AUDITORY TRAINING AND ITS EFFECT ON THE PHONEMIC AWARENESS DEVELOPMENT OF INDIVIDUALS WITH DYSLEXIA WHO HAVE A DEFICIT IN PHONOLOGICAL AND PHONEMIC AWARENESS

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ABSTRACT

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The purpose of this case study was to determine if an auditory, music-related, intervention connected to phonemic awareness development impacted the phonological and phonemic awareness abilities of an individual with dyslexia who had a deficit in phonemic awareness. Phonemic awareness requires the individual to (a) isolate individual sounds, (b) identify common sounds in words, (c) categorize sounds that sound similar or different, (d) blend individual sounds together, (e) segment words into the individual sounds, and (f) the ability to delete a given sound in a word and blend the remaining sounds together to create a new word (Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh, and Shanahan, 2001). Auditory training in this study required the participant to discriminate and isolate between sounds, distinguish between qualities of sound through major and minor chords, and included auditory memory tasks, which required the participant to remember and recall auditory information for a span of 5 to 30 seconds. Auditory examples were all played on an acoustic piano.

One college student over the age of 18, who was previously diagnosed with dyslexia, was used for this study. Single subject research, A-B method was used to compare pre-phonemic awareness abilities to post-phonemic awareness abilities after the completion of the intervention. The Lindamood Auditory Conceptualization (LAC-3) and the Comprehensive Test of Phonological Processing (CTOPP) were used as the formal assessment instruments.

After completing five auditory interventions, the participant demonstrated moderate growth and gains in the area of phonemic awareness and in particular in the area of auditory memory. The final assessments revealed that the participant increased in his phonemic awareness abilities as demonstrated by the increase in percentile rankings. This study has demonstrated that an auditory intervention using non-linguist sounds might be an effective method for increasing phonemic awareness abilities in individuals with dyslexia who have a phonological and phonemic awareness deficit.

Dedicated to all of those who relish the power of music.

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CHAPTER I. INTRODUCTION

One day while I was looking out the window of my office, I noticed a bus pulling up to a bus stop. As the people were waiting for the bus I could see them talking to one another, talking on cell phones, and waving hello and goodbye. As the bus pulled up and the people got on to travel to their destination, I realized that even with the window shut and being five stories above, I "heard" the entire scene unfold as if I had been outside. I did not actually hear the people talking, the bus brakes squealing, or the sound of the bus as it began to pull away, but what I did hear is a mental representation of the sounds that normally occur with these events. I have learned to identify the sounds of the bus and the sounds of conversations through various exposures of listening to these objects many times. Similar to reading, beginning readers learn to hear and "mentally hear" the sounds that letters make through various forms of active listening.

Statement of Problem

Developing phonemic awareness is an essential skill in the early stages of reading. Phonemic awareness requires the individual to (a) isolate individual sounds, (b) identify common sounds in words, (c) categorize sounds that sound similar or different, (d) blend individual sounds together, (e) segment words into the individual sounds, and (f) delete a given sound in a word and blend the remaining sounds together to create a new word (Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh, & Shanahan, 2001, p. 253). These skills not only teach the sounds of the letters, or phonemes, but they also develop the listening (aural) skills of the reader. However, individuals with dyslexia, specifically with a deficit in phonological or phonemic awareness, do not often develop these skills using the same methods as normal readers. Individuals with this subtype of dyslexia have difficulties in the six areas of phonemic awareness described by Ehri et al., and they frequently do not receive interventions to increase their skills in ear training and aural skills, which could improve their ability to obtain phonemic awareness and be successful in reading.

Research Question

The purpose of this study was to examine an alternative intervention to help an individual with dyslexia develop phonemic awareness. The research questions that guided the study were as follows:

(1) Will an intervention using non-linguistic sounds develop essential listening skills and the ability for individuals with the deficit in phonemic awareness subtype of dyslexia to mentally hear and discriminate sounds?

(2) Will ear training intervention using non-linguistic sounds support and increase dyslexic's listening skills, ability to mentally hear, skills in sound discrimination, and development of phonemic awareness in individuals with dyslexia who have a deficit of phonemic awareness?

(3) Will the development of the ability to mentally hear and discriminate sounds have a positive effect on the dyslexic individual's sensitivity to phonemic awareness?

Rationale

Liperote (2006) states, "Early development of aural skills prepares students to read notation with an aural understanding of what is implicit in that notation" (p.6). Individuals with the subtype of dyslexia with a deficit in phonemic awareness have difficulties with the "aural understanding" and sensitivity of phonemes. Wheeler (2007) agreed with Liperote, "We must acknowledge that ear and eye skills are equal and complimentary partners. The ultimate goal is to be able to 'see with the ears' and 'hear with the eyes" (p. 35).

This research is significant because it has the potential to benefit dyslexic readers, learners with phonological processing difficulties, reading teachers/specialists, and classroom teachers. Dyslexic readers with a deficit in phonological awareness would benefit from auditory training interventions designed to train the brain to recognize ("hear") and discriminate discrete phonemes and to develop skills in phonemic awareness, which could improve their reading abilities and reading acquisition. Consequently, the interventions would enable them to "see with the ears" and "hear with the eyes" (Wheeler, 2007, p.35). Likewise, this research would provide other learners with a deficit in phonological/phonemic awareness an effective method of intervention. Reading teachers/specialists could use this approach to intervention as an additional tool when working with students whose auditory skills need to be developed to acquire sensitivity for phonemic awareness. Similarly, classroom teachers might benefit from this research because they would be able to create auditory interventions to boost the reading abilities and skills of dyslexic readers. This research would provide teachers with examples of auditory interventions and a rationale for creating such interventions.

Definition of Terms

The following are a list of terms essential for understanding the nature and purpose of the study:

Aural skills – Aural skills are the ability to hear mentally or to "see with the ears and hear with the eyes" (Wheeler, 2007, p. 35)

Ear training – Ear training refers to the process of developing the inner ear or mental hearing through listening exercises.

Dyslexia –Dyslexia is "a specific learning disability that is neurological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. 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" (International Dyslexic Association, 2002, p. 1).

*Intervention*s – Interventions are specific programs designed to help students who are at risk or have not made adequate progress (Gunning, 2010).

Phoneme – A phoneme is the smallest discrete unit of sound in spoken language.

Phonemic awareness – Phonemic awareness is the understanding that there are individual sounds in words and that the spoken word is comprised of a sequence of sounds or phonemes (Gunning, 2010).

Limitations

One limitation of this study that may have altered the results was the student's previous music experience and/or exposure to music training. Students with prior music training and/or exposure to music training may already have begun to develop a deeper level of aural skills, which could influence their progress through the auditory interventions. The limited number of auditory interventions completed for this study might also have affected the results and not accurately portrayed the potential auditory training intervention has on phonemic awareness. The assessment instruments used for the study contained only one form; therefore, using only one form and repeating the examples might not have accurately measured the participant's phonemic awareness growth.

CHAPTER II. REVIEW OF LITERATURE

Music, reading, and dyslexia share many similar characteristics. Ridgway (2009) stated, "The inner voice and the inner ear (the phonological loop) are familiar constant companions, and vital components of short-term memory, which is itself what underpins our thinking, and therefore much of our learning" (p. 56). This chapter will explore the historical and theoretical perspectives of phonemic awareness, various auditory processing skills, and dyslexia. The last two sections of this chapter will address specific deficits of dyslexia and implications for ameliorating the deficit in phonemic awareness found in dyslexics. The final portion of this chapter will address the connection between music and reading. The research in this section provides connections found between music, auditory and language skills, and the reading process.

The review of literature in this chapter provides a foundation for the following research questions:

(1) Will an intervention using non-linguistic sounds develop essential listening skills and the ability for individuals with the deficit in phonemic awareness subtype of dyslexia to mentally hear and discriminate sounds?

(2) Will ear training intervention using non-linguistic sounds support and increase dyslexic's listening skills, ability to mentally hear, skills in sound discrimination, and development of phonemic awareness in individuals with dyslexia who have a deficit of phonemic awareness?

(3) Will the development of the ability to mentally hear and discriminate sounds have a positive effect on the dyslexic individual's sensitivity to phonemic awareness?

Historical Research

Phonemic Awareness

Bradley and Bryant (1983) conducted a longitudinal study comparing a student's ability in sound categorization before the student began to read, then assessed the student four years later and found, "a definite relationship does exist between a child's skills in categorizing sounds and his eventual success in reading and spelling" (p. 419). Bradley and Bryant also conducted an intervention in sound categorization with a different group of students to compare the longitudinal study results to the intervention study results to confirm a causal connection between sound categorizing, rhyming, and the ability to understand individual letter sounds compared to the reading success of the student. To get students to attend to the sounds each letter makes, they used plastic letters to teach the students a connection between each letter's sound and its shape. Bradley and Bryant concluded, "our longitudinal and training results provide strong support for the hypothesis that the awareness of rhyme and alliteration…has a powerful influence on their eventual success in learning to read and to spell" (p. 421).

Likewise, Ehri and Wilce (1985) conducted a similar study to determine whether pre-readers used visual or phonetic cues to learn how to read. The study lasted three days and used 56 students: 30 boys and 26 girls. All subjects in this study completed (a) letter name knowledge test, (b) *Gray Oral Reading Test*, (c) word identification tasks, (d) word-learning task, (e) paired reading of visual and phonetic spellings, and (f) memory of spellings task. The subjects in this study were also categorized into the following three subgroups: pre-readers, novice, and veteran readers. Pre-readers were defined as readers who could not read; novice readers could read a small amount of words, and veteran readers could read (Ehri & Wilce). Ehri and Wilce concluded:

> Among prereaders, visually distinctive spellings are easier to learn whereas among beginning readers, spellings where letters function as symbols for sounds are easier…Our interpretation for the present findings is that movement into effective word reading requires a shift from visual to phonetic cue processing and that this shift is what enables children to begin reading their first words reliably. (p. 172)

Bradley's and Bryant's study (1983) along with the Ehri's and Wilce's (1985) study concluded that phonemic awareness is (a) essential to the beginning stages of reading, (b) pre-readers move from visual to phonetic cues, and (c) abilities in pre-readers phonemic awareness can predict future reading success. The identification of less accurate phonetic abilities in children provides evidence to support the conclusion that these students will likely show difficulties in tasks related to memory, language perception, and comprehension (Brady, 1986). Brady continued, "Poor readers are generally lacking in metalinguistic awareness of phonological structure, produce more errors when naming objects, and are less accurate at comprehension of spoken sentences" (p. 149). Ball (1993) agreed and confirmed earlier findings (Brady; Bradley & Bryant; Ehri & Wilce) and stated that:

> relationship between phoneme awareness and reading acquisition is even more critical when we consider that phoneme awareness is linked to reading ability beyond simple word recognition….Furthermore, as the child attends to these letter-sound relationships, (s)he begins to have expectations of the words the letters spell, and the sentenced these words create. (p. 149)

The National Reading Panel (NRP) (NICHHD, 2000) conducted a meta-analysis of existing empirical research to identify the primary components of effective reading instruction. They identified the following five major elements: alphabetics, fluency, comprehension, teacher education and reading instruction, and computer technology and reading instruction. Phonemic awareness and phonemic awareness instruction were specifically cited as an essential alphabetic skill in the research. The Panel specifically tried to determine if phonemic awareness instruction was effective in teaching children to read, if previous studies were properly designed to validate their findings, and if the findings of the phonemic awareness studies could be applied to the classroom. The NRP defined phonemic awareness as, "the ability to focus on and manipulate phonemes in spoken words" (p. 2-1) and identified six tasks commonly used to assess phonemic awareness. The six primary phonemic awareness tasks include (a) phoneme isolation, (b) phoneme identity, (c) phoneme categorization, (d) phoneme blending, (e) phoneme segmentation, and (f) phoneme deletion. Their analysis of the research concluded that phonemic awareness training is most effective when, "children are taught to manipulate phonemes with letters" (p. 2-6) and "to draw preschoolers' or kindergartner's attention to the fact that words have sounds as well as meanings" (p. 2-31).

In their investigation, Bradley and Bryant (1983) were studying children's abilities in sound categorization. Sound categorization has been identified as an effective assessment of phonemic awareness abilities (NICHHD, 2000). By using plastic letters to teach letter sounds, Bradley and Bryant were teaching the children in the study to notice and think about individual sounds. The NRP also confirmed Ehri's and Wilce's (1985) conclusion that phonemic awareness is directly related to early reading abilities, and letter-sound relationships are essential in the beginning stages of reading. Many readers with dyslexia also experience significant deficits in phonological and phonemic processing and discrimination. A closer look at dyslexia provides an understanding of the relationship between phonemic awareness and reading achievement.

Dyslexia

Prior to 1975 federal law did not guarantee or require educational accommodations for students diagnosed with dyslexia. However, the 94th U.S. Congress passed an amendment to the *Education of the Handicapped Act* (EHA; PL 94-142); it was renamed the *Education for All Handicapped Children Act of 1975*. The law was codified as the Individuals with Disabilities Act (IDEA) in 1993 and most recently in 2004 (IDEA, 2004). This congressional act was the first law to mandate accommodations for children with dyslexia (*Education for All Handicapped Children*, 1975).

