bring this approach into the public schools. The Slingerland approach, developed in the 1950s, brought the approach directly into public school classrooms. Her materials are still used widely today.

The concept of using multiple senses predates the use of the term *multisensory*. Early pioneers in language learning disability talked about using sensory modalities but did not use the specific term *multisensory*. The term first appeared in IDA literature in 1971, when Beth Slingerland published a classroom adaption of the Orton-Gillingham approach entitled *A Multisensory Approach to Language Arts for Specific Language Disability in Children*.

The International Dyslexia Association (originally called The Orton Dyslexia Society), an international society dedicated to the treatment of dyslexia, began in 1949. Today the association has 46 branches across 37 states in the United States, a Canadian branch, and partnerships with 17 foreign countries. In 1970, Margaret Rawson drafted twelve guidelines for teaching the multisensory method, which the board of the Orton Dyslexia Society adopted in 1982. In her third guideline, Rawson described the sensory basis of the method: “It uses the learning pathways we all share of seeing, hearing, feeling, and awareness of motion, brought together by the thinking brain. It is multisensory” (p. 106).

As time advanced and teachers and clinicians learned more about each specific sensory component, some programs came to emphasize one or more components over others. For example, the Lindamood Phoneme Sequencing (LiPS program) (Lindamood & Lindamood, 1998) emphasized phonemic awareness through sensory cues from the mouth, pairing similar

sounds that have similar characteristics, and focused on articulatory feedback. This feedback creates an awareness of the phonological structure of language in order to develop phonological awareness. Many other programs include components of reading suggested by the National Reading Panel, such as phonemic awareness, fluency, vocabulary, and comprehension, while some add other aspects of language (grammar, text structure, composition) but do not specify the use of multisensory methods to teach these areas of reading.

## Methods

This dissertation is an examination of the available evidenced-based research on intervention for dyslexia. Lyon and Chhabra (2004) stated that evidenced-based research asks a clear question that can be answered using valid research methods. Traditionally, evidence-based research has meant the use of empirical methods, where a hypothesis is tested using a controlled experiment. Causation is determined through randomized control trials, peer review and convergence of data. Evidenced-based research also accurately analyzes and interprets data according to rigorous standards. These “gold standards” have been the hallmark of scientific inquiry, and they continue to move science forward today. Only empirical studies of this nature will be used to formulate a hypothesis and subsequent theoretical model of MSLI.

Rodgers (2010) offered a new perspective on modeling. He focused on mathematical modeling in research, heralding a “methodological revolution” that moved away from null hypothesis-significance testing (NHST) toward a “paradigm based on building, comparing, and evaluating (statistical/mathematical) models” (pp. 3-4). In typical NHST, the null is used as a means for providing evidence for the researcher’s alternative hypothesis. The null asserts that there is no relationship (statistical significance) between phenomena, or that the relationship or effect is due to chance. Rodgers pointed out two difficulties with this line of reasoning: (1) failing to reject the null hypothesis does not necessarily provide support for the null, and (2) rejecting the null does not necessarily provide support for the alternative. Rodgers suggested the focal point of this modeling revolution is NOT the null hypothesis, but the validation of the current model. Rather than reject a null, researchers should develop models and determine how well the data fit those models.

Although Rodgers (2010) spoke of statistical modeling, his paradigm shift can be extremely useful when thinking of theoretical or conceptual modeling. Rodgers described mathematical modeling as "...a set of assumptions together with implications drawn from them by mathematical reasoning" (p. 1). Rodgers' mathematical modeling can be modified for use in theoretical modeling as a set of assumptions together with implications drawn from theoretical reasoning. Rather than identify a null hypothesis and attempt to discredit that null, this dissertation will propose a theoretical model of MSLI grounded in current literature and empirical research.

### **Models and Factors**

What, then is a model? Rodgers (2010) defined models as "simplifications of a complex reality" (p.1). Models have two important functions: to match the reality that they attempt to describe and to be simpler than that reality. The paradox is that as a model matches reality more and more, it becomes less simple. Conversely, as it moves further from reality, it becomes simpler (Rodgers, 2010). As Rodgers stated, "a particular model is supposed to be simple and to match only certain specified parts of the complex reality" (p. 6), but it also needs to be useful by accurately matching the part of reality it attempts to describe.

Identified factors within the theoretical model of MSLI include the Visual, Auditory, and Kinesthetic-Tactile modalities. The interaction of these factors will be explored. These individual factors will be discussed in terms of their direction and strength of effect, interaction, and possible negative effects. Contributing and confounding factors will also be considered.

### **Outcomes**

Roberts and Pashler (2000) offered their evaluation standards for theoretical models: flexibility; the ability to rule out alternatives that are indefensible, theoretically speaking; and the

ability to predict unusual or surprising occurrences. These criteria will be applied to this dissertation's theoretical model of MSLI.

## Literature Review

### Reviews of MSLI

A basic tenet of MSLI is that instruction be delivered simultaneously through more than one sense: specifically, through visual, auditory, kinesthetic, and tactile modes (VAKT). Reading is a visual and auditory task, and both research and intervention have focused on visual and auditory sensory inputs. As Bryant (1979) wrote in her unpublished dissertation: “Reading is an act which utilizes both vision and hearing; teaching approaches which attempt to maximize one or the other, tend to be complex and artificial” (p. 34). However, the kinesthetic and tactile (KT) components have not been thoroughly investigated for their contribution to remediation of dyslexia. Although clinicians have gathered anecdotal evidence to support the use of KT, researchers have kept their focus on the visual and auditory.

Bryant (1979) reviewed the literature and found no evidence supporting the use of KT in the remediation of students with dyslexia. Specifically, she found tactile perception in typically developing children to be more difficult and less accurate than visual perception, less stable, and not as well encoded as visual input. She found learning disabled students to be essentially the same as typicals, with respect to tactile functioning (p. 15). She found that although most teachers were trained to use MSLI and entire textbooks were published on the subject, most case studies only published success stories based on anecdotal evidence. The prevailing theory in the 1970s focused on deficient cross-modal integration, but Bryant was unable to find empirical evidence to support it. In her literature review, she attributed the success of MSLI to small class sizes, 1:1 instruction and novel teaching methods.

Bryant (1979) went on to perform her own experiment for her doctoral dissertation. She studied two groups of first and second graders who both learned three words and one sound.

One group was instructed using all four modalities (VAKT) and the other was instructed using only VA. Both groups were taught using the same curriculum delivered in the same sequence. The VAKT group had the additional instruction in the KT, defined as tracing and writing. Results indicated no difference between the groups on 14 t-tests measuring short-term recall, long-term retention, learning errors, learning time, same-day spelling, long-term spelling, visual discrimination, sequence, and reversal errors in reading, and sequence and reversal errors in writing. The VAKT method took one-third longer to teach than the VA method alone. Bryant suggested that “the effective instructional variables in these and other successful multisensory (and non-VAKT) approaches may be components such as focused presentations, reduction of overload, immediate feedback, teaching to mastery, opportunity for over-learning, and provision for reinforcement” (p. 3). Overlearning, or additional practice after achieving initial learning, supported greater automaticity. Bryant pointed out that the original Gillingham method specifically provided eight forms of presentation of a single sound or a single concept. This meant that students were provided with plenty of practice of a correct concept. The teacher was able to correct errors immediately and reinforce the correct concept until it was over-learned.