In a study focusing on the auditory organization abilities of backwards readers, Bradley and Bryant (1978) looked specifically at dyslexic readers and their reading acquisition skills. They compared the auditory perception skills of backwards readers to those of normal reading children. The children completed a set of tests where the examiner read four words to the student. In series one, the child was asked to identify which word did not belong in the series by listening to final phoneme, series two required listening to the medial phoneme, and the third test required the child to listen to the initial phoneme to determine which word did not belong. The backward reading group was of normal intelligence but was, on average, 18 months behind in reading. The normal reading group was, on average, three years younger than the backward reading group, had normal intelligence for their age, and had an age appropriate reading level. Bradley and Bryant concluded:

> The difference is all the more remarkable, given that the backward reading group, being older by an average of 3 ½ years, was actually of a considerably higher intellectual level

> than the normal reading group. We suggest that many backward readers may be held back by a particular difficulty with organizing sounds. (p. 747)

In a second test, the children were given a word and were asked to say a word that rhymed with the word they were given (Bradley & Bryant). They again concluded that, "the relative failure of the backward readers in the second experiment is striking confirmation of their difficulty with categorizing sounds. Overall, our results strongly suggest that this difficulty could be an important cause of reading failure" (p. 747). Bradley's and Bryant's use of the term "backward reader," or "reading backwardness," were precursors to the term dyslexia and referred to early descriptions of readers who were cognitively capable of reading but unable to learn how to read.

In a related study, Aaron (1987) compared dyslexia to other forms of reading disabilities. The participants in the study completed a variety of word and non-word decoding assessments and comprehension assessments. Aaron concluded that dyslexics had more difficulty in decoding skills compared to other reading disabilities but did not exhibit difficulties in comprehension, and went on to surmise, "These observations indicate that dyslexic subjects may have normal listening comprehension and that the deficits seen in their reading comprehension may not be a primary problem but secondary to decoding and working-memory deficits" (p.123). Research during the same period suggested that a propensity for the profile of reading disability marked by high comprehension, low phonological awareness, and extremely low decoding skills may be genetic. Pennington, Leftly, Orden, Bookman, and Smith (1987) stated, "[there is] significant heritability for the phonological task but not the orthographic task, indicating that genetic influences on reading disability are somewhat specific to phonological processes" (p. 86). Pennington et al. support Aaron's findings that dyslexic readers struggle in developing phonological coding skills, which as Aaron identified, can lead to a deficit in decoding.

Alexander, Anderson, Heilman, Voeller, and Torgesen (1991) conducted a similar study to that of Aaron (1987) that investigated the effectiveness of a scripted program designed to support the auditory discrimination abilities in dyslexic readers on the reader's abilities to develop phonological awareness. The program used for the study was the "Auditory Discrimination in Depth Program," which required participants to "identify, classify, and label sounds" (p. 198). Participants demonstrated growth in their phonological awareness at the conclusion of the treatment. Alexander et al. concluded, as did Aaron and Pennington, Leftly, Orden, Bookman, and Smith (1987), that dyslexics "showed either moderate or severe performance problems on a pretest of phonological awareness" (p. 202), and that, "phonological awareness training may also be a useful part of education interventions for many dyslexic children" (p. 196).

As research in the area of dyslexia continued, researchers began looking deeper into causation and related factors. Frith (1999) investigated the cultural, behavioral, neurological/cognitive, and phonological perspectives aspects of dyslexia. "The consensus is emerging that dyslexia is a neuro-developmental disorder with a biological origin, which impacts on speech processing with a range of clinical manifestations" (Frith, p. 211). Frith explained, "The behavioral signs and the clinical impairments of the syndrome show great variability within and between individuals" (p. 211), as position that would later be supported by the International Dyslexia Association (IDA).

The International Dyslexia Association officially modified their definition of dyslexia in 2002. Although it is very similar to Frith's (1999) definition, the IDA more clearly identified the link between poor word recognition, spelling, and decoding to a neurological deficit in the area of phonological and phonemic awareness. IDA (2002) adopted the following definition of dyslexia:

> [Dyslexia is] a specific learning disability that is neurological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. 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. (p. 1)

The International Dyslexia Association and Frith both agree that dyslexia is neurological and causes a "range of clinical manifestations" (Frith, p. 211) that are unrelated to the reader's intelligence quotient (IQ). These findings support Aaron's (1987) conclusion that dyslexia is based on a phonological deficit unrelated to IQ.

Brady (1986), Bradley and Bryant (1983), and Ehri and Wilce (1985) also investigated the relationship between learning to read and the ability to categorize sounds in words; the importance of phonemic awareness in the acquisition of word identification, spelling, and decoding is strongly supported in the research (Aaron, 1987; Alexander, Anderson, Heilman, Voeller, & Torgesen, 1991; Bradley & Bryant, 1978; NICHHD, 2000; Pennington, Leftly, Orden, Bookman, & Smith, 1987). Although several of the studies focused primarily on the connection between categorizing sounds and learning to read, their participants were readers with dyslexia and the influence of sound categorization and phonemic and phonological awareness on their reading acquisition. Alexander et al., in particular, examined dyslexics' skills in identifying, labeling, and classifying sounds. Identifying, labeling, and classifying sounds is congruent with the definition of phonemic awareness as defined by the NRP. Phonemic awareness is "the ability to focus on and manipulate phonemes in spoken words" (NICHHD, 2000, p. 2-1). Bradley and Bryant (1978, 1983) also concluded that sound categorization was essential in learning to read. research in the area has concluded that phonemic awareness is an important process in learning to read, and a deficit in phonemic awareness can lead to reading difficulties, such as those found in dyslexia (Aaron; Alexander et al.; Bradley & Bryant; Brady; Ehri &Wilce; Pennington et al.).

Theoretical Framework

Scaffolding

Wood, Bruner, and Ross (1976) studied the role and responsibilities of an educational tutor. The children in this study ranged in age from three to five years. The children were instructed to build a pyramid that required advanced knowledge and skills that were beyond their age ability. A tutor was assigned to a group of children to assist them in building the pyramid. The task required the tutor to create instruction that (a) motived the student, (b) was challenging, (c) contained procedures that would build hindsight, (d) was not too challenging, and (e) did not require difficult fine motor skills (Wood, Bruner, & Ross, 1976). Wood et al. described the requirements for tutoring in the following manner:

> [Scaffolding is a] process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts. This scaffolding consists essentially of the adult "controlling" those elements of the task that are initially beyond the learners' capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence." (p. 90)

Wood, Bruner, and Ross (1976) identified the following features that result in effective scaffolding: (a) keep student interested, (b) simplify the task and number necessary steps, (c) define a set goal, (d) mark progress, (e) prevent frustration, (f) and model the appropriate actions to solve the task. This approach to scaffolding learning aligns nicely with Vygotsky's (1979) theory of the Zone of Proximal Development (ZPD). Vygotsky posited that novice learners could effectively be taught more complex ideas, tasks, or concepts if they were supported and gradually released through the learning process by a more experienced learner. Initially, the expert would need to strongly support the learner, but as the learner became more capable and independent the expert could begin to step away and reduce the amount of support, or scaffolding. The ZPD, as defined by Berk and Winsler (1995) is as follows:

> The distance between what an individual can accomplish during independent problem solving and what he or she can accomplish with the help of an adult or more competent member of the culture. The hypothetical, dynamic region where learning and development take place. (p. 171)

Lutz, Guthrie, and Davis (2006) support Vygotsky's notion that, "the pattern that teachers use may play a key role in facilitating student engagement in complex tasks, which translates into achievement gains" (p. 15). Likewise, Wood, Bruner, and Ross (1976) conclude that when students receive support, or scaffolding, of their learning, student motivation, learning, and achievement will increase.

Auditory and Phonological Processing

Kavahagh and Mattingly (1972) stated, "reading depends ultimately on linguistic awareness" (p. 144), and defined linguistic awareness as the ability to hear and manipulate sounds. The reader must be able to synthesize a particular sound, be cognizant of the sound, and, be able to reflect upon the sound Wagner and Torgesen (1987) defined the process of linguistic awareness as the ability to process the sounds of one's own language , which became the foundation for their theory of phonological processing. Phonological processing is a precursor to the development of phonological and phonemic awareness. The reader must have the ability to physiologically and neurologically discriminate discrete sounds in spoken language. Wagner's and Torgesen's meta-analysis of three studies to determine the effects of phonological processing on reading concluded that, "phonological awareness plays a casual role in the acquisition of reading skills" (p. 208). They also found that it is possible that phonological awareness related to reading and phonological awareness related to working memory are separate abilities

Mattingly (1972), as well as Wagner and Torgesen (1987), concluded that a reader must be skillful in the ability to hear and manipulate, or synthesize, language sounds. The ability to synthesize language sounds leads to, as Wagner and Torgesen identified, phonological processing and the ability to synthesize language sounds leads to the ability to read and understand written language.

Stanovich (1986) in a similar study to Mattingly (1972) and Wagner and Torgesen (1987) theorized, "the primary specific mechanism that enables early reading success is phonological awareness: conscious access to the phonemic level of the speech stream and some ability to cognitively manipulate representations at this level" (p. 362). Stanovich completed a meta-analysis, which studied the phonological awareness abilities of both high and low readers. Badian (1997) confirmed Stanovich's conclusion that, "Phonological awareness is casually related to the early development of reading skill" (p. 363). Stanovich also concluded that students who begin reading with a high level of phonological awareness continue to excel whereas students who begin reading with a low phonological awareness continue to struggle with reading.

The theory of phonological processing has been of interest to those working with readers with dyslexia. Stanovich (1986) supported the theory of phonological processing in his work with readers with dyslexia and theorized that, "deficient phonological awareness makes it difficult for the child to understand the alphabetic principle and delays the breaking of the spelling-to-sound code" (p. 389). He also suggested, as did Bradley and Bryant (1983), that, "slow development in this area delays early code-breaking progress and initiates the cascade of interacting achievement failures and motivational problems" (p. 393). Therefore, it will be defined as "the ability to focus on and manipulate phonemes in spoken words" (NRP, 2000, p. 2-1) for the purpose of this study and acknowledged as an essential auditory processes skill necessary for reading acquisition.

Auditory Discrimination

Wepman (1960) defined auditory discrimination as the "capacity to distinguish between phonemes, or individual sounds used in speech" (p. 325). The seven aspects of his auditory discrimination theory are as follows: (a) closely related phonemes will often be confused, (b) students differ in their auditory discrimination abilities, (c) the ability to discriminate increases with age, (d) slow auditory development leads to inaccurate pronunciations, (e) poor auditory discrimination leads to poor reading, (f) poor auditory discrimination only affects poor reading or speech, and (g) there is little relation between intelligence and auditory discrimination abilities. The process of auditory discrimination requires the student to keep the sounds in short term memory in the same order as the sounds were heard (Gromko, Hansen, Tortora, Higgins, & Boccia ,2009; Wepman). Wepman also suggested that, "essential to the development of auditory discrimination is the ability to retain individual sounds in mind to serve as models for later speech and as part of the phonic act necessary for reading" (p. 326). Forty-five years later Gromko (2005) concluded that as young pre-emergent readers prepare to learn how to read and begin to learn how to develop phonemic awareness that aural perception plays a very important role in the reading process and eventual reading achievement. Therefore, phonemic awareness has been identified as an aural or auditory discrimination skill.

Gromko, Hansen, Tortora, Higgins, and Boccia (2009) and Wepman (1960) concluded that auditory discrimination is an essential skill in reading, which supports the findings of Badian (1997), Mattingly (1972), Stanovich (1986), and Wagner and Torgesen (1987). This body of research also concluded that auditory skills are related to both spoken and written language and are important in learning how to read and write. Auditory discrimination is related to phonological awareness and an important function in auditory processing (Gromko et al., 2009; Mattingly, 1972; Stanovich, 1986; Wepman, 1960).

Music and Reading Research

Music and Phonemic Awareness

Lamb and Gregory (1993) studied the relationship between musical awareness and phonemic awareness. This study included 18 children with a mean age of 5 years and 1 month. Each child completed a reading assessment, pitch awareness, timbre awareness (timbre is the unique quality of sound produced by individual instruments and or voices), and a phonemic awareness assessment. The children who achieved high scores on the pitch discrimination assessment also performed well on the phonemic awareness assessment (Lamb & Gregory). The ability to discriminate a difference in pitch is more closely related to reading and the ability to discriminate between speech sounds (Anvari, Trainor, Woodside & Levy, 2001; Gromko, 2005; Lamb & Gregory, 1993; Rauscher & Hinton, 2011). Lamb and Gregory concluded, "An ability to perceive slight differences in phonemes thus appears to depend on the ability to extract information about the frequencies of the speech sounds. It is reasonable to assume that such an ability is related to the discrimination of pitch differences in music" (p. 7) and the student's ability to discriminate phonemic differences in words.

The early connection between the skills needed to discriminate pitch and timbre differences in music and phonemic differences in reading led Gromko (2005) to study the effects of music instruction in assisting students to improve their phonemic awareness abilities. The participants in Gromko's study participated in musical activities involving singing and kinesthetic movement. She stated that the kinesthetic movements "reinforced the children's perception of steady beat, word rhythms, or high, low, higher, and/or lower pitches" (p. 6). Gromko noted that the phoneme-segmentation abilities of the participants increased after the music intervention and concluded that the music intervention had a positive impact on the students' abilities because "phoneme-segmentation…is an aural skill" (p. 4), which is also related to skills used in music. Gromko's research paralleled Lamb's and Gregory's (1993) earlier findings and extrapolated on the concept, "when children learn to discriminate fine differences between tonal and rhythmic patterns and to associate their perceptions with visual symbols, they will benefit not only musically but in skills related to the processing of sound shown to be necessary for reading" (p. 4). Gromko, Lamb and Gregory, and Lucas and Gromko (2007) utilized a definition of phonemic awareness similar to the one developed by The National Reading Panel (NICHHD , 2000). The NRP defined phonemic awareness as the ability to notice, think about, and work with and manipulate sounds in spoken words. The ability to notice, think about, manipulate, and discriminate sounds in spoken words are the same aural skill shared with music tasks such as pitch recognition, sound discrimination, and pattern recognition (Gromko; Lamb & Gregory; Lucas & Gromko, 2007). This connection begs the following questions: Does music training improve the phonemic awareness skills of readers? Does music training have predictive abilities in reading abilities?

Tsang and Conrad (2011) conducted a study to determine if music-processing skills predicted reading abilities in children with and without formal music training. The participants in the study completed melody, rhythm, and timbre discrimination assessments. Participants listened to each example, which increased in difficulty, and had to determine if the two examples were the same or different. Tsang and Conrad noticed, "Pitch perception was associated with phonological skills and word identification for children without formal music training, this was not the case for children with formal music training" (p. 160). Their findings supported a larger body of research that also found a correlation between phonological skills and pitch perception (Anvari, Trainor, Woodside, & Levy, 2001; Bolduc, 2009; Gromko, 2005; Lamb & Gregory, 1993). Both sets of skills involve auditory discrimination and auditory processing abilities found in both music and language.

Music has the ability to shape the same basic auditory processes shared by speech, language, and reading (Anvari, Trainor, Woodside & Levy, 2001; Strait & Kraus, 2011). Children who are able to hear and manipulate the individual phonemes in words are able to more easily acquire reading skills (Bradley & Bryant, 1983; Ehri &Wilce, 1985; NICHHD, 2000; Stanovich, 1986). Anvari et al. examined the relationship between phonological awareness, music perception, and pre-reading skills. Participants in this study completed interventions in phonemic awareness and music discrimination tasks as well as tasks in math, vocabulary, and reading. To examine the effects the music intervention had on reading, Anvari et al. completed a hierarchical regression analysis, which accounted for phonological awareness, step one and the pitch variable on step two. In the regression analysis, the pitch, or music variable, accounted for significant variance after the phonemic awareness had been entered. The researchers concluded that because of the variance in the music variable that, "music ability adds to the prediction of reading skills, once phonological awareness has been accounted for" (p. 122). Based upon their findings, Anvari et al. arrived at the following conclusion, "Phonemic awareness and music perception ability tap some of the same basic auditory and/or cognitive skills needed for reading" (p. 127).

Several other studies confirmed the relationship between musical skills, phonemic awareness skills, and reading abilities. Santos, Joly-Pottuz, Moreno, Habib, and Besson (2007) agreed with Anvari et al.'s findings and suggested, "by increasing the sensitivity to pitch, musical training may have beneficial effects on reading skills" (p. 1088). Music perception was also found to be an indicator of reading skills, which suggests that music perception ability is related to the basic auditory processes associated with phonological awareness (Anvari et al.; Tsang & Conrad, 2011). Rauscher and Hinton (2011) conducted a similar study to Anvari's, Trainor's, Woodside's, and Levy's (2001) study in that they investigated how students' phonemic awareness abilities increased after completing a music intervention. However, participants in Rauscher and Hinton's study participated in 16 weeks of Suzuki Violin instruction. After completing a post-assessment on phonemic awareness abilities, the scores on the post-assessment increased compared to the control group who did not receive the Suzuki training. Rauscher and Hinton concluded, "These findings demonstrate an association between some of the auditory skills used in learning to read and certain elements of music perception, supporting the notion that early music instruction may influence reading acquisition" (p. 224). The conclusions of Rauscher and Hinton support the findings of Anvari et al.; Gromko, (2005); and Tsang and Conrad,(2011), who also concluded that music shares similar auditory processes as language and can positively impact language development; their contribution to the body of research is their conclusion that music training provided earlier in the pre-emergent or emergent stages of reading acquisition may be more beneficial than training administered later in terms of helping the read development more acute phonemic awareness and pitch perception..

The link between the aural skills of pitch perception (a component of music training) and phonemic awareness (a component of reading training) is noted in several studies. Four primary relationships emerged in the literature. First, several researchers concluded that an increase in pitch perception in early reading children resulted in an increase in phonemic awareness (Gromko, 2005; Lamb & Gregory, 1993; Tsang & Conrad, 2011). The second relationship explicitly associated the connection between pitch perception and phonemic awareness as expected because both sets of skills are aural skills (Gromko; Lamb & Gregory). Third, the ability to discriminate between pitches was related to the ability to discriminate between phonemes (Gromko; Lamb & Gregory; Tsang & Conrad). Finally, Anvari, Trainor, Woodside and Levy (2001) and Rauscher and Hinton (2011) summarized the findings and concluded that music and reading "tap some of the same basic auditory and/or cognitive skills needed for reading" (Anvari et al., p. 127). All of the above mentioned researchers agree that musical skills such as pitch and sound discrimination are similar to phonemic awareness and concluded because of the connection between music and phonemic awareness that music and reading share some of the same auditory pathways in the brain.

Music and the Auditory Processes

The notion that music skills and phonemic awareness utilize some of the same neurological auditory pathways has been explored a bit more vigorously in recent years. Strait, Chan, Ashley, and Kraus (2012) agreed with the findings of Anvari, Trainor, Woodside and

Levy (2001) and Rauscher and Hinton (2011) and conducted a study to extend their idea that musical training has the ability to fine-tune the brain to more effectively process sound and reshape basic sensory functions. In their study, professionally trained musicians in piano listened to musical examples of the piano, bassoon, and tuba. The participants were connected to electrodes specifically aligned to the auditory portions of the brain. The results of the study indicated that the professional musician's auditory brainstem responses more closely matched the sound of the piano compared to non-pianists' (Strait et al., 2010). They concluded, "Music practice has the power to shape sensory circuitry" (p. 362). Strait and Kraus (2011) posited that music training is not limited to specific music networks but applies to general auditory processing skills. Because of the connection between music training, the development of auditory skills, and auditory processing, Strait and Kraus further suggested that music training might be an effective intervention method for remediating reading impairments.

Habib and Besson (2009) further detailed the effects music training has on the plasticity of the brain related to auditory abilities. Their research indicated that, "repeated practice optimizes neuronal circuits by changing the number of neurons involved, the timing of synchronization, and the number of strengths of excitatory and inhibitory synaptic connections" (p. 281). Habib and Besson further outlined that playing and learning an instrument combined with auditory discrimination exercises shapes the cortical and subcortical structures. Therefore, improving the neurological processes associated with auditory perception and discrimination positively affects speech and reading skills (Habib & Besson, 2009; Kraus, Skoe, Parbery-Clark & Ashely, 2009; Strait, Chan, Ashley & Kraus, 2012; Strait & Kraus, 2011).

Similar to the research of Habib and Besson (2009) and Strait and Kraus (2011), Richardson, Ramsden, Ellis, Burnett, Megnin, Catmur, Schofield, Leff and Price (2011) further researched brain functions in cognitively normal individuals and individuals with dyslexia. The participants in Richardson et al.'s study completed a variety of auditory assessments such as digit spans, spoonerisms, repeating auditory pseudo words, and reading regular words. While participants were completing these assessments, they were connected to a functional magnetic resonance imagining (fMRI) machine to observe their brain functions in the area of the left posterior (left pSTS). The fMRI allows researchers to examine areas of the brain engaged in the process the patient is engaging in real time. The left pSTS is the portion of the brain located in the left temporal area of the brain responsible for connecting the words someone hears and to words the individual has stored in long term memory. Liebenthal, Desai, Humphries, Sabri, and Desai (2011) stated, "The left pSTS is responsive to both language and non-language, with preference to language in the anterior portion…"(Summary of results, para. 2) because the left pSTS is mainly responsible for auditory processing. Likewise, Richardson et al. concluded, "…the left pSTS responds more strongly when acoustic stimuli can be categorized as meaningful in some way" (p. 3753) and "is also activated during tasks that involve not only the perception by also the retrieval of words from memory" (p. 3753). Their study of the brain's gray matter for both dyslexic and non-dyslexic readers, it was determined that the gray matter density was the same in both groups of participants, ruling out congenital neural abnormalities.

Music training as well as auditory training supports the skills and cognitive abilities to categorize, discriminate, isolate, and manipulate sounds (Anvari, Trainor, Woodside & Levy, 2001; Gromko 2005; Lamb & Gregory, 1993). Auditory and music training also reshape and strengthen neurological pathways associated with speech, reading, auditory memory, and abilities (Habib & Besson, 2009; Kraus, Skoe, Parbery-Clark & Ashley, 2009; Richardson et al., 2011; Strait, Chan, Ashley & Kraus, 2012; Strait & Kraus, 2011). Their research noted a connection between pitch discrimination and phonemic awareness abilities as well as between music and reading abilities. Based upon the connection between music and reading, the above mentioned researchers concluded that music is in an auditory process, which shares some of same neural pathways associated with language and if music shares the same neural pathways and can “shape sensory circuitry”, (Strait, Chan, Ashley & Kraus, 2012, p. 362), then music has the potential to influence language and reading abilities.

Music, Reading, and Dyslexia

Definition of Dyslexia

Educators, researchers, and medical professionals have engaged in decades of debate concerning an acceptable definition for dyslexia. The International Dyslexia Association’s (IDA) (2002) definition of dyslexia is as follows:

> Dyslexia is a specific learning disability that is neurological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. 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. (Definition of Dyslexia, lines 1-7)

Lyon, Shaywitz, and Shaywitz (2003) also conclude that dyslexia is neurobiological in origin and includes difficulties with fluent word recognition, poor spelling, and decoding; dyslexics have a deficit in phonological processing and often have average to above average IQ’s. Lyon et al. posited that dyslexics have a neurological disruption in the left posterior hemisphere of the brain. This region of the brain has been identified as the region responsible for language and reading (Khan, Hamalainen, Leppanen, & Lyytinen, 2011). Most dyslexics also have a deficit in fluent reading and phonological processing (Lyon et al.). Some researchers speculate that these phonological difficulties may stem from abnormal auditory discrimination and perception.

Dyslexia, Auditory Processing, and Phonological Awareness

To date, researchers have been unable to identify the cause(s) of dyslexia; however, a symptomatic profile of the disability continues to be refined by on-going research. As outlined in the IDA definition, most readers with dyslexia demonstrate an abnormal discrepancy between cognitive ability and reading/spelling performance. In recent decades, researchers have identified another processing disorder that seems to be prevalent among those diagnosed with dyslexia: low auditory and phonological processing.

Several studies have been conducted to test the hypothesis that auditory processing may be partially responsible for the readers' difficulties with decoding and spelling. Fostic, Bar-El, and Ram-Tsur (2012) defined auditory processing as the ability to distinguish between different sounds on a level of loud to soft and high to low sounds. Related to auditory processing is phonological processing. Phonological processing is the ability to further use auditory information to distinguish and create spoken and written language (Wagner & Torgesen, 1987). Fostic et al. investigated the hypothesis that readers with dyslexia may have an "auditory temporal perception deficit" (p. 77) and that the deficit in auditory temporal perception leads to the reading impairment experienced by individuals with dyslexia. Participants in this study completed a variety of diagnostic reading and auditory tasks such as, reading regular words, non-words, and phoneme deletion. Results were compared between the readers diagnosed with dyslexia and the normal (neurotypical) reading participants and, after controlling for working memory, Fostic et al. concluded that "…the deficit in auditory temporal processing was evident even after controlling for differences in working memory, suggesting that the deficit in auditory processing is independent of difficulties in working memory" (p. 86). The findings of Fostic et al. support the earlier findings of Thomson and Goswami (2010) who also concluded that dyslexics have an auditory deficit that affects phonemic awareness, phonological awareness, and ability to acquire reading skills. Tallal (1980) confirmed and concluded the findings that the performance of readers with dyslexia on auditory reading tasks "became significantly inferior to that of normal children" (p. 194). These findings indicate that one of the primary deficits influencing the reading ability of dyslexics appears to be a deficit in auditory processing which inhibits their abilities in phonological and phonemic awareness (Fostic et al.; Talla; Thomson & Goswami).

Researchers and educators have studied readers with dyslexia to determine possible causes for impaired auditory processing in readers who have the cognitive and physiological capabilities to read. One perspective suggests that poor auditory processing may be the primary culprit. Auditory training using non-linguistic sounds has shown some promise in the development of auditory discrimination. Kujala, Karma, Ceponiene, Belitz, Turkkila, Tervaniemi, and Naatanen (2001) conducted a study to determine if an audiovisual training that did not contain linguistic material would positively affect the reading skills and central auditory processing in children with dyslexia. Participants in this study used a computer game that contained "abstract, nonverbal tasks that require audiovisual matching" (Kujala et al., p. 10510). As the children were engaged in the computer game, the participants' brain functions were observed using electrophysiological recordings. The results of the study concluded that compared to the control group, the participants with dyslexia demonstrated an increase in reading ability; an increase in brain activity in the regions that control auditory tasks was also noted. Kujala et al. concluded that "[the] results suggest that perceptual training with nonlinguistic audiovisual stimuli causes plastic changes in the neural substrate of sound discrimination and an improvement in reading skills" (p. 10512). Kujala et al. continued and stated, "the fact that training even altered the early preattentive stage of sound discrimination while also improving reading performance gives support to the view that reading difficulties in dyslexic individuals, at least in part, stem from bottom-up processing constraints" (p. 1053). They further concluded that because of the participants' increase in reading skills after using the non-linguistic training, it appeared that the neurological processes responsible for processing language may be constructed by ordering "acoustic nonspeech representations" (p. 10513).