Ritchey and Goeke (2006) conducted an extensive literature review to determine the effectiveness of MSLI. Criteria for inclusion in their review were as follows: (1) publication in a peer-referred journal or dissertation; (2) the study analyzed a multisensory method based on an Orton-Gillingham approach; (3) the study was an experimental, quasi-experimental, or single-subject design; and (4) a sample size of at least 10. Ritchey and Goeke found just 12 studies that met these criteria. This is much less in number than expected, given the popularity of MSLI and its historical use for many decades. Findings were: five studies reported that the MSLI treatment was more effective than the comparison group on all outcome measures; four studies reported

that the MSLLI treatment was more effective than the comparison group on one, but not all, outcome measures; and two studies reported that the alternative treatment was more effective than MSLLI. One study found no significant difference between treatment groups.

Ritchey and Goeke's (2006) results indicated overall positive effects for word reading, word attack/decoding, spelling and comprehension for the MSLLI groups. However, vocabulary effects were only reported in two studies and fluency results in one study. Vocabulary and fluency are two of the five areas of effective reading instruction outlined by the NRP, but they are not typically included in traditional MSLLI instruction. Ritchey and Goeke concluded "there is insufficient evidence to conclude that Orton-Gillingham and Orton-Gillingham based reading instruction meet the requirements of scientifically based reading instruction" (p. 181). They also noted the "practice to research gap" in which research provides little evidence for the effectiveness of an intervention that has been practiced for decades. This is the converse of the "research to practice gap" commonly referred to by researchers, or the reluctance of teachers and clinicians to utilize evidence-based practices.

### **Theoretical Models of Treatment**

Lyon and Moats (1988) conducted a comprehensive review of theoretical models of dyslexia and outlined six treatment model types. In the *medical model*, the learning disability is a symptom of a biological problem and instruction remediates the underlying processing problems. In a *psychoeducational model*, the learning disability has the same etiology, but treatment focuses on using the student's area of processing strength, or "modality strength," such as visual, auditory or kinesthetic. The clinician uses that strength as a method for teaching. The *bypass model* is neuropsychologically based. Intact or efficient regions of the brain are used to bypass deficient areas. Subtypes of disability are classified according to lack of function, and



treatment is based on neuropsychological aptitudes identified through assessment. *Behavioral models* conceptualize learning disability as a result of mismatched behaviors and academic tasks with no assumption of underlying biological or neuropsychological pathology. Instruction targets academic deficits and remediates those deficits through teaching strategies derived from learning theory. *Linguistic models* are not specifically visual, auditory, or kinesthetic but focus on a “linguistic deficit that interferes with the reader’s ability to grasp the concept that words have parts--phonemes, syllables, and morphemes--and that these are parts represented abstractly by the alphabetic code” (Lyon & Moats, 1988, p. 833). Programs such as Linguistic Remedies (Wise, 2007) and the LiPS system (Lindamood & Lindamood, 1998), which are articulatory-motor and also teach the phonemic structure of the English language are effective, not necessarily because of their oral-motor component but because of their linguistic and structured teaching components. Finally, *cognitive models* place an awareness on task demands, metacognitive strategies, and the use of efficient and appropriate learning strategies.

Based on their comprehensive review of treatments for dyslexia, Lyon and Moats (1988) theorized that instructional approaches that are directly related to the content of the academics to be learned and that also rely on *well-established principles of learning* (linguistic, behavioral, and cognitive approaches) are “significantly more efficacious” than approaches “limited in content and ecological validity” (medical, psychoeducational, and neuropsychological approaches) (p. 834). Models that use learning theory and principles are effective in remediation. This supports the notion that MSLI is effective due to its structured teaching approach which is congruent with learning theory. The use of multiple senses as a teaching methodology, in and of itself, is not supported. The most widely accepted theory of dyslexia is the “double deficit” theory, which includes phonological processing. Both are discussed below.

## **Current Theories of Dyslexia**

It is clear that science has contributed greatly to defining dyslexia and investigating its causes, but research has not provided sufficient or even adequate evidence to support the efficacy of MSLI (Birsh, 2005). While the effectiveness of structured, systematic, explicit instruction for literacy skills is no longer questioned by leading researchers in the field (Lyon, Fletcher, Fuchs, & Chhabra, 2005), MSLI is still a popular method for intervention. This may be due to an underlying hypothesis that has been alluded to in the literature about the use of MSLI to support attention. Birsh (2005) conceded that empirical support is lacking in recent studies, but added that theoretical support may be found in the neuroscience and cognitive literature dealing with memory (p. 31). Shaywitz (2003) stated that 12-24% of those struggling with dyslexia have comorbid attention disorders, and Birsh (2005) hypothesized that sensory input may have a mediating effect on attention and subsequent recall.

**Phonological processing.** Phonological processing was defined by Wagner, Torgeson, and Rashotte (1999) as “the use of phonological information, especially the sound structure of one’s oral language, in processing written language (i.e., reading, writing) and oral language (i.e., listening, speaking)” (p. 2). It is widely accepted as the most common cause of dyslexia and consists of three components: phonological awareness, phonological memory, and rapid naming. *Phonological awareness (PA)* is the use of phonological information in processing written and oral language. It predicts word reading skills later in a student’s academic career and follows a developmental trajectory. Children begin imitating and identifying larger chunks of sound, moving toward discrimination of smaller units of sound. This leads to fine-tuned discrimination, moving from the level of the word, to the level of a syllable, and finally to the level of a phoneme, or sound bite.

*Phonological memory* (PM) is the ability to code auditory information for temporary storage. Low PM does not impair reading or listening as long as the words are already in the student's vocabulary. Deficient PM has been linked to the inability to acquire new written and spoken words (Gathercole & Baddeley, 1990; Gathercole, Willis, & Baddeley, 1991).

*Rapid naming* (RN) requires efficient retrieval of phonological information from long-term memory. Individuals with slow or deficient RN have difficulty reading fluently due to a slow timing mechanism which impacts the ability to rapidly acquire common letter patterns in printed words. A student with low RN will read in a dysfluent and labored manner, and comprehension will be poor due to being stuck at the level of decoding the same words repeatedly rather than moving those words into the student's sight word vocabulary.

**Double-deficit hypothesis.** For many years dyslexia was thought to be caused by a phonological processing deficit alone, until Wolf and Bowers (1999) published their seminal work that extended the deficit model to include rapid naming. The double-deficit hypothesis attracted so much attention that the *Journal of Learning Disabilities* devoted a special issue of invited papers on the topic of the double-deficit (Manis, Doi, & Bhadha, 2000; Wolf, Bowers, & Biddle, 2000; Wolf, Miller, & Donnelly, 2000) and research from other studies supported the model (Badian, 1997; Bowers, Sunseth & Golden, 1999; Levy, Bourassa, & Horn, 1999; McBride-Chang & Manis, 1996). Wolf and Bowers (1999) were the first to categorize naming-speed deficits as separate from phonological processing deficits, identifying two separate causes of reading dysfunction. They categorized two subtypes of readers with dyslexia and one combined type: those with phonological processing deficits alone, those with naming-speed deficits alone, and those with a "double-deficit" (both phonological processing and naming-

speed deficits). The double deficit theory remains the most robust and clinically accepted theory of dyslexia to date.

The phonological processing subtype includes those with PA and PM deficits, yet no deficit in rapid naming. Phonologically based treatments, such as linguistic models on explicit instruction in phonics, are recommended. There is no recommendation of multisensory methods for teaching these students. Wolf and Bowers' research (1999) found that impaired readers could have a naming-speed deficit without having a phonological processing deficit. Denckla (1998) discussed that naming-speed tasks predict how rapidly visual-verbal connections are made and that naming speed plays a causal role in the development of the emerging reading system in a young reader.

These visual-verbal connections are multisensory and are effortless in a typically developing reader, supporting the rapid acquisition of sight words. Words eventually become automatically recognized without having to decode them every time they are presented visually; moving from decoding to fluency, to comprehension – the new reading system becomes increasingly efficient and fluent. An example of this progression is imagining a stop sign. An adult does not approach the sign and sound out s-t-o-p, nor does the adult consciously read the word stop. The word has become fluent long ago and has been stored in memory, so that when an adult sees the stop sign, it is impossible to prevent recognition or to go back to decoding. Naming-speed deficits are unrelated to intellectual functioning, but are related to processing speed. Slow naming speed creates an insensitivity to previously practiced letters, letter patterns, and letter-sound associations, which are hallmarks of dyslexia that lead to a limited sight-word vocabulary. When visual-verbal connections are slow, the addition of the kinesthetic modality may help to support rapid naming.

There is no difference in rate of processing in visual or auditory presented material with respect to RN in the reader with dyslexia at an early level of processing (Wolf & Bowers, 1999). The difference in processing speed becomes apparent when stimuli are presented closer together in rapid succession. Individuals struggling with dyslexia are weaker with visually presented material and require longer interstimulus intervals (ISIs) with auditorally presented material. This means that a reader with dyslexia needs more time to process auditory information and has more difficulty retaining visual information. Wolf and Bowers (1999) also reviewed the rate differences across modalities and found no difference at basic levels of perception, but they did find significant processing speed problems for readers with dyslexia as the complexity of the task increased, demanding more speed and accuracy from the reader (p. 429). Interestingly, Merzenich (1993) found that the cortex builds representations by grouping sensory information together that is temporally correlated (i.e., close in time), supporting Wolf's notion that there is a "temporal synchrony of sensory input" (p. 429). Use of the kinesthetic modality can keep the learner with dyslexia on track, effectively scaffolding the lesson in such a way that the student is able to focus attention on a sound or symbol being presented and create a temporal marker in time. Later, this kinesthetic movement serves as a memory cue, linked to the sound or symbol. In fact, Dr. Orton hypothesized that kinesthetic-tactile reinforcement of these visual and auditory connections could correct the confusion of similar letters and the tendency of an individual with dyslexia to transpose the sequence of letters during reading and writing (IDA, 2009).

The final subtype described by Wolf and Bowers (1999) is the combined (or "double-deficit") subtype, that has both phonological processing and rapid naming deficits. This is the most severely impacted group. A modest relationship between phonological processing and rapid naming exists. According to Wolf and Bowers, phonological processing and rapid naming

are independent yet they are contributing factors to word identification, orthography, fluent reading, and comprehension. In languages with a more predictable orthography than English, which therefore produce less strain on phonological processing, it is naming speed that is the single best factor for diagnosis. Although phonological awareness is related to word analysis, rapid naming is related to orthographic accuracy and speed and reading fluency (Torgeson, Wagner, Rashotte, Burgess, & Hecht, 1997). The double-deficit theory attributes dyslexia to a number of deficits across a spectrum of disability, therefore one intervention is not necessarily effective for every student with dyslexia.

### **Brain Function and Reading**

Berninger and Richards (2002) wrote of learning mechanisms that contribute to brain development, not unlike the learning theory noted by Lyon and Moats (1988) and alternative hypotheses for gains made by students in MSI classrooms by Bryant (1979). There are six mechanisms involved in stimulating dendritic growth in response to academic instruction (Elliott, 1999). These mechanisms are as follows: *habituation*, *novelty-seeking*, *classical conditioning*, *operant conditioning*, *imitation*, and *verbal learning*. In *habituation*, the individual responds for a while to what is novel, until it becomes familiar, and at which time the individual stops responding to that stimulus. Habituation is a “selective function” that screens out stimuli that are no longer useful to the individual. *Novelty-seeking*, or curiosity, is related, because the individual is always alert to what may be new. A balance between habituation and novelty-seeking is necessary for learning. If there is no self-regulation between habituation and novelty-seeking, there will be problems with learning. For example, when an individual habituates too soon, they will have problems with attention and inappropriately seeking out novelty. In the classroom, this premature novelty-seeking translates into problems with practice activities,

automatization of skills, and creation of word representations in memory (Berninger & Richards, 2002).

In *classical conditioning*, an association is made between two closely occurring stimuli. Once the connection is made, presentation of one stimulus will activate the other. In *operant conditioning*, a connection is made between an action and another stimulus (reward or punishment) to increase or decrease the action. Imitation is oftentimes the basic form of learning when the memory system is young and immature, as in the case of infants imitating sounds or facial expressions. The infant imitates what is in the environment. Once internal representations are stored and memory capacity expands, the ability to imitate those representations, rather than what is represented in the external world, develops, and higher-order learning can occur. Finally, verbal learning capitalizes on the use of language to achieve cognitive goals by self-instructing during learning, relating life events or discussing cognitive concepts (Berninger & Richards, 2002).

Not only does the brain respond to learning mechanisms, but it also creates a “functional reading system by building upon previously acquired brain functions” (Berninger & Richards, 2002, p. 109). The authors call this a remodel, not a new construction. The brain is flexible in its organization; one structure participates in more than one functional system and may relay information across layers of neurons, which makes it difficult to map exactly when, where, and why the reading process breaks down in the reader with dyslexia.

The most important brain functions that support literacy learning are sensory, motor, aural/oral, cognition, memory, attention, and executive functioning (Berninger & Richards, 2002). Although each of these brain systems functions on its own developmental pathway, they work together to produce a new function (reading, writing, listening, spelling). For example, the

sensory and motor functions are separate functions, but they work with each other and with other functions when a child learns to read and write. If one system is not functioning optimally, the other may need to take a more pronounced role.

Writing is more than a grapho-motor act, and reading is more than an ocular-motor act. Several systems (visual, auditory, motor) may be used for purposes other than reading, or may be shared with other task demands, creating new systems for decoding, phonological processing, phonological memory, and ultimately, comprehension. The visual system, which is not only spatial but temporal, uses already existing skills to create a new system for written words, what Berninger and Richards (2002) call the “orthographic processor” (p. 112). Poor readers oftentimes have deficits in fast visual processing, which can be thought of as the visual version of RN. If the visual processing system is slow and not working in synchronicity with the auditory system, the kinesthetic modality may help the student with dyslexia learn the visual and auditory information necessary to read through sustained attention and at a pace that allows the visual and auditory to be slowly integrated.

The nervous system has two types of motor systems, gross- and fine-motor. The gross-motor system involves large muscles of the trunk and limbs; the fine-motor system involves the small muscles of the hands, fingers, and mouth. The fine-motor system can be further broken down into oral-motor (mouth), grapho-motor (hand), and ocular-motor (eye) systems. All motor movement is not necessarily kinesthetic. Kinesthesia is the sensation of movement through space which also detects body position, weight, and movement of muscles. These movements are mediated by receptors in the muscles, tendons, and joints. In essence, gross motor movement is kinesthesia. The etymology of the word *kinesthesia* comes from the Greek *kinesis* which means motion or movement and *aisthesis*, which means feeling, or sensation.



MSLI practitioners include all motor activities under the umbrella of “kinesthetic” activity, making every learning activity multisensory because it is impossible to parse out the movement of even the smallest muscle in the body from sensory input through the eyes, hands, and fingers. This provides a convenient loophole for labeling every learning activity multisensory. For the purpose of this dissertation, “kinesthetic” is defined as whole body or gross-motor movement, maintaining a focus on large muscle movement throughout space.