One method of improving auditory processing is to use auditory training. Auditory training is the process of changing a "listener's ability to perform an auditory perceptual task" (Moore & Amitay, 2007, p. 99). The purpose of auditory training is to increase a listeners' sensitivity to pitch, timbre, and quality of sound discrimination (Joly-Pottuz, Mercier, Leynaud & Habib, 2008; Moore & Amitay). Moore and Amitay suggest that an increase in auditory sensitivity could positively influence speech and language development. Thompson and Goswami (2010) and Gromko (2005) also concluded that auditory training could impact the development of language especially at the level of phonemic and phonological awareness.

Neurological Perspective on Dyslexia

Similarly, Gaab, Gabriele, Deutsch, Tallal, and Temple (2007) conducted a study to test the hypothesis that participants with developmental dyslexia have reading difficulties because they, too, might have a deficit in auditory processing. In Gaab et al.'s study, the participants were asked to listen to non-linguistic auditory examples and to identify if the two auditory examples they heard were similar or different. While completing these tasks, the participants were connected to a functional magnetic resonance imaging (fMRI) machine to observe their brain functions. This diagnostic tool provides real time images of the patient's neurological activity. Gabb et al. found that children with dyslexia had widespread disruptions of the neurological networks that were associated with auditory stimulation. After completing the auditory tasks, the participants completed auditory interventions using the Fast ForWord ® program (Scientific Learning Corporation). Gaab et al. found that many of regions of the brain demonstrated an increase in response to rapid versus slow frequency transitions in both normal reading children and children with dyslexia. Several studies have concluded that readers with dyslexia share similar limitations in auditory discrimination when asked to discriminate, isolate, sequence, or recall nonverbal acoustic sounds, especially when the sounds are brief and presented rapidly (Gaab et al.; Kujala et al., 2001).

A significant body of research suggests that individuals with dyslexia have an auditory deficit that is neurological in origin (Fostic et al., 2012; Gaab et al., 2007; Lyon, Shaywitz, & Shaywitz, 2003; Thomson & Goswami, 2010). They surmise that the auditory deficit leads to difficulties in phonemic and phonological awareness that later leads to reading impairments, specifically in the areas of decoding and spelling. Gaab et al. and Kujala et al. agreed and concluded that the auditory deficit found in dyslexics is rooted in the auditory processing centers of the brain that control both linguistic and non-linguistic sounds. The centers identified in this study that showed increased activity after the auditory training were the bilateral insula, left operculum, right inferior frontal sulcus, left superior frontal regions, right precuneus, cingulate gyrus, and bilateral thalamic regions. Because of the shared auditory processing between linguistic and non-linguistic sounds, and the centers of the brain that demonstrated increased activity, they concluded that training in non-linguistic sounds benefits the development of linguistic sounds, which then has an effect on phonological and phonemic awareness and eventually, reading skills.

Auditory Training

The relationship between auditory processing and training using linguistic sounds has demonstrated promising results in helping readers with dyslexia develop keener auditory processing skills. In a study conducted by Schaffler, Sonntag, Hartnegg, and Fischer (2004), they observed the connection between auditory training and language-related phonological skills and spelling. Dyslexic participants in this study completed a series of auditory intensity and frequency discrimination, gap detection, and time-order and side-order judgment tasks. Their findings confirmed the previous research suggesting that linguistic, just like non-linguistic, sounds could be used in auditory training to improve low auditory and phonological processing in readers diagnosed with dyslexia (Gaab et al., 2007; Kujala et al., 2001; Schaffler et al.). Schaffler et al. stated, “Since both the frequency discrimination task and the time-order task require frequency discrimination, one could argue, that both tasks challenge the subjects in the same auditory domain” (p. 126), and they also reported a transfer effect between the non-linguistic auditory training and the phonological or, language skills, of the dyslexic participants. The transfer effect was observed when the auditory training including the non-linguistic sounds positively impacted the language skills of the participants in the study. They concluded that training including non-linguistic sounds affects the same auditory processing centers of the brain that process language.

Joly-Pottuz, Mercier, Leynaud, and Habib (2008) also conducted a study to determine if an auditory and articulatory training program would improve the phonological deficit found in individuals with dyslexia. They combined auditory training and articulatory exercises with phonemic awareness exercises to determine if the participants would demonstrate an increase in their phonemic awareness abilities. Articulatory exercises were included in this study because the researchers identified that articulatory training not only increased articulatory precision but also included auditory short-term memory tasks. Auditory and articulatory training and phonological processing, according to Joly-Pottuz et al. share a connection in that they all require short term memory and auditory abilities. They concluded, "The main result of this study was that combining articulatory and auditory phonological training adds significant advantage to auditory training" (p. 421). They concluded that the combination of auditory and articulatory exercises with phonemic awareness activities positively impacted the reading, spelling, phonological awareness, and speech production abilities in dyslexics.

The effectiveness of auditory training (linguistic, non-linguistic, and combinations of both) led to further explorations of auditory and articulatory exercises to improve phonological and phonemic awareness abilities. Schaffler, Sonntag, Hartnegg, and Fischer (2004) and Joly-Pottuz, Mercier, Leynaud, and Habib (2008) posited that implementing interventions containing auditory training in individuals with dyslexia was a viable way of improving auditory, phonemic, and reading skills in dyslexic readers. In the early 2000s, Overy (2003) extended the use of non-linguistic sounds and studied the effects of using musical auditory exercises to improve the phonological, spelling, and auditory processing skills dyslexic readers; the findings supported earlier studies confirming the effectiveness of auditory training. The findings of Joly-Pottuz et al., Schaffler et al., and Overy provided additional support to earlier studies using linguistic and non-linguistic sounds (Gaab et al., 2007; Kujala et al., 2001). Study of the relationship between auditory training, music, and auditory and phonological processing began to emerge

Pitch Processing

The first step in this strand of research was to move auditory training from the music room with musicians to the reading room with readers. Besson, Shon, Moreno, Santos, and Magne (2007) specifically studied the connection between pitch processing abilities and music and speech and observed the pitch processing abilities between musicians and non-musicians. Besson et al. concluded:

> The results…show that musical expertise improved pitch discrimination and this was reflected by an increased positivity to weak incongruity in musicians but not in non musicians….Similar effects were found in music and speech which demonstrated clear positive transfer effects from music to speech processing. (pp. 401-402)

They also researched the connection between pitch processing and dyslexia. Participants in this study completed an auditory intervention that required the participants to distinguish between different musical pitches and musical intervals. After the training period, the dyslexic participants were compared to a normal reading group, and Besson et al. (2007) concluded:

> [There were] no significant differences were found between the two groups of children. Therefore, the combination of phonological and audio-visual training clearly improved the detection of strong pitch incongruities in speech in dyslexics… Dyslexic children also have difficulties in pitch processing, an important aspect of speech. (p. 407).

The link between dyslexics' ability to discriminate pitch in musical notes and their (dis)ability to discriminate phonemes in speech and reading intersected in the implementation of specific auditory training.

Santos, Joly-Pottuz, Moreno, Habib, and Besson (2007) completed a study to examine the pitch-processing deficit in dyslexics and to observe if specific training—combining pitch and auditory exercises with phonemic awareness exercises—would increase the phonemic awareness and pitch processing abilities in the participants with dyslexia. The participants in this study listened to recorded sentences where the pitch of the last word in the sentence was modified. The participant then had to decide if the pitch of the last word in the sentence sounded unusual or different compared to the other words. Compared to the dyslexic group, Santos et al. found that the control group outperformed the dyslexics in accurately identifying the pitch differences in the last word of the sentence; they concluded that "…dyslexic children have more difficulties than controls to discriminate pitch manipulations when they are embedded within natural speech" (p. 1086). Contemporary studies (Besson, Shon, Moreno, Santos, & Magne, 2007; Santos, Joly-Pottuz, Moreno, Habib, & Besson, 2007) also supported the notion that dyslexics have a deficit in pitch processing. Santos et al. further observed that after an intensive training including pitch and auditory examples combined with phonemic awareness exercises, the dyslexic participants performed the same on the pitch identifying tasks as did the normal reading participants. "Impaired pitch processing within natural speech…may contribute to a deficient phonological representations in dyslexics that may, in turn, led to an impaired development of reading skills" (Santos et al., p. 1088). These results provide teachers and reading specialists with new interventions that appear to help readers with dyslexia develop undeveloped or absent skills. Santos et al. summarized their findings with a hopeful message, "children with developmental dyslexia are not only trainable, as indicated by improvement in the level of reading performance, but also that specific training can be associated with noticeable changes in brain's response to pitch manipulations" (p. 1089). The convergence of supporting research points toward effective intervention for phonemic awareness using auditory training.

The intersection of studies in auditory training and the development of auditory and phonological processing appear to be promising for readers diagnosed with dyslexia. The link between pitch processing deficits and dyslexia (Besson, Shon, Moreno, Santos, & Magne, 2007; Santos, Joly-Pottuz, Moreno, Habib, & Besson; 2007) and the amelioration of auditory discrimination and processing deficits with linguistic and non-linguistic auditory training (Joly-Pottuz, Mercier, Leynaud, & Habib, 2008; Schaffler, Sonntag, Hartnegg, & Fischer, 2004) provide educators with effective intervention strategies for struggling readers. The pitch deficit observed by Besson et al. and Santos et al. also supports the theory that dyslexics have an auditory discrimination and processing deficit (Fostic, Bar-El, & Ram-Tsur, 2012; Gaab, Gabriele, Deutsch, Tallal, & Temple, 2007; Kujala, Karma, Ceponiene, Belitz, Turkkila, Tervaniemi, & Naatanen, 2001; Lyon, Shaywitz, & Shaywitz, 2003; Thomson & Goswami, 2010). Because pitch is an auditory function that is distinguishable through differences between high and low sounds (Oxford Music Online, 2012), Besson et al. and Santos et al. concluded that pitch is an auditory function; therefore, dyslexics who have an auditory deficit will also have a pitch deficit.

Music Training

Focusing on the auditory discrimination abilities of children with dyslexia, Forgeard, Schlaug, Norton, Rosam, Iyengar, and Winner (2008) conducted four studies of analysis comparing the musical abilities and phonemic awareness abilities of children with dyslexia. The participants in this study completed the Gordon's Primary Measures of Music Audiation (Gordon, 1986). This music assessment included a variety of musical discrimination tasks that required the participants to judge if the combination of tones they heard were the same or different. Participants also completed a variety of phonemic awareness tasks. Forgeard et al.

then compared the results of the musical assessments to those of the phonemic awareness assessments; they observed that, "the children with dyslexia in Study 3 showed deficits in both melodic and rhythmic discrimination abilities….In addition, phonemic awareness was predicted by musical discrimination skills, and in turn phonemic awareness predicted reading abilities" (p. 387). They also observed a connection between music discrimination abilities and phonemic awareness. Because of this connection, Forgeard et al. concluded, "…our results also suggested that children with dyslexia appear to have deficits in both pitch and rhythm processing…Taken together, the results of [our] studies…confirm that a strong relationship exists between auditory musical discrimination abilities and language-related skills in children" (p. 388).

The conclusion that children with dyslexia have a deficit in both pitch and auditory abilities is congruent with the findings of Besson et al. (2007) and Santos et al. (2007). Besson et al., Forgeard et al., and Santos et al. concluded that the auditory deficit in dyslexics caused the pitch deficit. The auditory and pitch deficit then caused a deficit in phonemic awareness, which then can lead to reading difficulties. Overy, Nicolson, Fawcett, and Clarke (2003) completed a study that also involved the assessment of musical auditory skills in children with dyslexia and found that children with dyslexia had difficulty with musical discrimination skills. Overy et al. further concluded the following:

> musical activities…may provide a valuable medium in which to develop dyslexic children's timing skills and language skills. Such activities have a particular advantage of being non-literacy based, thus removing the frustrations that may be associated with reading and writing activities." (p. 34)

This congruence provided an understanding of the relationship auditory and phonological deficits as they are related to the disability of dyslexia.

Summary

Dyslexia is a learning disability that is neurological in origin (International Dyslexia Association, 2002; Lyon, Shaywitz, & Shaywitz, 2003) which results in an auditory deficit (Fostic, Bar-El, & Ram-Tsur, 2012; Gaab, Gabriele, Deutsch, Tallal, & Temple, 2007; Kujala, Karma, Ceponiene, Belitz, Turkkila, Tervaniemi, & Naatanen, 2001) which can potentially be ameliorated through auditory interventions including linguistic and non-linguistic sounds (Besson, Shon, Moreno, Santos, & Magne, 2007; Forgeard, Schlaug, Norton, Rosam, Iyengar, & Winner, 2008; Overy, Nicollson, Fawcett, & Clarke, 2003)

Through the research presented, it has been identified that music and reading share some of the same basic auditory pathways. Rauscher and Hinton (2011) stated, “[there is an] association between some of the auditory skills used in learning to read and certain elements of music perception” (p. 224). Moreover, music training and auditory training provide some encouragement as effective strategies to help dyslexic readers develop better auditory processing and discrimination. Strait, Chan, Ashley, and Kraus (2012) further concluded, “Music practice has the power to shape sensory circuitry” (p. 362). The research presented concluded that because of the shared auditory pathways, music might be an effective strategy for increasing auditory and phonemic awareness abilities in individuals with dyslexia (Lucas & Gromko, 2007; Strait and Kraus, 2011).

CHAPTER III. METHODS AND PROCEDURES

The purpose of this study was to find a possible connection between aural skill developments in individuals with dyslexia, specifically the subtype with a deficit in phonemic awareness. The following three research questions guided the study:

(1) Will an intervention using non-linguistic sounds develop essential listening skills and the ability for individuals with the deficit in phonemic awareness subtype of dyslexia to mentally hear and discriminate sounds?