## Results

Although clinicians and educators the world over have used MSLI to teach students with dyslexia to read, there has been very little research to support the efficacy of the multisensory component within the model. Evidence does support the pedagogical structure of the system, which includes explicitly teaching the structure of the English language, building slowly from phonemes to words, teaching morphology and orthography, and training students in fluency and comprehension (Partnership for Reading, 2006). What sets MSLI apart from other teaching approaches is the use of multiple senses (VAKT) simultaneously. However, the specific use of multiple senses is not yet fully supported by the research.

MSLI claims effectiveness due to the use of two or more senses simultaneously while reading or writing. *All* motor movement is considered “kinesthetic”, including ocular-motor, grapho-motor, and articulatory movement. It is quite obvious that one cannot read without moving the eyes (if reading silently) or the mouth (if reading aloud), nor can one write without moving the fine muscles of the hand. It is impossible to separate the motor action from the cognitive processing when reading or writing and therefore impossible to empirically investigate. For purposes of this dissertation, “kinesthetic” is defined as gross-motor movement. This theoretical model proposes an indirect pathway from the kinesthetic modality to reading comprehension via working memory, phonological working memory and attention.

### Working Memory

In 1974, two British psychologists developed an elaborate theory of short-term memory. Baddeley and Hitch proposed a multicomponent model of short-term memory in which one compartment serves as storage and another as a processor. Baddeley (1986) defined *working memory* as “a system for the temporary holding and manipulation of information during the

performance of a range of cognitive tasks such as comprehension, learning and reasoning” (p. 34). The working memory model consisted of three components: a phonological loop, a visuospatial sketchpad, and a central executive that controlled the two other subsystems. Over the years many researchers (e.g., Engle, Tuholski, Laughlin, & Conway, 1999; Swanson & Berninger, 1996) have studied Baddeley’s model and provided overwhelming empirical evidence that supported the division of working memory into modality-based short-term storage and a modality-free processing center, with a central executive controlling both.

The *phonological loop* is a speech-based storage unit of verbal information (Baddeley, 2003). Like a tape recorder loop, it has a specific length where auditory units are recorded in the order perceived. Unless rehearsal is used to re-record the information, it either degrades quickly or is recorded over by new auditory information. Baddeley (2003) divided the phonological loop into two subcomponents: a passive and temporary phonological input store and a subvocal, articulatory rehearsal process. Verbal information gains immediate access to the phonological loop and is stored briefly in phonological form (Logie, 1996). The subvocal, articulatory rehearsal process is important because it ensures preservation of incoming phonological information through rehearsal. Unless something is done to preserve this phonological information, the phonological loop will hold the information for two seconds or less (Hulme & Mackenzie, 1992). This is the length of the “tape loop” regardless of age. The number of verbal items that can be fitted onto the tape depends on the time taken to articulate them, not the time taken to hear them. For example, an adult can recall five one-syllable words, presented in a two second time frame, with 90% accuracy. But when given five multi-syllable words, accuracy drops to 50% (Baddeley, 2003). This implies that retention of verbal information in short-term memory past two seconds depends on rehearsal, and the number to be rehearsed is limited by the

two second loop (Dehn, 2008). Of particular importance, though, is that subvocal rehearsal is just as effective as verbal rehearsal. If prevented from rehearsing verbally, performance is impaired (Baddeley, 1990). Therefore phonological short-term memory is a function of rate of decay + the rate of rehearsal. An individual's verbal span is essentially determined by the ability to rehearse verbal stimuli at a more rapid rate than the rate of decay (Baddeley, 2006).

The visuospatial *sketchpad* stores visual and spatial information and generates and manipulates mental images (Baddeley, 2006). It also has passive storage and an active rehearsal process; depending on the complexity of visual image and the time of exposure, decay happens in a few seconds. The primary function of the visuospatial sketchpad is to maintain spatial stimuli. It has been linked to control and production of movement (Logie, 1996). Most people verbally recode visuospatial input into a speech form, but not until the age of 10 (Dehn, 2008). For example, at age five children have limited recall that is impaired by objects or symbols that are visually similar, just as phonological similarity affects the phonological loop (Hitch, 1990). Younger children may be unable to use verbal rehearsal to store the names of visual stimuli due to limitations in their developing working memory capacity. As this capacity increases, children rely on recoding visual input to verbal codes. This step is accomplished through rehearsal (Hulme & Mackenzie, 1992).

The *central executive* controls both the phonological loop and the visuospatial sketchpad and is responsible for higher-order processing of verbal information, such as combining whole words to form an idea or feeling. Baddeley (2003) considered it the core of working memory. It is modality-free, linking subsystems that are dependent on visual or auditory processing. The central executive is involved when an individual is required to simultaneously process and store information, and it manages multitasking situations such as processing information while also

attempting to retain it (Tronsky, 2005). Baddeley (1986, 1996, 2003, 2006) outlined several functions of the central executive. *Selective attention* focuses attention on relevant information while inhibiting attention toward irrelevant or competing information. *Switching* is the coordination of multiple, simultaneous cognitive tasks. Using flexible strategies, the central executive also *selects and executes plans* and *allocates resources* to other parts of the working memory system. The central executive can also *retrieve, hold, and manipulate* temporarily activated information from long-term memory.

Miyake, Friedman, Emerson, Witzki, and Howerter (2000) narrowed these central executive functions down to three: inhibition, switching, and updating. *Inhibition* is the most crucial function because it screens out impertinent information and discards information that is no longer useful. *Switching*, or shifting, is the ability to alternate between tasks or operations. *Updating* is the ability to control and update information in working memory. This system is a constant process of revision when newer information replaces or modifies old information (Swanson, Howard, & Saez, 2006).

Swanson and Sachse-Lee (2000) conducted a analysis of working memory in children with reading disability which built on the Baddeley model of the phonological loop and central executive. Subjects were grouped according to high, moderate, or low executive functioning and were compared on phonological, visual-spatial, and semantic working memory tasks across baseline, gain, and maintenance conditions. Results showed that the subgroup with dyslexia and executive functioning difficulties performed most poorly on all task and memory conditions. The investigators theorized that an inefficient phonological system creates a “bottleneck” restricting flow of information to higher levels of processing, and that a working memory system

with limited capacity underlies some problems in recall of information in students with dyslexia. In other words, reading processes are competing for limited working memory resources.

### **Phonological Working Memory**

Torgeson (1996) described phonological working memory as “a phonological memory store to hold speech information for a brief period while speech is being interpreted by an articulatory control process that activates speech-motor programs” (p. 31). Phonological working memory is the integration of holding phonological information in mind while simultaneously interpreting it. This is another task of the central executive: to integrate the memory components of the phonological loop with the articulatory control process that supports rehearsal. This component of the phonological loop within working memory has been implicated in dyslexia. The inability of a student with dyslexia to maintain phonological codes in working memory significantly impacts their ability to recall information and also impairs decoding (Dehn, 2008; Masoura, 2006).

A study by Mousavi, Low, and Sweller (1995) focused on the “split attention effect” which occurs when a student is forced to split their attention between more than one source of information, therefore increasing cognitive load and taxing working memory. Mousavi and colleagues presented typical geometry students with both a diagram and written statements, forcing the students to split their attention and search for relationships between the two forms of information. Results of six variations on this experiment found that integrating multiple sources of information into working memory is easier when the material is physically integrated (multisensory) than when information is presented separately to each modality (unisensory), supporting their hypothesis of modality effects of presenting material, and that “working memory has partially independent processors for handling visual and auditory material”

(Mousavi et al., p. 319). This lends credence to the multisensory approach for students with dyslexia, who are slow to process auditory and visual information. If the material is presented in a multisensory format and the integration of the senses is explicitly taught, the student with dyslexia is less likely to make errors in connecting the sounds to symbols and can move words into the student's sight vocabulary once they become fluent.

These results, coupled with Merzenich's (1993) finding that the chronological order of sensory input is critical to retention, reinforces the hypothesis that MSI supports working memory and therefore positively impacts the ability of a student with dyslexia to hold phonological information in mind in order to decode and process that information. The teacher carefully sequences and paces the instruction so that the sensory characteristics of letters and letter-sound combinations can be imitated, repeated, and consolidated into memory. The use of temporally integrated information increases retention, while modality effects are skewed in the positive direction when instruction is delivered in a structured, multisensory manner.

### **Movement and Attention**

There is an increasing body of research supporting the fact that movement improves learning. Psychiatrist John Ratey recommended physical exercise as an alternative intervention for ADHD and to stimulate learning in his book *Spark: The Revolutionary New Science of Exercise and the Brain* (2008). Neuroscience has long held the position that novel experiences stimulate neuronal synapses and dendritic growth. Ratey cites current neuroscience in explaining that exercise sparks long-term potentiation (LTP), a cellular mechanism for learning and memory that requires that brain cells are strengthened so they can send a signal across a synapse. Exercise also increases brain-derived neurotrophic factor (BDNF), a protein produced

inside nerve cells when they are active, which keeps brain cells functioning and growing and encourages new brain cell growth.

Ratey (2008) outlined how exercise improves learning on three levels. First, exercise improves alertness, attention, and motivation. Physical activity is a novel experience to the brain and also helps the brain to release many important neurotransmitters such as serotonin, dopamine, and norepinephrine, all of which are important in maintaining attention. Attention and motor activity also share many overlapping pathways, and the attention system is dependent on dopamine and norepinephrine for regulation. Exercise increases both.

Second, exercise encourages nerves cells to bind to one another which supports “logging in” new information in the brain. BDNF builds and maintains cell circuitry, which is how brain cells communicate. Ratey (2008) calls BDNF “a crucial biological link between thought, emotions and movement” (p. 40). And finally, exercise spurs development of new nerve cells in the hippocampus, which has a critical role in forming memories and new learning.

Ratey warns against learning and rigorous exercise at the same time. Too high a level of exercise will divert blood flow away from prefrontal cortex, which ultimately hampers executive functioning. Physical activity can regulate the amygdala, which in turn can slow the impulsivity component in ADHD (Ratey, 2008). This has a direct connection to intervention for students with poor RN who tend to guess at a word based on beginning letter or sound, cutting down on the impulsive guessing so they can attend to direct instruction that informs active decoding of words.

### **Three Tenets of the Theoretical Model**

**A pedagogical tool.** In her extensive literature review on MSLI, Bryant (1979) concluded that MSLI was effective due to pedagogical strategies, such as the use of overlearning



and rehearsal, rather than the use of multiple senses. Good pedagogical strategies can be directly linked to Baddeley's principles of working memory and executive functioning mentioned above. Effectively supporting students with poor executive skills who have difficulty attending to what is important and *inhibiting* what is not important, kinesthetic involvement highlights important information and provides an outside structure for selective attention. Directing focus on what is taught in the moment, the teacher also structures instruction in a manner that eliminates extraneous input. Overlearning occurs through rehearsal and repetition of this input by tagging the content for storage in short-term memory.

Setting goals and creating a plan to move toward that goal is clearly articulated by the instructor and imitated by students through movement paired with vocalization or subvocalization. Movement encourages *updating*, which is directed by the teacher and supported through pairing the movement with prior knowledge. *Switching* is also encouraged with movement cues once these pairings are overlearned. Switching between subgoals or dissimilar sounds is not taught so as not to confuse students, and no additional sounds or units of sounds are introduced until prior building blocks are overlearned and automatized. Updating and monitoring storage and processing are supported continuously through repetition, anchoring a concept onto a cue, which in this case is a physical movement. The teacher does not allow the information to be recorded over within the phonological loop. During all of these strategies, MSLI teachers are using movement as a pedagogical strategy to support executive functioning.

**A memory aid.** Movement, as used in an MSLI classroom, is a form of rehearsal that leads to overlearning, which in turn assures that the recording of input stays active in the phonological loop rather than being recorded over. Movement is always combined with sounding out, or reading the symbol, which increases articulatory rehearsal whether vocally or

subvocally. This rehearsal is crucial for overlearning and for information to move from working memory to short-term memory.

Redintegration is a longstanding psychological theory that explains the phenomenon of an entire state of mind being restored from just one element of that whole (Shams & Seitz, 2008). Shams and Seitz (2008) cite neuroimaging studies that show recognition of a visual image activated through other sensory means, and visual recognition of words that were encoded using auditory and visual representations activated auditory areas of the brain even though that recognition did not require retrieval of that information through auditory means. Shams and Seitz (2008) concluded that multisensory exposure to stimuli enables multisensory encoding that can later activate a larger network of brain areas than those used in unisensory encoding. Therefore a student with dyslexia could recall multisensory content later through activation of one modality, such as movement. If movement is connected to a sound, letter, symbol, or word during instruction, then it can be used as a memory cue to help the student with dyslexia retrieve that information and apply it to a current task. Because the movement is anchored to the sound or visual representation, use of the movement (a single element) restores the sound-visual connection (entire state of mind).

**Teacher feedback.** Teaching and learning is an interaction between student and teacher. The teacher is continually learning about the student's level of understanding, motivation, and attention through feedback given by the student. This feedback can be verbal, nonverbal, behavioral or, as in kinesthetic learning, through active movement of the body. This student-teacher feedback loop is enhanced by movement. The teacher serves as the students' central executive, until that skill can become fluent and automatic, at which time the teacher can build on the newly acquired fluency or introduce more complex material. For example, when a

student is asked to “sky write” a letter in the air, the teacher has an immediate understanding of where the student is in their understanding because it is easily seen. The student benefits from the teacher’s immediate intervention, rather than later or perhaps not at all. An added benefit is that the student also has a feedback loop that is connected to the other students in the environment and can use that feedback to self-correct if the teacher is not available.

## The Model

### Theoretical Model

The visual model below (Figure 3) can be divided into several actions, represented by arrows between elements. Kinesthetic involvement in learning increases attention. As discussed in the literature review, if a student habituates too soon, he or she will have problems with attention, seek out novelty, and have difficulty with practice activities. This has an adverse effect on the ability to automatize skills and create word representation in memory (Berninger & Richards, 2002). Using movement creates a novel approach to learning that may appeal to those who cannot regulate between habituation and novelty seeking and serves a dual role as a measurement of attention to the teacher.