(2) Will ear training intervention using non-linguistic sounds support and increase dyslexic's listening skills, ability to mentally hear, skills in sound discrimination, and development of phonemic awareness in individuals with dyslexia who have a deficit of phonemic awareness?

(3) Will the development of the ability to mentally hear and discriminate sounds have a positive effect on the dyslexic individual's sensitivity to phonemic awareness?

Methods

Research Design

The single subject research design, A/B, was used for this study. The single subject research design is a quasi-experimental design that allows for a comparison between pre-intervention data sets and post-intervention data sets (Stocks, 2000). A series of two pre-assessments were completed to obtain a baseline. The baseline is a repeated measure that establishes a pattern of responses that can then be used to predict future outcomes (Horner, Carr, Halle, McGee, Odom & Wolery, 2005). After completing the two assessments and the baseline was identified, auditory interventions were implemented. After completing the five auditory interventions, another series of post-assessments were completed to identify a final baseline.

Two post-assessments were completed to determine a baseline. The two pre- and post-baselines were compared for growth made during the intervention.

The single subject research design allows for identifying evidence-based practices and allows the researcher to document relationships between both independent and dependent variables. This design incorporates one or two dependent variables that are consistently defined and measured throughout the research. Dependent variables should be observable and measured repeatedly. The independent variable in single subject research is normally the intervention, or behavior modification, that occurs between the baseline assessments. Single subject research is an effective measure for individuals with special needs because it focuses on the individual's specific need, provides active intervention, and often focuses on practical procedures that can be incorporated into the home or school environment (Horner, Carr, Halle, McGee, Odom & Wolery, 2005).

Participation

The participant in this study, John as he will be named, attended a medium-sized state university in the Midwest. John had been previously diagnosed with dyslexia and was identified as having a deficit in phonemic awareness. The participant was in his mid-twenties and was a college freshman at the time of this study.

Instrumentation

The Lindamood Auditory Conceptualization (LAC-3) and the Comprehensive Test of Phonological Processing (CTOPP) assessments were used to determine the pre- and post-baselines. The LAC-3 is an "individually administered, norm-referenced assessment that measures an individual's ability to perceive and conceptualize speech sounds using a visual medium….The LAC-3 also measures the cognitive ability to distinguish and manipulate sounds, which success in reading and spelling requires" (Pearson Education, Inc., 2012, Summary). The LAC-3 is normed for ages 5.0-18.11. The CTOPP assessment is an assessment that is used to "identify individuals who need help in developing phonological skills" (Pearson Education Inc.). The CTOPP is useful in determining an individual's strengths and weaknesses in processing phonological information such as phonological memory, rapid naming, and retrieval of phonological information (Pearson Education Inc.). Only the following select subtests from the CTOPP were administered and scored for this research: Ellison, Memory for Digits, Non-word repetition, and Blending of Non-Words. These subtests were specifically selected because the researcher felt they had a strong connection between phonemic awareness and the skills that were reinforced during the auditory interventions.

Procedure

The participant for this study completed both the LAC-3 and the CTOPP assessments to determine a baseline. After completing two pre-assessments, John began the auditory interventions. During the auditory intervention, John completed tasks that scaffolded his auditory discrimination, chord quality, and auditory memory abilities. The auditory discrimination exercises (See Appendix B) required John to listen to two notes played separately on the piano and to identify if the notes played were the same or different. Based on the theory of scaffolding, the difficulty of this task increased gradually as the interval of the notes played was shortened. The next exercise focused on chord quality (See Appendix C). During this task, John was given instruction on identifying major and minor chords. After the instruction on major and minor chords, John was asked to listen to the chords and correctly identify if the chord played was major or minor. To explore John's abilities in aural skills, the researcher played some chords shortly, or staccato, and other chords were held out for three beats at about 80 beats per minute. Inversions, playing the same chord quality while rearranging the notes of the chord, were also included that required John to focus on the chord quality because the chord arrangements were not always played in the same sequence. The next task was an auditory memory task (See Appendix D). The auditory memory task required John to listen to a short melody initially containing three notes and gradually increasing to include seven or eight notes. After listening to the melody, John waited five seconds then listened to two additional melodies containing the same amount of notes compared to the first example played. He was asked to identify which of the second melodies played matched the first melody. The wait time gradually increased after each example from 5 to 10, 10 to 15, 15, to 20, then to 25, and lastly to 30 seconds between hearing the initial example and the two comparison examples. The fourth exercise contained another three-note melody with a wait time of ten seconds. This pattern continued until John completed all of the examples containing three notes. The final set of exercises began with the four-note melody and progressed through the wait times. During the intervention, any example that John answered incorrectly was replayed and discussed to help him compare and understand the differences between the initial example and the two examples played after the wait time. Incorrectly identified chord or pitch discrimination examples were reviewed and discussed to assist John in his auditory skills. The last procedure of the study was the post-assessment of John's auditory and phonological skills using the LAC-3 and the CTOPP. The post-assessment of the CTOPP included the same four subtests as the pre-assessment.

Data Collection

Quantitative data were collected from the LAC-3 and the CTOPP assessment. These data were used to determine a pre- and post-baseline. Qualitative data were also collected from observational notes taken during the auditory intervention. An audio recording of each intervention session was made to aid in the collection of observational notes and discussions between John and the researcher. Observational notes included discussions between the researcher and the participant, comments the participant made in relation to the study, and informal observations of John's reactions and body language. Any errors and incorrect responses John made during the auditory interventions were recorded and charted to track his progress and identify patterns in his auditory skills.

Data Analysis

Pre- and post-assessment data were collected from the LAC-3 and the CTOPP assessments. Pre- and post-baselines were compared to determine if John's phonological processing as measured by the CTOPP, and his auditory conceptualization skills as measured by the LAC-3 improved. Qualitative notes taken during the intervention session were then used to analyze the participant's attitude and interest in the auditory interventions as well as to compare the qualitative data to the quantitative data collected from the assessments. The quantitative data were placed on line chart to express and outline the baselines and potential growth made during the interventions. The qualitative data were analyzed and used to describe and support the quantitative data.

Summary

Two formal assessments, the CTOPP and the LAC-3, were used to analyze John's growth in the auditory skills and phonemic awareness, and to identify a pre- and post-baseline. John took part in a variety of auditory exercises that were scaffolded to his abilities in the areas of auditory discrimination, identifying chord quality, and auditory memory tasks designed to increase his abilities in phonemic awareness. The final assessment data were then analyzed to determine if the auditory interventions increased John's sensitivity to phonemic awareness, ability to hear mentally, and ability to discriminate between sounds.

CHAPTER IV. DATA ANALYSIS AND DISCUSSION OF RESULTS

The purpose of this study was to find a possible connection between aural skill developments in individuals with dyslexia specifically the subtype with a deficit in phonemic awareness. The following questions guided the study:

(1) Will an intervention using non-linguistic sounds develop essential listening skills and the ability for individuals with the deficit in phonemic awareness subtype of dyslexia to mentally hear and discriminate sounds?

(2) Will ear training intervention using non-linguistic sounds support and increase dyslexic's listening skills, ability to mentally hear, skills in sound discrimination, and development of phonemic awareness in individuals with dyslexia who have a deficit of phonemic awareness?

(3) Will the development of the ability to mentally hear and discriminate sounds have a positive effect on the dyslexic individual's sensitivity to phonemic awareness?

Results

Pre-Assessments

Two assessments, the Comprehensive Test of Phonological Processing (CTOPP) and the Lindamood Auditory Conceptualization Test (LAC-3), were used to assess John's abilities in phonological processing, auditory memory, and phonemic awareness. Both the CTOPP and the LAC-3 were given on day one and were repeated on day two. John's phonemic awareness, phonological processing, and auditory memory were assessed using the following four selected subtests from the CTOPP: Ellison (EL), Memory for Digits (MD), Nonword Repetition (NR), and Blending Nonwords (BN).

Results of the first pre-assessment using the CTOPP and LAC-3 can be found in Table 1. John scored in the 25th, 5th, 5th, and 16th percentiles on the subtests of the CTOPP respectively. His individual results can be found in Table 1. The LAC-3 combined all of the subtests together to provide a percentile rank; John scored in the 6th percentile overall. John received a descriptive rating of "poor" and an age equivalent of 9 years 6 months.

Results of the second day of pre-assessment using the same assessments can be found in Table 1. John scored in the 37th, 25th, 25th, and 50th percentile for the CTOPP subtests respectively. Based on the combined scores of all of the LAC-3 subtests, John scored in the 23rd percentile and received a descriptive rating of "below average" and an age equivalent of 12 years 6 months. See Table 1 for individual scores of the subtests.

Table 1

Pre-assessment Results for the CTOPP and LAC-3 Assessments

	1st Pre-assessment		2nd Pre-assessment	
	Number Correct / Total Number of Questions	Percentile Ranking	Number Correct / Total Number of Questions	Percentile Ranking
Pre-CTOPP EL	13/20	25	17/20	37
Pre-CTOPP MD	10/21	5	13/21	25
Pre-CTOPP NR	7/18	5	12/18	25
Pre-CTOPP BN	8/18	16	11/18	50
Pre-LAC-3 Isolated Phonemes	14/16	n/a	15/16	n/a
Pre-LAC-3 Tracking Phonemes	12/18	n/a	15/18	n/a
Pre-LAC-3 Counting Syllables	2/10	n/a	6/10	n/a
Pre-Lac-3 Tracking Syllables	8/10	n/a	7/10	n/a
Pre-LAC-3 Tracking Syllables and Phonemes	3/12	n/a	4/12	n/a

Interventions

Intervention Day 1

John completed the auditory discrimination, timbre, chord quality, and auditory memory tasks. The intervention began with an overview of the interventions including a description of the types of auditory training exercises John would be completing as well as a quick training in hearing and understanding the difference between major and minor chords. John was also informed that the interventions were different from the formal assessments in that auditory examples could be repeated, discussed, and reviewed if he did not understand or answered incorrectly.

The intervention began with the auditory discrimination exercise; the exercise provided 30 pairs of notes. John was asked to determine if the two notes played separately were the same or different. Out of the 30 examples, John answered all of them correctly. During the auditory discrimination exercises, John was provided with the mental imagery of a string. On this "string," John was asked to imagine when he hears a note to determine if it is low on the string for lower notes or high on the string for higher notes. After he heard each note, he was asked to place the notes on the string and determine if they were the same of different. The next exercise focused on timbre. For this exercise, John listened to the same note played on the piano then on the iPad. John was instructed to identify on which instrument the first note was played. John successfully completed all examples of this exercise.

The next exercise that John completed was the chord quality exercise. Each chord was played for three counts at a tempo of 80 beats per minute. The chord quality exercise included 29 chords, and John correctly identified 26 chords. When asked how he distinguished the major from the minor chords, he said that the major chords had a higher ring to them and the minor chords did not. He also stated that the major chords sounded "happy" and the minor chords sounded "sad." John's ability to identify the chords was quick, and there were negligible delays or pauses in his response time.

The final auditory exercise John completed was the auditory memory task. This exercise included 30 musical examples ranging from three to seven notes. John correctly answered all examples except for the 4-note 30 second wait time and the 5-note 5 second wait time sets. For each example John initially answered incorrectly, the example was played again and he was asked to compare the correct example to the incorrect example. Then, John was asked to identify if the difference he heard was in the beginning, middle, or end, or if the rhythm was different but he was unable to determine where the difference occurred. During these discussions, John would wave his hands in the air as if to "paint" the melody line he heard and to describe its "shape." Also during the exercise, John would place his elbows on his knees and then place his head in his hand as he was deeply concentrating on keeping the melody in his mind, especially on the examples that lasted 20 seconds or longer. John's response time increased as the wait time increased.

At the conclusion of the intervention, I asked John to identify which exercises he believed were the most challenging. He responded to these questions by stating he believed the chord quality exercise and the auditory memory exercise were the most challenging. He stated that the auditory memory exercise was difficult because he had to remember the sounds and keep the mental image of the sounds he heard in his mind. He further stated that the number of notes did not seem to affect his ability to remember but what caused the most difficulty was the wait time. John also stated that the timbre exercise was the easiest simply because the piano has a louder sound compared to the iPad. This difference enabled him to easily tell the difference between the two sounds. Lastly, John described himself as being "very mentally tired" after completing the auditory exercises. He said he was more tired completing these exercises compared to completing the CTOPP and LAC-3".

Intervention Day 2

The second intervention followed the same format as the first day. John began with the auditory discrimination exercise, which now included playing short (staccato) random examples.

John missed two examples that were both played staccato, and the two notes played were a half-step apart on the piano which means the notes were very similar in sound yet discretely different. When John first heard the notes in the exercise played staccato, he laughed; his wait time increased before he gave a response. Because of the sound difficulties of the iPad compared to the piano, the timbre exercise was dropped and not included in the intervention.

Next, John completed the chord quality exercise where again random chords were played staccato. John incorrectly answered eight chords, all of which were played staccato. The final exercise was the auditory memory. John missed 2 examples that included a 6-note example with a 20 second wait time and a 7-note example with a 25 second wait time.