RAN Rapid Naming  
 WM Working Memory  
 PWM Phonological Working Memory

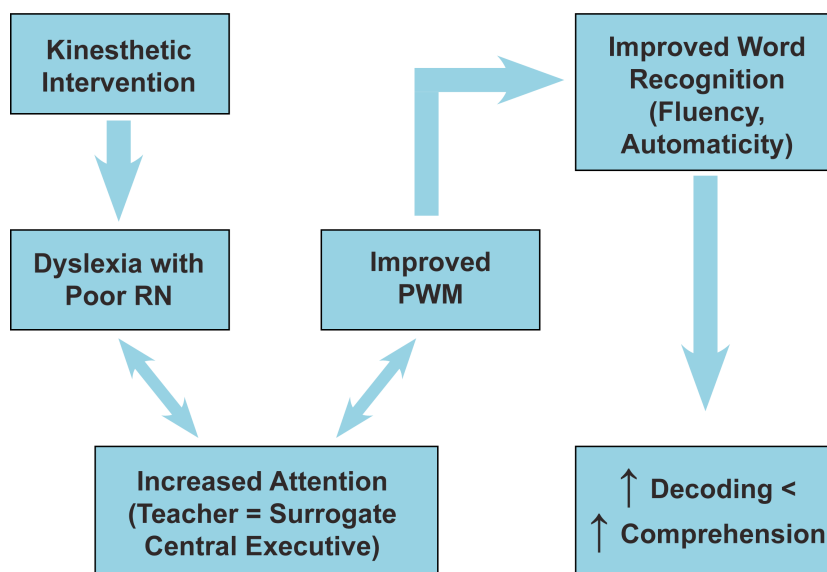


Figure 3. Theoretical Model of the Kinesthetic Modality in MSLI

In the MSLI approach, involvement of movement is connected to the sound (phoneme) or letter (grapheme). The movement influences memory through association with prior knowledge

and a method of rehearsal. Eventually, if the incoming phonological information is connected to prior meaning it can activate relevant information in long-term memory storage, which in turn facilitates short-term recall without rehearsal (Baddeley, 2003). In this way, the movement is linked to meaning, which in turn holds attention and impacts memory.

In Baddeley's model (2003) working memory, which includes phonological working memory, is the job of the central executive. Dehn (2008) extended the notion of working memory to include phonological working memory. The central executive benefits from the development of automatic processing because mastered skills require less monitoring and free up the central executive for higher-level processing. Automaticity depends on the degree of rehearsal and overlearning and supports the fluency of phonological working memory. It also supports the freedom of the central executive to process higher-level content.

As stated earlier, the phonological loop transforms auditory information into phonological codes according to acoustic, temporal, and sequential properties. MSLI instruction relies on a specific, repetitive sequence, which removes the working memory burden of simultaneously remembering and processing from the student. Because the teacher is keeping track of the sequence and temporal order of information and the pace and frequency of repetition, the teacher essentially serves as the student's central executive.

Phonological working memory is necessary to develop a fund of sight words and increase vocabulary. Once automaticity of phonemes is reached, students become automatic in recognition of letter combinations, then short words, then longer words. This moves the student away from simple decoding toward reading fluently. Fluency means not only a quick rate, but also accuracy. Birsh stated that "previous knowledge of the domain of information being processed determines comprehension more than any limitation of working memory

capacity...comprehension is a product of prior knowledge...” (2005, p. 31). However, readers with dyslexia are excruciatingly slow decoders who do not free up any part of the central executive to process information and do not develop a fund of vocabulary or sight words. If the student cannot acquire new words, store them, and read fluently, there will be no comprehension. The teacher role of central executive is crucial in order to explicitly teach connections between phonemes, graphemes, and orthographic symbols that might otherwise consume the student’s central executive and leave little room for fluency and comprehension.

### **Intervention Model**

This intervention model (Figure 5) is an adaptation of a three-tiered Response to Intervention (RTI) model (Figure 4) which is becoming popular in public school systems. RTI is a process that serves two purposes: to identify students with a learning disability, and to enhance educational opportunities for all children (Fletcher, Lyon, Fuchs, & Barnes, 2007). It includes the use of reliable and valid measures that assess progress over time; valid intervention protocols for targeted outcomes such as word recognition, fluency, and comprehension; and a school-level coordinated model of screening, intervention, placement, and ongoing assessment. It is intended to replace the discrepancy model of learning disability currently employed in the current Diagnostic and Statistical Manual, 4th edition, text revision (American Psychiatric Association, 2000). Students are typically screened and placed in one of three leveled groups. If a learning disability is suspected after screening, the student is placed for intervention and progress is consistently monitored. The identification of a learning disability is based on failure to respond to empirically based intervention, and students are moved up through the levels of the model based on their response to intervention, rather than a discrepancy between their cognitive ability and their academic achievement.

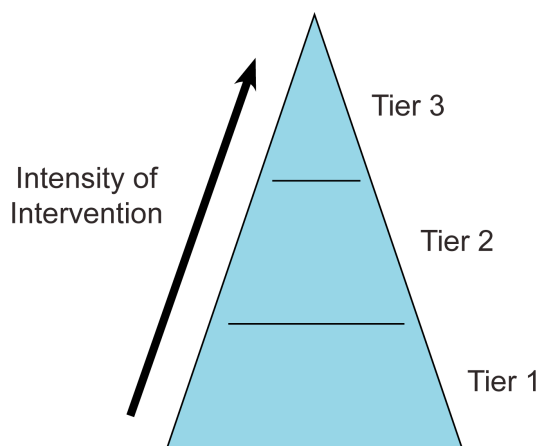


Figure 4. Response to Intervention (RTI) model

Tier I students are those without learning disabilities who will learn to read easily, as well as those who are struggling to read but due to lack of exposure, poor instruction, or acquiring English as their second language rather than a learning disability. Treatment for these students should include increased direct instruction; increased exposure to oral, aural, and written language; and parental support. These students do not have a learning disability and will respond positively to direct instruction and to an appropriate learning environment.

Tier II consists of students with phonological awareness (PA) deficits only. These are students with deficits in only one area of reading (PA) as defined by Wagner, Torgeson, & Rashotte (1999). Gillon (2000, 2002) found evidence that children with phonological disabilities improve in phoneme awareness, reading, and spelling when they are sensitized to the articulatory features of phonemes and phoneme sequences within words and when they learn the written symbols that represent them. Breier, Gray, Fletcher, Foorman, and Klass (2002) used discrimination tasks with children with dyslexia but no ADHD, dyslexia with ADHD, ADHD with no dyslexia, and typically developing children with no ADHD. Children with dyslexia performed more poorly than children without dyslexia only on a measure of speech stimuli, but

not on non-speech stimuli, and phonological processing measures were more closely related to speech stimuli, independent of the presence of ADHD. In light of current research findings, including Breier et al. (2002), these students respond best to linguistically based interventions, such as Linguistic Remedies (Wise, 2007) or the LiPS program (Lindamood & Lindamood, 1998). Use of the kinesthetic modality is unnecessary with this group because their single deficit in phonological awareness responds to linguistic interventions due to difficulty with speech stimuli. This group does not exhibit the rapid naming deficit or the double-deficit discussed in Wolf's theory.

Tier III represents students who fall into the double-deficit group, having difficulties in two or more areas: phonological awareness (PA), phonological (working) memory (PM) and rapid naming (RN), or who have a single deficit in RN alone. These students may also be dually diagnosed with ADHD or other difficulties with executive functioning. Treatment for this group should include the kinesthetic modality in order to address problems within the central executive and rapid naming. Use of the kinesthetic modality provides immediate feedback to the teacher, who is acting as a surrogate central executive to the student and keeps the student's attention steady so that working memory can work with the new information. In effect, the use of the kinesthetic is simultaneously supporting the student's poor working memory, while using the teacher as a substitute central executive as working memory is remediated. Movement increases attention, which in turn supports working memory.



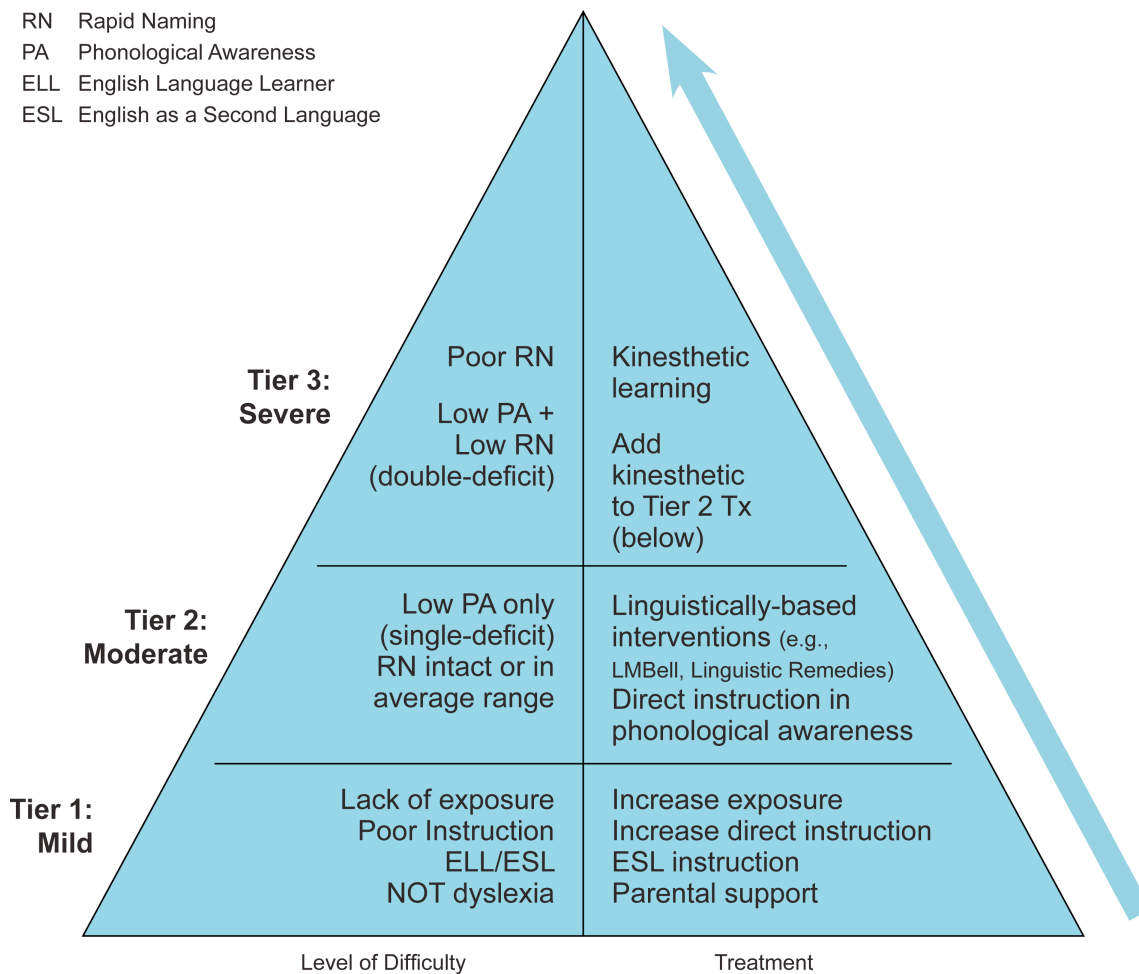


Figure 5. Three-Tiered Intervention Model for Dyslexia Using the Kinesthetic Modality

## Conclusion

The review of the literature for this dissertation did not reveal direct evidence to support the use of multisensory modalities to teach students with dyslexia. However, longstanding theoretical models of executive functioning and working memory (Baddeley, 1986, 1990, 2003, 2006), double-deficits in phonological awareness and rapid naming (Wolf & Bowers, 1999; Wolf, Bowers & Biddle, 2000), and research on the topics of phonological memory (Gathercole & Baddeley, 1990; Gathercole, Willis, & Baddeley, 1991; Torgeson, 1996) and phonological processing (Torgeson, et al., 1994) support a theoretical model for the use of MSLI as an intervention for some students with dyslexia. With respect to the multisensory aspect of MSLI, the use of the kinesthetic modality may have an *indirect* effect on reading comprehension via attention, working memory, and phonological working memory.

Baddeley's (1986) three-part working memory model consists of a phonological loop, a visuospatial sketchpad, and a central executive that controls the two other subsystems. Working memory is divided into a modality-based short-term storage and a modality-free processing center, with a central executive controlling both. This central executive links subsystems that are dependent on visual or auditory processing, and it is involved when an individual is required to simultaneously process and store information. The central executive also manages multitasking situations such as processing information while also attempting to retain it (Tronsky, 2005). Because the central executive links subsystems that are modality-dependent, it is easy to place the blame on either of these two subsystems when a student cannot learn to read. Rather, this dissertation combines Baddeley's model of working memory with Wolf and Bowers' double-deficit hypothesis to theorize the role of rapid automatic naming in dyslexia.

Baddeley (1986, 1996, 2003, 2006) noted several functions of the central executive: selective attention, switching, selecting, and executing plans, resource allocation, retrieval, holding, and manipulating information. These functions were narrowed down by Miyake, et al. (2000) to three: inhibition, switching, and updating. This executive system is in a constant state of revision when newer information replaces or modifies old information. If a student is unable to rapidly name objects or concepts (rapid automatic naming), this revision process slows, and the functions of the central executive become laborious rather than fluent.

Phonological working memory is a component of the phonological loop within working memory (Torgeson, 1996). Phonological working memory is responsible for holding phonological information in mind while simultaneously interpreting it. The inability of a student with dyslexia to maintain phonological codes in working memory significantly impacts the ability to recall information and also impairs decoding (Dehn, 2008; Masoura, 2006). Again, the central executive, and specifically, working memory and phonological working memory are implicated in dyslexia.

The split attention study by Mousavi, et al. (1995) and Mezernich's (1993) findings reveal that the chronological order of sensory input is critical to retention, providing evidence for the hypothesis that MSLI supports working memory and therefore positively impacts the ability of a student with dyslexia to hold phonological information in mind in order to decode and process that information. MSLI's use of temporally integrated information increases retention, while modality effects are skewed in the positive direction when instruction is delivered in a structured, multisensory manner.

For pedagogical reasons, MSLI may be effective because it employs teaching strategies that fall in line with empirically based learning theory. Overlearning occurs through rehearsal

and repetition of movement anchored to a sound or symbol. This overlearning helps the new material to move into memory, rather than rely on working memory to process the information at the first moment of exposure. Movement also encourages updating, which is directed by the teacher and supported through pairing it with the student's prior knowledge. Once the concept is overlearned, the teacher can encourage switching with movement cues. Attention is continually monitored by the teacher, across all students, in an effective manner when movement is involved because the teacher has continuous feedback from the student as to their ability to attend to the task. This is a continuous feedback loop between the students and teacher, who can then give specific attention when needed, slow the pace of instruction, or direct individual attention to a student who is falling behind. This immediate intervention helps the student in the moment.

The net effect of evidence-based instruction grounded in learning theory, coupled with the use of the kinesthetic modality to support attention, working memory, and phonological working memory is the increase in rapid naming/automaticity, decoding, acquisition of sight word vocabulary, and, ultimately, reading comprehension. The proposed intervention model effectively links teaching strategies and sensory modalities to specific subtypes of dyslexia based on a theoretical model produced from current research.