The intervention ended with John commenting on how he felt for the day. He stated that it felt like “someone took a sledge hammer to my head.” John further described that he believed the mental processing of the sounds and trying to recall what he heard was making him tired. John then said that what made recalling difficult was that he had “gaps in his memory” when trying to recall what he heard. He described trying to remember pieces of the sounds or melody he heard and then trying to put them together; and essentially, he had to guess because he did not have the entire auditory picture. John also commented that picturing the string we talked about during the first intervention helped him to remember the sounds because he could associate what he heard with a picture in his mind. He also then described the moment at which he began to “feel the holes” in his auditory memory beginning to affect his recall ability, which he described was at the 20-second mark during the auditory memory exercise. He also stated that when he first heard the sound it was “vibrant,” then after a few seconds the sound started to dim and he was no longer able to replay those sounds in his head.

Intervention Day 3

The order of the third intervention was different from the previous two days in that the auditory memory came first, then the discrimination, and the intervention ended with the chord quality exercise. John missed the following auditory memory examples, 3-note set at 10 seconds, 5-note set at 20 seconds, 6-note set at 30 seconds, 7-note set at 15 seconds, and 7-note set at 30 seconds. John then missed two examples on the auditory discrimination exercise. The two he missed on this exercise were both played staccato and were only a half-step apart on the piano. He was able to correctly identify where the change occurred in the melody line (e.g., beginning, middle, end) or if the rhythm changed after his first incorrect example was replayed. John also noticed not only the location of the change in the melody but also if the notes that changed went either up or down. Lastly, John missed six chord quality examples where four were staccato and two were held for three counts at 80 beats per minute.

John stated that he did not have class prior to coming to the intervention and as a result, he felt more refreshed and not tired from class prior to the intervention. He went on to say that after the second day of auditory intervention, he was extremely tired that he could not even play video games. He reported that after the third intervention he felt tired but not as extremely tired as he had the day before.

Intervention Day 4

The order of exercises was the same as the previous intervention. John missed three memory examples, which included the following: 5-note set at 30 seconds, 6-note set at 20 seconds, and 6-note set at 30 seconds. He only missed one example in the discrimination exercise, which was played staccato and was a half-step apart on the piano. Lastly, John missed two chord quality examples, one that was played staccato and one that was held for three counts at 80 beats per minute.

After the intervention, John was again asked to describe how he felt mentally. John had class prior to coming to the intervention but stated that he only felt “foggy and sluggish” but not as tired as the previous day. It was observed that John’s response time increased and his responses seemed to become more automatic.

Intervention Day 5

The final intervention again had the same order of exercises as the previous session. John began with the auditory memory exercise and missed two examples, which included the following: 2-note set at 30 seconds, and the 7-note set at 25 seconds. Next, he completed the auditory discrimination exercise and only missed one example, which was played staccato and was a half-step apart on the piano. Lastly, John completed the chord quality exercise where he missed six chords, two of which were played staccato and four that were held for three counts at 80 beats per minute.

At the conclusion of the session, John was asked to describe how he felt after completing the interventions. He stated that after this intervention, he did not feel mentally tired but more like this was a warm up. He also stated that while he was listening to the chord quality examples he began to notice “a subtle ring” that distinguished the major from the minor chords.

Post-Assessments

The CTOPP and the LAC-3 were used as post-assessments to assess John’s abilities in phonological processing, auditory memory, and phonemic awareness. The CTOPP was administered first and again only included the subtests administered in the pre-assessment. Individual assessment results are presented in Table 2. He was ranked in the 50th, 25th, 25th, and

37th percentiles respectively. Following the administration of the CTOPP, John was administered the LAC-3 (see Table 2 for results). For the combined score, John ranked in the 18th percentile with a descriptive rating of "below average" and an age equivalent of 11 years 6 months.

The second day of post-assessment John performed at the 84th, 50th, 37th, and 50th percentiles on the CTOPP subtests; individual scores can be found in Table 2. For the LAC-3, John scored in the 27th percentile with a descriptive rating of "average" and an age equivalent of 13 years 6 months. See Table 2 for individual scores of the subtests.

Table 2

Post-assessment Results for the CTOPP and LAC-3 Assessments

	1st Post-assessment		2nd Post-assessment	
	Number Correct / Total Number of Questions	Percentile Ranking	Number Correct / Total Number of Questions	Percentile Ranking
Pre-CTOPP EL	18/20	50	19/20	84
Pre-CTOPP MD	13/21	25	15/21	50
Pre-CTOPP NR	12/18	25	13/18	37
Pre-CTOPP BN	10/18	37	11/18	50
Pre-LAC-3 Isolated Phonemes	16/16	n/a	16/16	n/a
Pre-LAC-3 Tracking Phonemes	16/18	n/a	16/18	n/a
Pre-LAC-3 Counting Syllables	3/10	n/a	6/10	n/a
Pre-Lac-3 Tracking Syllables	8/10	n/a	9/10	n/a
Pre-LAC-3 Tracking Syllables and Phonemes	1/12	n/a	1/12	n/a

Discussion of Results

The essential question of this research study was, "Will an intervention using non-linguistic sounds develop essential listening skills and the ability for individuals with the deficit in phonemic awareness subtype of dyslexia to mentally hear and discriminate sounds? To determine the phonemic awareness abilities of the participant in this study, John, pre-assessments were completed using the CTOPP and the LAC-3, which indicated that John had a deficit in phonemic awareness as indicated by the percentile ranks, age equivalents, and grade equivalents identified by the assessments. John struggled with auditory memory as indicated by the scores of the CTOPP subtests MD, NR, and BN. In these subtests, John was required to remember sounds and either repeat or modify the sounds he heard. The LAC-3 supported these findings as the subtests of this assessment also required John to remember sounds he heard and either repeat or manipulate the sounds. Both assessments agreed that John is scoring significantly below his expected age and grade abilities (See Appendix E).

The auditory interventions were designed to "work the auditory muscle." The auditory exercises were created to help John to remember sounds, to quickly identify sounds he heard, to identify if two sounds were the same of different, and to expand his ability to hold an auditory memory in his mind. In the span of only five auditory interventions, gains were identified in the area of auditory memory and in fine listening skills.

Evidence of growth appears in the area of auditory memory by analyzing the errors John made during the interventions. During the first three days of the intervention, John missed nine auditory memory examples. The average total of notes and wait time is 5-note sets with a 20-second wait time. The average of notes and wait times for the last two days of intervention were 6-note sets at 27 seconds; this yielded an increase of one note and seven seconds. This is evidence that John was able to increase the amount of auditory information he was able to keep in his short term memory as well as the duration of time in which the auditory information was accurately retrievable. Evidence to support this also comes from the post-assessment of the CTOPP, which identified that John increased his auditory processing and discrimination in in the areas of MD, NR, and BN.

The second research question was, “Will ear training intervention using non-linguistic sounds support and increase dyslexic’s listening skills, ability to mentally hear, skills in sound discrimination, and development of phonemic awareness in individuals with dyslexia who have a deficit of phonemic awareness?” The intervention results indicated that this intervention was successful. Fine listening skills were one of the areas where John demonstrated growth. Evidence to support this comes from the increase in accuracy on the auditory discrimination exercises and in comments John made following each intervention. John began with missing two auditory discrimination examples, and by the end of the intervention, he had decreased his errors to only one incorrect example on days four and five. These results are small but when combined with statements that John made concerning his perception of the activities, they indicate that he did increase his fine listening skills using nonverbal sounds. During the auditory memory exercises on day four, examples he initially answered incorrectly were replayed. During this reviewing time, John was able to identify the similarities and differences between the two examples played for him. He was also able to identify how the notes changed (i.e., went up or down, if the rhythm changed) and was able to describe the overall shape of the melody. After the fifth intervention session, John said that he was able to identify a subtle difference between the major and minor chord qualities.

The third research question, “Will the development of the ability to mentally hear and discriminate sounds have a positive effect on the dyslexic individual’s sensitivity to phonemic awareness?” was demonstrated qualitatively and quantitatively. Support for John’s auditory growth also comes from observations of how mentally “tired” he was feeling after each intervention. In the beginning he described his head as feeling like someone took a “sledge hammer” to it. He said he did not have a headache, but rather, he was extremely mentally tired and exhausted from processing and thinking about the auditory information he was presented. By the end of the interventions, John stated that he did not feel mentally tired, even after having a full day of class; rather, he only felt like the interventions were now a “warm up.”

Following the five days of intervention, two days of post-assessments were completed. John demonstrated an increase in percentile, grade equivalents, and age equivalents in all of the CTOPP subtests and areas of phonemic awareness development. He also demonstrated growth on the LAC-3 assessment as he progressed in the percentile rank, descriptive rating, and age equivalent. On the LAC-3, John increased his descriptive rating from “poor” to “average” (See Appendix F).

Not only did John increase his aural skills, but he also demonstrated growth in the area of phonemic awareness. John demonstrated an increase in the areas of phoneme memory, discrimination, and phoneme identification. These areas of growth are supported by the CTOPP post-assessment, which identified an increase in his abilities in all four of the assessed subtests, which measured John’s abilities in phoneme manipulation, discrimination, and phoneme memory. The results of the LAC-3 also supported the findings of the CTOPP, as John increased his scored on all subtests of the LAC-3 indicating that his abilities in phonemic awareness had improved.

Summary

Overall, the results of this research indicate that an auditory intervention utilizing non-linguistic sounds can have a positive impact on not only auditory discrimination and processing but also on phonemic awareness abilities. When asking John how he felt mentally after each auditory intervention, a trend emerged which indicated that the auditory interventions were "working the auditory muscle." It also became clear that, even though data results were small, that auditory training using non-linguistic sounds might positively impact phonemic awareness abilities in individuals who have a deficit in phonemic awareness.

CHAPTER V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to find a possible connection between aural skill developments in individuals with dyslexia, specifically the subtype with a deficit in phonemic awareness, and to answer the following research questions:

(1) Will an intervention using non-linguistic sounds develop essential listening skills and the ability for individuals with the deficit in phonemic awareness subtype of dyslexia to mentally hear and discriminate sounds?

(2) Will ear training intervention using non-linguistic sounds support and increase dyslexic's listening skills, ability to mentally hear, skills in sound discrimination, and development of phonemic awareness in individuals with dyslexia who have a deficit of phonemic awareness?

(3) Will the development of the ability to mentally hear and discriminate sounds have a positive effect on the dyslexic individual's sensitivity to phonemic awareness?

Summary

This study investigated the effectiveness of an auditory training intervention using non-linguistic sounds, such as developing listening skills using musical examples, and its ability to increase the phonemic awareness abilities of individuals with dyslexia who have a deficit in phonemic awareness. The study began with two sessions of pre-assessments and using the Comprehensive Test of Phonological Processing (CTOPP) and the Lindamood Auditory Conceptualization Test (LAC-3). After completing the pre-assessments and determining a baseline, five days of auditory interventions were administered. The interventions included auditory exercises designed to scaffold auditory and listening abilities and to mimic similar skills used in phonemic awareness such as discrimination, isolation, fine listening skills, and auditory memory skills. After the five auditory interventions, two sessions of post-assessments were completed again using the CTOPP and the LAC-3 to determine a final baseline as well as determine potential growth in the participants, John, phonemic awareness abilities.

Conclusions

The results of this study identified that John demonstrated an increase in his auditory memory, fine listening or aural skills, auditory discrimination skills, and phonemic awareness abilities. He also demonstrated a growth in not only his phonemic and phonological awareness abilities but also increased his fine listening skills. Wepman (1960) concluded that prior to the development of auditory discrimination, it is essential to be able to remember and recall sounds, or phonemes. Habib and Besson (2009), Krause, Skoe, Parbery-Clark and Ashley (2009), Richardson, Ramsden, Ellis, Burnett, Megnin, Catmur, Schofield, Leff, and Price (2011), Strait, Chan, Ashley and Kraus (2012) and Strait and Kraus (2011) later identified that music or auditory training can reshape and strengthen the neurological pathways that are connected to reading and auditory memory abilities. The exercises that were included in the auditory interventions helped to improve John's auditory memory, which in turn affected his abilities in phonemic memory. The increase in John's auditory memory also lead, as Wepman identified, to an increase in auditory discrimination and fine listening skills.

Moreover, John demonstrated growth in the areas of fine listening skills, or aural skills, and auditory discrimination. Based on the results of the LAC-3 and its subtest of tracking phonemes and tracking syllables, John was able to increase his scores on each of these subtests as well as on the subset of the CTOPP of blending non-words. The tracking phonemes and tracking syllables required John to listen to a non-word and to manipulate it to match the next non-word that was read aloud. Each non-word would change by one sound, and John had to identify if the non-word changed in the beginning, middle, or end. The skills that John was required to demonstrate on the LAC-3, CTOPP, and mimicked in the auditory interventions, are described by the NRP's (NICHHD, 2000) meta-analysis as the six common tasks used to identify and assess phonemic awareness. These six areas are phoneme isolation, identifying phonemes, categorizing phonemes, blending phonemes, segmentation phonemes, and phoneme deletion tasks. John was essentially demonstrating skills in fine listening when he identified the phoneme that changed, identified the location of the change, and manipulated the word to create a new word.

Connected to John's increase in phonemic discrimination tasks on the LAC-3 and CTOPP, John also demonstrated these skills during the auditory interventions. He increased his abilities during the auditory memory exercise to be able to successfully identify if the change in the melodic pattern occurred in the beginning, middle, or end. He also demonstrated an increase in this ability to identify if the change in the notes went higher, lower, or if the there was a change in the rhythm. Gromko (2005) stated that when individuals are able to identify the fine differences in melodic and rhythmic patterns and associate the sounds with visual symbols, the individual would be able to increase their abilities in sound processing which has been shown to be required for reading. During the auditory intervention, John increased his abilities in sound processing in the areas of fine listening. He also began to connect the sounds he heard to visual or mental images. The skills that John acquired during the auditory intervention were reflected on the post-assessments by the growth in phoneme manipulation, discrimination, and fine listening skills.