Use of the kinesthetic modality with students who have double deficits in both PA and RN, or who have a single deficit in RN only, increases attention via the use of the teacher as a surrogate central executive. The teacher scaffolds these executive functions for the student, effectively freeing up the student's attentional system to acquire new content. The teacher may act as the central executive in as large a capacity as needed by the student, for as long as the student may need. Once the student acquires working memory and phonological working memory skills, the teacher can slowly withdraw their scaffolding, allowing the student to work

toward independent executive functioning. One way to assess this is for teachers to follow a pedagogical protocol that explicitly outlines what executive functions will be scaffolded and to keep data on how long they support students in this manner when they begin to reduce the scaffolding, and monitoring student achievement through assessment.

At the point when students have achieved independence with working memory and phonological working memory skills, they no longer need to allot brain power to decoding a word every time they encounter that word. It will become part of their sight vocabulary, effectively increasing their automaticity and fluency (rate + accuracy). Fluency, being the ultimate goal, means less time spent slowly decoding and more time for comprehension of increasingly complex text.

### **Evaluation Standards**

Roberts and Pashler (2000) offered their evaluation standards for theoretical models: flexibility; the ability to rule out alternatives that are indefensible, theoretically speaking; and the ability to predict unusual or surprising occurrences. These criteria are applied to this theoretical model and used to evaluate its usefulness.

This model, by nature, is flexible. It is intended to provide both a diagnostic structure to dyslexia and a treatment structure. It is based on the RTI model, which implies that each individual will respond differently to intervention. An individual's response or lack of response to intervention determines where they will fall within the model and if they will move up to a higher tier. Much of the diagnostic categorization and response to intervention is dependent on where the individual falls within the double-deficit model: one of the single deficits or both. This affects the intensity of the learning disability and which intervention is most appropriate.

There is also room for movement within the model, dependent upon the individual's response to the intervention provided.

Proponents of MSLI argue that the use of multiple senses provides “multiple inputs” to the brain. But isn't reading, by its very nature, multisensory? MSLI proponents also overgeneralize when they label absolutely any movement of the body “kinesthetic.” This includes eye movement (oculomotor), fine motor movement of the fingers (graphomotor), and movement of the mouth (oral motor). Again, this notion of “kinesthetic” is difficult to parse out as a separate modality because reading and writing are, by nature, “multisensory” all of the time.

This model can be seen as a diagnostic model because it is built to categorize the intensity of a learning disability based on the double-deficit theory (i.e., varying degrees of intensity based on a single deficit or a double deficit). Any movement within the model can be accommodated through the response to intervention of the student. For example, with training, a student who is categorized as having a single deficit in phonological awareness and is treated with a linguistically based model of intervention, may respond positively and, therefore, move to the lower tier. At the same time, this same student may not respond positively to this treatment, at which time further investigation may reveal difficulty with rapid naming, thus a double deficit. Because the student did not respond to treatment, the clinician assumes that there is a more serious disability. This student would be moved to the top tier, and treatment would be altered to include the kinesthetic modality to support attention and working memory.

### **Limitations**

Building the perfect model is not an easy pursuit, and it takes many years of research to modify a model to perfection. Even then, research moves forward, and elements of a theory or model are investigated, changed, or completely thrown out. In the spirit of Rodgers' (2010)

thoughts on modeling rather than using NHST, it is the investigator's hope that this dissertation ignites research into MSLI and the use of multiple senses to teach students with dyslexia.

This model is not intended to be a developmental model that moves in a longitudinal manner across an individual's lifespan. It is, however, intended to be flexible, depending on the individual's response to the intervention implemented. While dyslexia itself has been given much attention in the research, how dyslexia changes over the lifespan, especially with respect to neuroplasticity, has not. As adults, we come to know and understand our individual differences and limitations. Adults with dyslexia are no different. Perhaps, in the end, the best intervention provides these work-arounds to the dyslexic brain in lieu of the teacher serving as the central executive and as a means to the end result of reading with comprehension and fluency.

The human brain is incredibly complex and also capable of infinite plasticity. The working model of the human brain is not localized or specialized, as once thought. One region may have several "jobs" and may take over a job from a damaged or dysfunctional area. The dyslexic brain tries to make up for deficiencies by using other, less efficient areas of the brain to compensate (Berninger & Richards, 2002).

This model is necessarily narrow in its scope, focusing on external sensory-motor input, rather than internal imagery. "Bottom-up" brain operations are driven by both sensory-motor input and internal imagery and can therefore drive the attentional system from within (Berninger & Richards, 2002). Just one of these drivers – the kinesthetic – is accounted for in this model.

### **Future Research**

There is a critical need for further research in this particular area of dyslexia intervention. Ideally, rigorous studies that manipulate instructional strategies and conditions, then measure outcomes and compare results, would further the field and benefit individuals struggling with

dyslexia. The Bryant (1979) dissertation is an excellent example of this work. Further exploration of this dissertation's theoretical model could be accomplished through replicating and improving on Bryant's study, such as refining methodology by narrowing the subject base to students with the same subtype of dyslexia, according to the tiered classification; keeping all instruction identical with the exception of the kinesthetic modality; operationally defining the MSLI intervention employed; explicitly stating how instructors were trained in MSLI intervention; measuring severity of disability among subjects (single-deficit, double-deficit, RN deficit only); and taking pre- and post- measures both immediately after intervention and longitudinally.

Exploring the concept of teacher as surrogate central executive would further the field as well. Teachers and students maintain a constant feedback loop as they move through the teaching-learning cycle. From this perspective, students and teachers are not independent, rather they are interdependent partners in learning who are job-sharing. Teachers are able to take the burdensome pieces of learning off their students' shoulders until such time they are able to handle the task. Which pieces they take over, and for how long, is a critical component of the feedback loop that provides useful assessment information for planning and curriculum development. In an ideal research study, students would be grouped according to level of executive functioning skills, intervention would be operationally defined and manualized, and teachers would be trained to administer treatment according to protocol. Outcome measures would include executive functioning, rapid naming, and comprehension. Adding a pre- and post-intervention self-rating for students could be valuable in measuring real gains versus perceived gains.



As mentioned at the beginning of this dissertation, the theoretical model proposed is intended to ignite future research in several ways. Answering the question: “Does use of a kinesthetic-tactile modality to teach students with dyslexia affect reading comprehension?” would consider the model as a whole. This may be one approach for future research, while breaking the model down into its component parts might be another approach. Answering these questions can shed light on one or more aspects of the model that may prove to be particularly strong, or an aspect that may be weak. It can point out flaws in the model as well as strengths.

The connection between the kinesthetic modality and increased attention was outlined through models based in learning theory, executive functioning, and attention. Starting at this point is most logical and could replicate the study Bryant (1979) used in her doctoral dissertation. The connection between increased attention and working memory has been documented widely in the research; however, specifically investigating phonological working memory would have a greater impact on the dyslexia literature and application to intervention for students struggling with dyslexia due to the correlation between phonological working memory and dyslexia. An investigation into the correlation between working memory, phonological working memory and the increase in word recognition and sight vocabulary could also yield information of great importance to the dyslexia research community. The ultimate goal is to increase a student’s fluency and comprehension. The way to understand how to increase comprehension in a student with dyslexia is to follow the path backwards, gaining a clear understanding of the prerequisite skills needed, the deficits that impede acquiring these skills, and the means to teach and support those skills.

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