John demonstrated growth in specific skills related to phonemic awareness such as auditory discrimination, fine listening skills, and auditory and phonemic memory. After completing the auditory intervention, John not only increased these specific skills, but he also increased his phonemic awareness and phonological processing skills. This growth is outlined on the LAC-3; his overall descriptive rating of "poor" on the first pre-assessment progressed to "average" on the final post-assessment. John also increased from the 6^{th} percentile to the 27^{th} percentile in overall phonemic awareness abilities. The CTOPP also confirmed John's phonemic awareness growth as measured by the increase in his percentile ranking. Anvari, Trainor, Woodside, and Levy (2001) and Rauscher and Hinton (2011) stated that there seems to be a connection between music training and phonemic awareness and reading abilities. Because music has the potential to reshape some of the auditory pathways shared with reading and phonemic awareness abilities, individuals who are able to discriminate, manipulate, and process sounds are more likely to have strong phonemic awareness abilities (Anvari, Trainor, Woodside, & Levy, 2001; Strait & Kraus, 2011).

Recommendations

For Pre-Service Teachers, In-Service Teachers, and Administrators

As the results of this study suggest, auditory training has potential benefits to students who struggle with phonemic awareness, especially those students who have dyslexia and a deficit in phonemic awareness. Implementing the type of auditory intervention described in this study may be difficult for classroom teachers to complete individually; however, the majority of schools already have built-in auditory intervention classrooms— music classrooms. Music classrooms at the elementary, middle, or high school levels already involve students in a variety of auditory tasks such as listening to and distinguishing between melodies, rhythms, and larger pieces of music, learning the differences between major and minor keys and chords, taking a melody and manipulating it to create a new melody, comparing and contrasting the same piece of music recorded by two different musical groups, and many other auditory tasks. The tasks that students in music classrooms are engaging in are connected to and share some of the same basic auditory pathways associated with reading and phonemic awareness (Anvari, Trainor, Woodside, & Levy, 2001). Teachers and administrators should encourage their students to take part in music training and various musical activities as the non-linguistic auditory training they receive through these courses/activities could potentially impact their reading and language development.

For Teacher Educators

Understanding the benefits auditory training and listening may have on the development of reading and language could benefit pre-service and in-service teachers' understanding of how to better serve their students who have dyslexia and a deficit in phonemic awareness. Teacher educators can instruct pre-service teachers on the importance of developing fine listening skills in their future students, as it is related to phonemic awareness development, through non-linguistic auditory training found within music classrooms. This approach provides teacher educators and music educators to engage in collaboration during teacher preparation. Teacher educators can also help pre-service teachers make connections between the listening skills used in developing phonemic awareness and the skills included in the auditory interventions. Practice in fine listening skills is easily embedded in phonics, early literacy, intervention, and assessment courses at the undergraduate and graduate levels.

For Further Study

One limitation of the study was the absence of an assessment to measure the sustainability of the improved skills. Further research is needed to determine the lasting effects auditory intervention has on the phonemic awareness growth and abilities after completing the intervention. Determining how long the results of the auditory intervention last would be useful in not only realizing how long the auditory intervention benefited the individual but also understanding how an auditory intervention reshapes the neurological pathways in the brain and how permanent are these changes.

Another limitation of the study was the small number of intervention sessions. Further research is also needed in determining the appropriate frequency, duration, and lengths an auditory intervention must last before evident changes occur in the auditory pathways in the brain leading to changes in phonemic awareness, phonological processing, and language development in individuals with dyslexia who have a deficit in phonemic awareness. Contrary to Gaab et al. (2007), Soboleski (2011) found that an overuse of the Fast ForWord software resulted in a decline of reading ability and suggested that may be contributed to the notion that 'one size fits all' is not effective. Not all dyslexic students struggle with phonemic awareness difficulties in the same way; therefore, more research needs to be done to identify which readers benefit most from intervention at the phoneme level. This bottom-up approach may inadvertently lead to a deconstruction of skills previously acquired by the student resulting in reading delays and deficits. As Soboleski pointed out, one size does not fit all, and more is not always better.

Future studies might also administer the non-linguistic ear training to a wider variety of participants to determine how age affects the acquisition of benefits. As Rauscher and Hinton (2011) concluded, "early music instruction may influence reading acquisition" (p. 224). If younger children with dyslexia benefit from this particular type of intervention, then more research needs to study the inclusion of non-linguistic ear training for children who have been diagnosed with dyslexia or have a genetic predisposition to the disability.

Summary

The following primary research question guided this study: Will an intervention using non-linguistic sounds develop essential listening skills and the ability for individuals with the deficit in phonemic awareness subtype of dyslexia to mentally hear and discriminate sounds? After analyzing the results, it was evident by this study that a non-linguistic auditory training intervention did have a positive effect on the phonemic awareness abilities of the subject for this study. It is unclear how long these results will last and the overall impact the auditory training has on the subject. However, this study did bring to light the possibility that an auditory training using non-linguistic sounds may have a positive impact on the phonemic awareness abilities in individuals who have an auditory deficit.

REFERENCES

The Education for All Handicapped Children, 94-142 (U.S.C November 29, 1975).

Aaron, P. (1987). Developmental dyslexia: Is it different from other forms of reading disability. *Annals of Dyslexia, 37*, 109-125.

Alexander, A., Anderson, H., Heilman, P., & Torgesen, J. (1991). Phonological awareness training and remediation of analytic decoding deficits in a group of severe dyslexics. *Annals of Dyslexia, 41*, 193-206.

Anvari, S., Trainor, L., Woodside, J., & Levy, B. (2002). Relations among musical skills, phonological processing, and early reading ability in preschool children. *Journal of Experimental Child Psychology, 83*, 111-130.

Badian, N. (1997). Dyslexia and the double deficit hypothesis. *Annals of Dyslexia, 47*, 69-87.

Ball, E. (1993). Phonological awareness. *Reading and Writing: An Interdisciplinary Journal, 5*, 141-159.

Berk, L., & Winsler, A. (1995). *Scaffolding children's learning: Vygotsky and early childhood education. NAEYC research into practice series. Volume 7.* Washing D.C.: National Association for the Education of Young Children.

Besson, M., Schon, D., Moreno, S., Santos, A., & Magne, C. (2007). Influence of musical expertise and musical training on pitch processing in music and language. *Restorative Neurology and Neuroscience, 25*, 399-410.

Bolduc, J. (2009). Effects of a music proframme on kindergartners' phonological awareness skills. *International Journal of Music Education, 27*(1), 37-47.

Bradley, L., & Bryant, P. E. (1983). Categorizing sounds and learning to read - a casual connection. *Letters to Nature, 301*(3), 419-421.

Bradley, L., & Bryant, P.E. (1978). Difficulties in auditory organisation as a possible cause for reading backwardness. *Nature, 271*, 746-747.

Brady, S. (1986). Short-term memory, phonological processing. and reading ability. *Annals of Dyslexia, 36*, 138-153.

Ehri, L.C., & Wilce, L.S. (1985). Movement into reading: Is the first stage of printed word learning visual or phonetic. *Reading Research Quartely, 20*(2), 163-179.

Forgeard, M., Schlaug, G., Norton, A., Rosam, C, Iyengar, U., & Winner, E. (2008). The relation between music and phonological processing in normal-reading children and children with dyslexia. *Music Perception: An Interdisciplinary Journal, 25*(4), 383-390.

Fostic, L., & Bar-El, S., & Ram-Tsur, R. (2012). Auditory temporal processing as a specific deficit among dyslexic readers. *Psychology Research, 2*(2), 77-88.

Frith, U. (1999). Paradoxes in the definition of dyslexia. *Dyslexia, 5*, 192-214.

Gaab, N., Gabriele J.D.E., Deutsch, G.K., Tallal, P., & Temple, E. (2007). Neural correlates of rapid auditory processing are disrupted in children with developmental dyslexia and ameliorated with training: An fMRI study. *Restorative Neuroscience, 25*, 295-310.

Gromko, J. (2005). The effect of music instruction on phonemic awareness in beginning readers. *Journal of research in music education, 53*(3), 199-209.

Gromko, J., Hansen, D., Tortora, A., Higgins, D., & Boccia, E. (2009). Effects of temporal sequencing and auditory discrimination on children's memory patterns for tones, numbers, and nonsense words. *Journal of Research in Music Education, 57*(2), 140-151.

Gunning, T. (2010). *Creating literacy instruction for all students seventh edition* (7th ed.). Pearson.

Habib, M., & Besson, M. (2009). What do music training and musical experience teach us about brain plasticity. *Music Perception: An Interdisciplinary Journal, 26*(3), 279-285.

Haynes, B., & Cooke, P. (2012). *Pitch.* Retrieved from Oxford Music Online: www.oxfordmusiconline.com.maurice.bgsu.edu/subscriber/article/grove/music/40883

Horner, R., Carr, E., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children*, 165-179.

International Dyslexia Association. (2002). *Definition of Dyslexia.* Retrieved from The International Dyslexia Association: http://www.interdys.org/ewebeditpro5/upload/Definition.pdf

Kavahagh, J., & Mattingly, I. (1972). *Language by ear and by eye.* Boston, MA: Massachusetts Institute of Technology.

Khan, A., Hamalainen, J., Leppanen, P., & Lyytinen. (2011). Auditory event-related potentials show altered hemispheric responses in dyslexia. *Neuroscience Letters*, 127-132.

Krause, N., Skoe, E., Parbery-Clark, A., & Ashley, R. (2009). Experince-induced malleability in neural encoding of pitch, timbre, and timing. Implications for language and music. *Annals of the New York Academy of Sciences*, 543-557.

Kujala, T., Karma, K., Ceponiene, R., Turkkila, P., Tervaniemi, M., & Naatanen, R. (2001). Plastic neural changes and reading improvement caused by audiovisual training in reading-impaired children. *Procedings of the National Academy of Science of the United States of America, 98*(18), 10509-10514. doi:10.1073

Lamb, S. J., & Gregory, A.H. (1993). The relationship between music and reading in beginning readers. *Educational Psychology: An International Journal of Experimental Educational Psychology, 13*(1), 19-27.

Liebenthal, E. H. (2007). *The functional organization of the left STS: a large scale meta-analysis of PET and fMRI studies of healthy adults.* Retrieved from Language Imaging Laboratory: http://www.neuro.mcw.edu/~einatl/poster_OHBMposter_2011.pdf

Liperote, K. (2006). Audiation for beginning instrumentalists: Listen, speak, read, write. *Music Educators Journal, 93*(1), 1-10.

Lucas, J., & Gronko, J. (2007). The relationship of musical pattern discrimination skill and phonemic awareness in beginning readers. *Contributions to Music Education, 34*, 9-17.

Lutz, S., Guthrie, J., & Davis, M. (2006). Scaffolding for engagement in elementary school reading instruction. *Journal of Educational Research*, 3-20.

Lyon, G.R., Shaywitz, S.E., & Shaywitz, B.A. (2003). Defining dyslexia, comorbidity, teachers' knowledge of language and reading. *Annals of Dyslexia, 53*, 1-14.

Moore, D., & Amitay, S. (2007). Auditory training: Rules and applications. *Seminars in Hearing, 28*(2), 99-109.

Overy, K. (2003). Dyslexia and music. *Annals New York Academy of Sciences, 999*, 497-505.

Overy, K., Nicolson, R., Fawcett, A.J., & Clarke, E.F. (2003). Dyslexia and music: Measuring musical timing skills. *Dyslexia, 9*, 18-36. doi:10.1002/dys.233

Pennington, B., Lefly, D., & Orden, G. (1987). Is phonology bypassed in normal or dyslexic development. *Annals of Dyslexia, 37*, 62-89.

Perason Education Inc. (2012). *Clinical Assessment*. Retrieved 12 2012, from Pearson: http://www.pearsonassessments.com/HAIWEB/Cultures/en-us/Productdetail.htm?Pid=CTOPP2&Mode=summary

Rauscher, F., & Hinton, S. (2011). Music instruction and its diverse extra-musical benefits. *Music Perception: An Interdisciplinary Journal, 29*(2), 215-226.

Richardson, F., Ramsden, S., Ellis, C., Burnett, S., Megnin, O., Catmur, C., Schofield, T., Leff, A., & Price, C. (2011). Auditory short-term memory capacity correlates with gray matter density in the left posterior STS in cognitively normal and dyslexic adults. *Journal of Cognitive Neuroscience, 23*(12), 3746-3756.

Ridway, A. J. (2009). The inner voice. *International Journal of English Studies, 9*(2), 45-58.

Santos, A., Joly-Pottuz, B., Moreno, S., Habib, M., & Besson, M. (2007). Behavioural and event-related potentials evidence for pitch discrimination deficits in dyslexic children: Improvement after intensive phonic intervention. *Neuropsychologia, 45*, 1080-1090.

Schaffler, T. S. (2004). The effect of practice on low-level auditory discrimination, phonological skills, and spelling in dyslexia. *Dyslexia, 10*, 119-130. doi:10.1002/dys.267

Soboleski, P. K. (2011). Fast forword: An investigation of the effectiveness of computer-assisted reading intervention. Bowling Green State University. *ProQuest Dissertations and Theses*, 153.Retrieved from http://search.proquest.com/docview/865891680?accountid=26417. (865891680).

Stanovich, K. (1986). Matthew effects in reading some consequences of individual differences in the acquisition of literacy. *Reading Research Quartely, 21*(4), 360-407.

Stocks, T. (2000). *AB baseline and intervention design*. Retrieved 11 2012, from Introduction to Single Subject Designs: https://www.msu.edu/user/sw/ssd/issd10b.htm

Strait, D., & Krause, N. (2011). Playing music for a smarter ear: Cognitive, perceptual and neurobiological evidence. *Music Perception: An Interdisciplinary Journal, 29*(2), 133-146.

Strait, D., Chan, K., Ashley, R., & Krause, N. (2012). Specialization among the specialized: Auditory brainstem function is tuned in to timbre. *Cortex, 48*, 360-362.

Tallal, P. (1980). Auditory temporal perception, phonics, and reading disabilities in children. *Brain and Language, 9*, 182-198.

Thomson, J., & Goswami, U. (2010). Learning novel phonological representations in developmental dyslexia: Associations with basic auditory processing or rise time and phonological awareness. *Reading and Writing: An Interdisciplinary Journal, 23*(5), 453-473.

Tsang, C., & Conrad, N. (2011). Music training and reading readiness. *Music Perception: An Interdisciplinary Journal, 29*(2), 157-163.

Vygotsky, L. S. (1978). Mind and society: The development of higher mental processes. Cambridge, MA: Harvard University Press

Wagner, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101*(2), 192-212.

Wepman, J. (1960). Auditory discrimination, speech, and reading. *The Elementary Schoo Journal, 60*(6), 325-333.

Wheeler, D. (2007). Neglected skills: Aural perception and music reading. *American Music Teacher*, 35.

Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology, 17*(2), 89-100.

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Appendix A
Letter of Consent

Dear Participant,

My name is Brent Hildebrandt and I am a graduate student at Bowling Green State University in the Masters of Education Reading program. I also attended BGSU for my undergraduate degree in Music Education.

For my thesis, I am studying how an auditory intervention effects the development of phonemic awareness in individuals with dyslexia. Phonemic awareness is the ability to hear and identify sounds in words. I would like to ask your participation in this study. This study will contain 18 fifty-minute sessions, which takes place three times a week, for six weeks. Two assessments will be used in this study, which are the Lindamood Conceptualization Test (LAC-3) and the Comprehensive Test of Phonological Process (CTOPP). The LAC-3 is an assessment that assesses an individual's skills in recognizing speech sounds. It also measures the ability to distinguish and manipulate between different sounds in speech. The CTOPP assessment assesses an individual's ability in phonological processing such as remembering, identifying, and quickly naming phonemes in words.

The potential benefit of participating in this study is to contribute new knowledge to the understanding of dyslexia, reading development, and language development.

The pre and post assessments will take place on the BGSU campus in the College of Education Building on the 5th floor in the Martha Gesling Weber Reading Center. The interventions will take place on the BGSU campus in the College of Musical Arts in a practice room. The intervention sessions, held three times a week can be scheduled to fit your class schedule. The pre and post assessment will take place on the first and last day of the interventions for a total of 18 days, 16 days of actual intervention, and 2 days for pre and post assessment.

To protect your privacy, I will not use your name or other identifiable information in my study. All data that is collected will only be used to show the potential growth of your phonemic awareness and auditory abilities. The data collected will be stored in a locked cabinet in my advisor's office. Your name will not be included on the pre and post assessments. Instead, I will assign your name a random number. I will then create a master list, which only I will have access which will list your name and the assigned random number. This list will be kept in a lock cabinet and will be destroyed at the end of the study.

Participation in this study is completely voluntary and you have the option of ending your participation at any time. Also, the risk of participating in this study is no greater than that experienced in daily life. If you choose not to participate, or end your participation early, it will not affect your relationship with BGSU or the Reading Center. To participate in this study, you must be 18 years or older.

In addition, before the study begins, I will also complete a very short phonemic awareness test and a short interview to see if you would be eligible for this study. The results of these tests will be kept confidential and will not be included in the final study.

If you should have any questions regarding your right as a research participant, please contact Chair of Bowling Green State University's Human Subjects Review Board, 419-372-7716, or email at HSRB@bgsu.edu. If you should have any questions regarding the overall study, please contact me, Brent Hildebrandt, at

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bjhilde@bgsu.edu or by phone at 419-372-7320. You may also contact my advisor by email, Dr. Soboleski, at pennys@bgsu.edu or by phone at 419-372-8004. I would greatly appreciate your assistance for my thesis and will await your timely response.

I,____, volunteer to participate in this study and have been informed that my participation is voluntary and I may opt out at any time. I have been informed that my name and other identifiable information will be kept safe and secure and this sensitive information will not be included in the final report/thesis.

Signature: ____Date: ______________________

Please select three days, for the intervention, that will best fit your class schedule in the spring.

____Monday from ______to _______

____Tuesday from _______to ______

____Wednesday from _____to _____

____Thursday from _______to _____

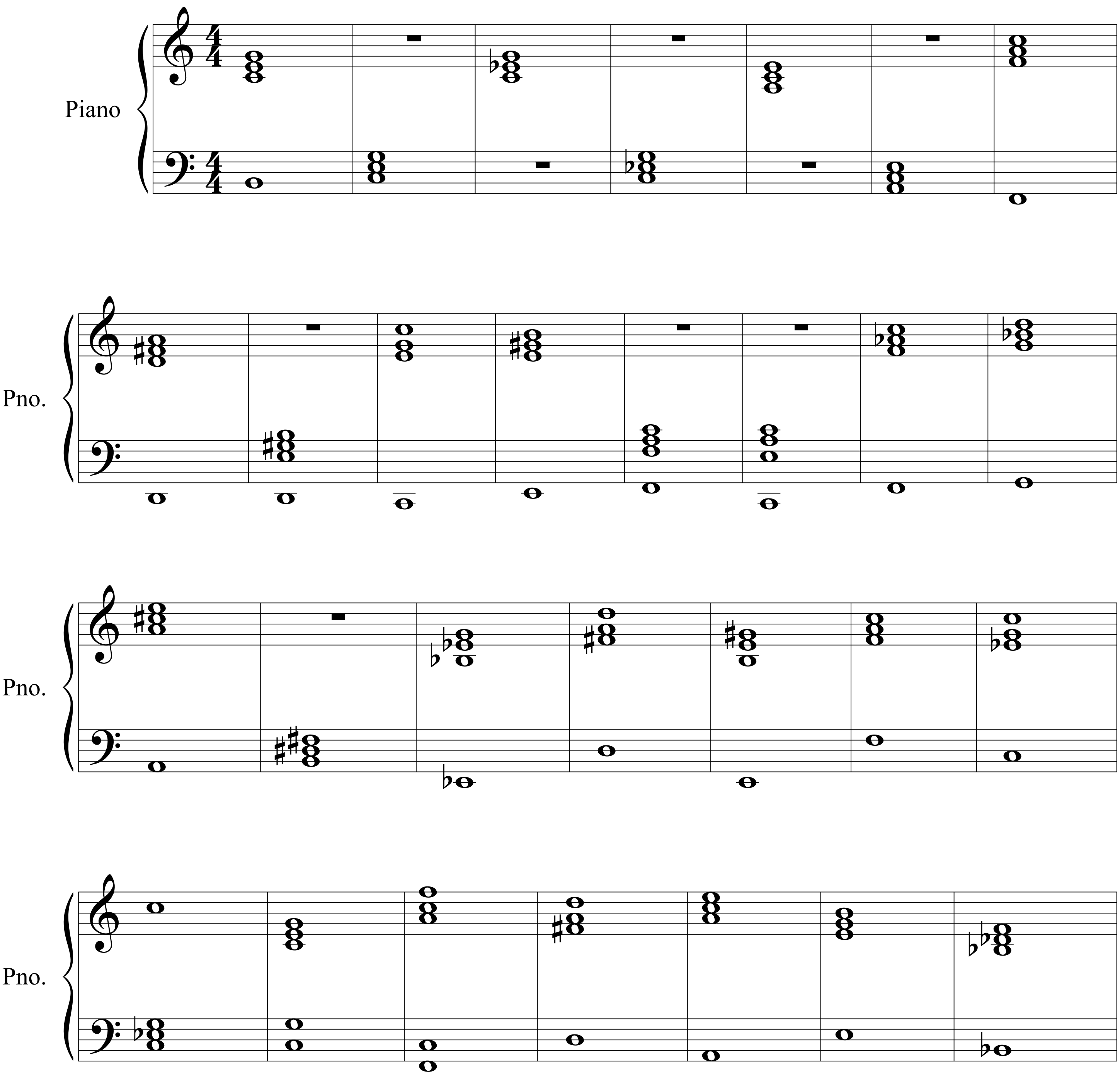
_____Friday from _______to _______

Appendix B

Pitch Discrimination Exercises

Appendix C

Chord Quality Exercises



Appendix D

Auditory Memory Exercises

Appendix E

LAC-3 Pre- and Post-assessment Data

Table E1

Results of LAC-3 Pre-assessment 1

Raw Score	LAC-3 Standard Score	Percentile Rank	Descriptive Rating	Age Equivalent	Grade Equivalent
39	77	6	Poor	9-6	4.4

Table E2

Results of LAC-3 Pre-assessment 2

Raw Score	LAC-3 Standard Score	Percentile Rank	Descriptive Rating	Age Equivalent	Grade Equivalent
47	89	23	Below Average	12-6	6.7

Table E3

Results of LAC-3 Post-assessment 1

Raw Score	LAC-3 Standard Score	Percentile Rank	Descriptive Rating	Age Equivalent	Grade Equivalent
45	86	18	Below Average	11-6	6

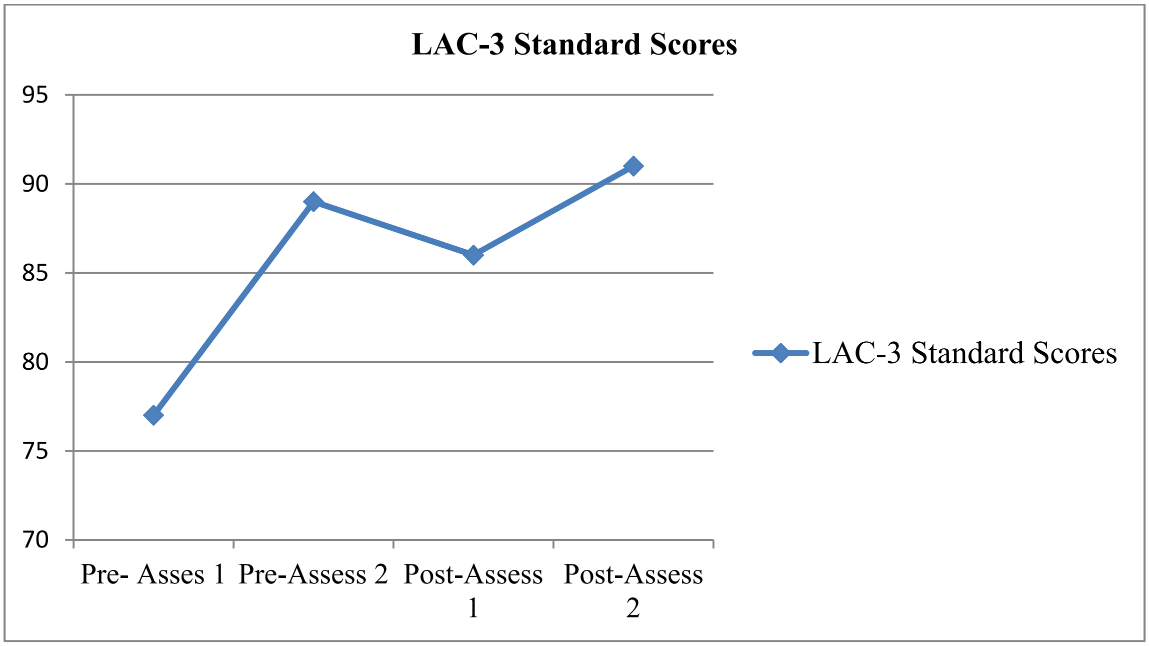
Table E4

Results of LAC-3 Post-assessment 2

Raw Score	LAC-3 Standard Score	Percentile Rank	Descriptive Rating	Age Equivalent	Grade Equivalent
48	91	27	Average	13-6	7.2

Figure E1

Standard Scores for the LAC-3 Assessment



Appendix F

CTOPP Pre and Post Assessment Data

Table F1

Results of CTOPP Pre-assessment 1

EL	Raw Score	Age Equivalent	Grade Equivalent	Percentile Rank	Standard Score
EL	16	10.6	5.4	25	8
MD	10	5.6	k.4	5	5
NR	7	5.3	k.2	5	5
BN	8	8.9	3.7	16	7

Table F2

Results of CTOPP Pre-assessment 2

	Raw Score	Age Equivalent	Grade Equivalent	Percentile Rank	Standard Score
EL	17	12.6	7.4	37	9
MD	13	8.6	3.7	25	8
NR	12	11.6	6.4	25	8
BN	11	14.9	9.7	50	10

Table F3

Results of CTOPP Post-assessment 1

	Raw Score	Age Equivalent	Grade Equivalent	Percentile Rank	Standard Score
EL	18	14.9	9.7	50	10
MD	13	8.9	3.7	25	8
NR	12	11.6	6.4	25	8
BN	10	13.6	8.4	37	9

Table F4

Results of CTOPP Post-assessment 2

	Raw Score	Age Equivalent	Grade Equivalent	Percentile Rank	Standard Score
EL	19	14.9	9.7	84	13
MD	15	14.9	9.7	50	10
NR	13	14.9	9.7	37	9
BN	11	14.9	9.7	50	10

Figure F1

Results of CTOPP Pre- and Post -assessments